



Transforming Library Services Through Virtual Reality and Augmented Reality

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ABSTRACT

Libraries are shifting from traditional to virtual. Needs of users are also changing. Virtual Reality and Augmented Reality play a significant role in enhancing library services. Such technologies are utilized to make libraries more interactive, engaging and involving. Present paper explains how such technologies can transform the character of library services in terms of interaction with the users, accessibility and experiences. VR offers an experience where one gets to learn information in an active and meaningful manner. Access to information and support is also improved under AR. These tools advance the interests of users and their interaction within the library. They also provide access to library services to users with cognitive, physical, and educational requirements. With regards to learning, VR and AR enable the users to learn in a better way, both visually and experientially. Some of these disadvantages include high cost, absence of technical expertise and need for an infrastructure. Regardless of all these obstacles, VR and AR have a wonderful chance in libraries in the future. They can support new services and improve the utility of libraries in a digital society. The paper concludes that these technologies would help libraries to survive and be more user-centered, flexible, and inclusive.

INTRODUCTION

Libraries have been valuable places of knowledge, learning and interacting with the community. Digital transformation is altering the way of user's access and consumes information. VR and AR are new technologies that promise new opportunities to change the way libraries work. VR is synonymous with AR and XR, and it is an interactive experience that allows users to engage with information. AR assists physical resources with online layers of information to enhance the physical library environment. All these technologies bridge the physical-digital divide in libraries. New library services focus on the improvement of interaction with the user, access, and learning (Farney, 2020). VR and AR that allow making libraries more interactive and user-driven allow users to

interact with information rather than just read it. They also provide users of different abilities and learning styles with solutions. It is a shift towards newer, more open-minded, and flexible library areas. This paper discusses the transformation of library services by these technologies. It also talks about the issues and future opportunities relating to their implementation.

LITERATURE REVIEW

Recent research also shows the increased contribution of VR and AR to change library services. These are immersive learning technologies, tools that help to visualize information and interact with users in modern libraries and include virtual museum and historical tours and science simulations. It increases accessibility, especially to

the audiences who cannot visit the real sites due to distance, physical disability or remoteness. Libraries are using VR both to consume and create content. The proposed tools that were suggested by the study are the implementation of 360-degree cameras and VR content creation platforms (Holland, 2020). It also emphasizes the need to follow best practices in the instructional and entertainment uses in enhancing the learning outcomes in libraries. VR helps to create a successful learning environment in libraries. These environments are interactive and collaborative research (Mandal & Mandal, 2025). There is also improved access to online content. In turn, VR promote the increased activity and productivity of the learning process in the digital age (Miltenoff, 2024). Libraries have to struggle to achieve the correct infrastructure and devise clear policies (Miltenoff, 2024). Use of physical globes is combined with AR to demonstrate geospatial information in an interactive way. It presented different applications and provided examples of how users can more interactively view complex datasets. Studies have shown that almost 86 per cent of the top 100 successful university libraries in the United States have embraced the use of these technologies. The analysis has also found infrastructure and training to be among the biggest obstacle to the adoption of AR in libraries (Farida et al., 2025). The tendencies of this study indicate that they are becoming increasingly important in the education and library sphere (Anwar et al., 2025). Results indicate that AR improves the perception of spatial information and facilitates an improved analysis. This method shows that the old tools can be enhanced with the help of new technologies. One paper discussed the creation of VR-based library user education programs (Mandal, 2025). This paper emphasized the application of immersive VR spaces created by using 360-degree imaging. It expressed the idea that VR HMD displays can also provide real-life experiences as in a real-life environment. Virtual library tours were also mentioned as a useful tool for leading the users in the research. Other recent studies also find the application of VR and AR in libraries. One of the studies suggests that the degree of user engagement, accessibility, and learning outcomes is more likely to be increased with the help of immersive technologies. AR is usually used in interactive catalogues and navigation, and VR is used in virtual touring and collaborative learning. VR and AR in libraries can enhance the library user experience because they offer learners an immersive academic environment (Patil, 2025). These technologies allow making library users more interested in the materials. They help in redefining the process of accessing, experiencing and sharing knowledge in libraries to highlight the possibility of the AR to redefine library services (Agwuna, Ejezie and

Nwankwo, 2024). It supports applications, such as information searching, interactive displays and virtual meetings. This study also highlights such obstacles as the necessity of effective technological support and the acceptance of the users (Sen, 2025). The above studies show the use, need and demand of these modern technologies in various disciplines. The present study is carried out to investigate the application and implications of these technologies in library services.

OBJECTIVES

New technologies are being embraced in libraries to enhance their services and address the evolving needs of users. AR and VR technologies produce immersive and interactive experiences that can be used to improve learning, interaction, and access. The aim of this study is as follows:

- To determine the advantages and disadvantages of these technologies in library services.
- To investigate the new ways of using these technologies within libraries;
- To discuss on various challenges of VR and AR technologies.

APPLICATION OF VR AND AR IN LIBRARY SERVICES

VR and AR render the libraries more contemporary, interactive and user-friendly. VR is some sort of computer-generated environment, which individuals are able to navigate through in a more active way. AR brings the real world to the virtual world. Experience-based activities invite patrons to the physical and online library spaces. They provide flexibility in learning to people with disabilities. It increases library access. They use passive reading as an exploration. One studies show that there are improved interactions and understanding of immersive technologies. Finally, libraries of the future are made through VR and AR. They help the libraries become knowledge-based, technology-centred and innovation-centred. Such services as Overly, Stories AR, Ricoh clickable paper and Aurasma, which make print publications interactive, are mentioned in the file. These tools can be enhanced in a library, like books, magazines, brochures, posters, and exhibition materials. One such event is a poster of a library event, which might display a video introduction to the event when scanned by a user. On the contrary, an author interview, a summary of contents, and other academic documents may appear on the cover of a book. Another application is visual search and information overlay. Examples of a tool used to identify text, objects and places and give real-time information through AR include Google Lens and

Wikitude. These technologies can help individuals in libraries locate books, translate the text, define material they are not familiar with or access immediate and subject-related knowledge. These technologies, together, enhance user interaction, accessibility, and support deep learning in library services:

User Interaction: VR and AR can make library experiences more engaging and appealing. They also enable users to navigate library resources in new and exciting ways. Digital content related to physical and virtual materials can be interacted with by users instead of just reading shelves or searching catalogues. AR allows users to view book information instantly, displaying things like titles, summaries, reviews, and other related resources. Immersive learning environments in which users can engage in a more active experience with information are also supported by VR.

Accessibility: VR and AR enhance access to library services as well. Libraries cater to individuals of various backgrounds, capabilities and learning needs. These technologies offer adaptive technologies to assist individuals with physical or mental disabilities. In particular, immersive systems may provide visual, audio, and interaction assistance to users who require alternative methods of accessing information. Mobility users can also have an easier time navigating through virtual library areas and resources. By doing so, VR and AR can eliminate information access barriers. They enable libraries to be inclusive and support a wider range of communities.

Supporting Deep Learning: Practice of using libraries traditionally is passive, as the user usually reads or views information. When using these technologies, the user is able to interact with the content in a more direct manner and can practically interact with information. Virtual field trips, 3D models and simulations can be used to understand complex topics. Users can visit places, objects or events that do not exist physically in the library. VR and AR would help in deeper learning and turn libraries into more potent learning and discovery centres.

IMPLICATION OF VR AND AR IN LIBRARIES

VR and AR transform libraries into a place where information is stored for a process of learning that is user-based and interactive. These kinds of technologies can help libraries become more efficient in terms of information access providers, friendliness and service modernization, and education can also be further enabled in more interactive programs. In the provided material, AR is mentioned as a device that may be utilized to fill the gap between the real and the digital media. On the contrary, VR is also presented as a method of delivering immersive learning, orientation, collaboration and training within

libraries. These technologies can find numerous applications in libraries. Libraries are using these technologies to enhance service delivery and address the evolving demands of their users. They transform library spaces to be more interactive, flexible, and engaging. They also enable learning, creativity and access to information in new ways. These are being used in libraries both digitally and in the real world.

Augmented Physical Spaces: AR can improve spaces in physical libraries by providing digital information to printed and tangible materials. With their phones, tablets and other gadgets, users are able to scan books, shelves, and library signposts to get real time information. They can view the titles of books, synopses, reviews, authors, and other related materials. AR can also guide the users towards the correct shelves or sections in the library. Physical libraries are enhanced with the help of AR. It overprints books and shelves with computerized information. AR makes it possible to discover books. Users are able to scan books and see metadata, reviews, etc., in real time. AR is also interactive. They are interactive and promote exploration and collaboration. Recent research proves that AR enhances the level of user participation and information connectivity in libraries. It enhances navigation and saves time. AR makes the physical library more interactive by enhancing user satisfaction and making the library resources more effectively used.

Virtual Tours and Orientation: VR is also used in libraries to offer virtual tours and orientation programs. These tours enable new users to be acquainted with spaces and services as well as collections found in libraries. Users can also navigate the library in a virtual world, as opposed to relying solely on printed instructions or personnel descriptions. At the height of COVID-19, when numerous users were unable to visit libraries in person, virtual tours were extremely helpful. This tool can be done on a mobile phone as follows:

- First: Install the Google Street View application in the Play Store on an Android phone.
- Second: After activation, the app creates a tab, Photo Sphere, and takes photos using the dots on the screen.
- Third: Release the images taken in the form of a tour.
- Fourth: Click on Google Maps and then put the Street View icon (pegman).
- Fifth: Find the URL or location link.
- Sixth: On a laptop or desktop, download Google Street View or go to the 360 image downloader.
- Seven: Open the 360 downloader tool.
- Eight: Choose Single Panorama, cut the URL and

download the panorama picture.

- Nine: Sign up with Webobook and enter.
- Ten: Select Create Tour and type the name of the tour.

This application remains useful as it provides versatile access and accommodates users who are potentially distant from the library or incapable of accessing it physically.

Virtual Field Trips and Learning Programs: The libraries may use such platforms as Meta Horizons, MeetinVR, and Telia VR to conduct the workshops, meetings, and group discussions. These systems allow libraries to perform virtual programs that allow users and staff to interact in common locations even when they are far away. VR allows the user to see places and get to know more about interacting. Students can learn about historical places, museums, landmarks, and other locations anywhere in the world without necessarily going outside the library. These online field trips help individuals who are studying their curricula to connect theory with practice. They break down abstract concepts and help to memorize them. The science, technology, engineering, mathematics and art education programs also utilize VR in libraries. The students can participate in activities, simulations and creative tasks, and this improves learning. As a result, VR will enable libraries to provide more meaningful and profound learning experiences.

VR Studios and Makerspaces: A variety of libraries currently offer VR studios and makerspaces in their services. The educational experience can be immersive with the use of tools such as Librarium, IR Books, Google Arts and Culture, and Nearpad. Examples include IR Books, which can be described as a combination of physical books and VR or AR experiences of geography, animals, and space, which will be particularly useful in school and public libraries. It is possible to facilitate virtual field trips to museums, historical locations, and cultural landmarks using Google Arts and Culture and NearPad and extend the learning opportunities of libraries well beyond their walls. Those spaces enable users to develop and create digital content and build practical skills. Users are allowed to create 3D models, create virtual objects and participate in interactive projects. They can also dabble in digital storytelling, game creation, and visual art creation. Such activities promote creativity, solutions and innovation. The VR labs and makerspaces also favour collaborative learning since students can collaborate on the project and discuss the ideas. Using these technologies, libraries are transformed into spaces of acquiring information, as well as spaces of producing knowledge and acquiring new skills. One example is given for a visual marker:

Each marker is linked to a specific virtual object.

“Willkommen” marker plays a short video about the library. It is placed at the library entrance. “Bibliotheksordnung” marker shows the library rules as a PDF document. It is placed near the entrance and at the library desk. “Bedienungsanleitung” marker shows step-by-step instructions for using the book scanner. It is attached to the scanner.

AR-enabled Interactive Catalogues: Libraries have been implementing augmented reality (AR) to enhance their catalogues and physical spaces (<https://eurosystem.it/en/news-and-events/>). They are QR codes or markers that are used to give more digital information. It assists users in getting a better idea of the content. AR can also be used to navigate the library. To certain sections, they are directed by virtual arrows or markers. Users are able to see 3D models, historical timelines or artistic processes using their devices.

Research and Data Visualization: Virtual Reality (VR) helps libraries with research and data visualization (<https://eurosystem.it/en/data-visualization/>). It enables users to see and manipulate complicated information in 3D. Researchers are able to examine data on more than 2D screens. They can also find their way through big and multi-dimensional data. VR assists in the process of pattern recognition and concealed insight. It can also be used to simulate various scenarios and predict results. Collaboration is another advantage. Several users can collaborate in a common virtual environment. They can share thoughts and discoveries. Example of data visualization:

Fig 2 states ‘Visualisation Theatre’ which is a large-group presentation and viewing of educational or scholarly audio and video performances. It is capable of hosting between 12 and 15 individuals. It has an 8ft x 14ft true 8K display wall constituted of 16 monitors, each 46 inches. The resolution of the display is 7,680 x 4,320. It is driven by a premium Windows 10 workstation with an NVIDIA Quadro 6000 video card. The theatre also includes JBL studio monitor speakers, teleconferencing systems and lounge chairs with attached desks. When the room is not in use due to a room reservation, it remains a curated study room, with first-come, first-served seating.

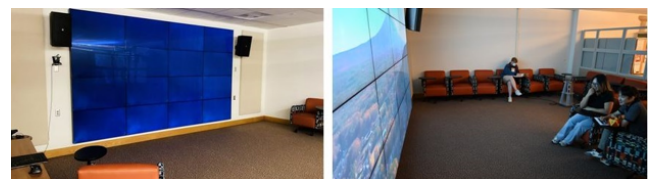


Figure 2. Visualisation Theatre (<https://www.library.illinois.edu/enx/idea-lab-homepage/spaces/>)

Improving Digital Literacy: AR and VR technologies

help in the employment. Users get knowledge from the use of advanced tools. It also builds critical thinking and problem-solving skills. These technologies find application in numerous areas, including education, healthcare, design and entertainment. Users are also taught to use new software and virtual platforms. These activities promote creativity and innovation. Collaboration and sharing knowledge occur during group sessions. Users share ideas and learn with one another.

ADOPTION OF VR AND AR IN LIBRARIES

VR and AR have been implemented in many university libraries. It is starting to become a core component of library development and service provision. These tools are used in libraries to support research, help users navigate the library, create digital exhibitions, instruct, and even in creative projects. There are some bright examples of such adoption in several universities. Harvard Library provides a

library studio called The Hive, a workspace in which students and researchers are free to collaborate on shared virtual worlds, data visualization, and immersive design tools. NC State University Libraries offer VR and AR environments, equipment rental, teaching and learning, development, and recreation. University of Minnesota Libraries also offers virtual reality services to assist coursework, instruction and research. VR / AR resources are available at the University of Miami Libraries in the Creative Studio of the library. These instances indicate that immersive technologies are available in both practical and scholarly applications in various institutions. Adoption of VR and AR in libraries indicates that the technologies are an emerging valuable asset in the future. They assist libraries to advance user experiences, access and services which develop more dynamic learning applications. A list of libraries which adopt AR and VR technology is given below:

Table 1: List of Selected Universities and Public Libraries Adopting AR and VR Technologies

Name of the University	Country	URL	Purpose
Harvard Library	United States	https://library.harvard.edu/	For research, learning, and teaching with AR/VR for designing and data visualization.
NC State University Libraries	United States	https://www.lib.ncsu.edu/	Support teaching, learning, entertainment, and interactive media development.
Princeton University Library	United States	https://library.princeton.edu/	Provide education technology, data visualization, and access.
University of Illinois Library	United States	https://www.library.illinois.edu/	Support class viewing, content creation, and access.
University of Minnesota Libraries	United States	https://www.lib.umn.edu/	Support coursework, instruction, and research.
Penn State University Libraries	United States	https://libraries.psu.edu/	Provide VR centres, equipment, and academic applications.
Arizona State University Library	United States	https://lib.asu.edu/	Offer teaching, lending and makerspace for VR exploration.
University of Arizona Libraries	United States	https://lib.arizona.edu/	Provide VR stations and studio spaces for software use and project creation.
University of Miami Libraries	United States	https://www.library.miami.edu/	Offer resources to faculty, students, and researchers.
National University of Singapore Libraries	Singapore	https://nus.edu.sg/nuslibraries	Support education and research using AR, VR, and MR.
Bodleian Libraries, University of Oxford	United Kingdom	https://www.bodleian.ox.ac.uk/home	Provide virtual orientation and immersive access.
Georgetown University Library	United States	https://library.georgetown.edu/	Support teaching, learning and research exploration.
University of Tennessee Libraries	United States	https://lib.utk.edu/	Offer a VR room for immersive applications, gaming, and multimedia projects.
UTSA Libraries	United States	https://lib.utsa.edu/	Use AR-enhanced books and learning materials to combine print content with digital interaction.
Carnegie Mellon University Libraries	United States	https://www.library.cmu.edu/	Create educational VR experiences linked to library exhibitions and digital scholarship.

New York Public Library	United States	https://www.nypl.org/	Provide public VR programs to explore immersive worlds with library headsets.
Toronto Public Library	Canada	https://tpl.ca/	Offer public demonstrations and programs.
National Library Board	Singapore	https://www.nlb.gov.sg/main/home	Support reading experiences, digital learning, and interactive public programs.
State Library of Queensland	Australia	https://www.slq.qld.gov.au/	Support literacy, kit lending, and community programming.
Cornell University Library	United States	https://www.library.cornell.edu/	Provide XR guidance and resources for teaching, exploration, and academic use.

Table 1 includes a list of some of the chosen universities and public libraries that have embraced AR and VR technologies in their services. It contains the name of the institution, country, website link, and the primary purpose of using immersive technologies. It shows that AR and VR are mostly used in libraries to facilitate research, teaching and learning. VR labs, studios and equipment are also widely available in many libraries. Other institutions specialize in creative practice, data visualisation, and the creation of interactive media. These technologies are primarily utilized in community outreach and awareness by public libraries. In general, the table demonstrates the increased significance of immersive technologies in current library services in various countries.

CHALLENGES IN IMPLEMENTATION

Despite all the disadvantages, libraries would also experience a number of challenges when adopting the said technologies. The first one is high cost. Tools and software are expensive and demand a high level of investment. Maintenance and licensing expenses are also a hindrance in libraries. Adoption is hard because of limited budgets. Technical infrastructure is another challenge. Libraries require good internet connectivity and modernized systems. AR and VR services cannot have good operation unless appropriate infrastructure is in place. Shortage of quality personnel is also a significant problem. Library professionals should be trained on how to utilize and control these technologies. The process of training is time and resource-intensive. It also has usability issues. Some users are not conversant with the sophisticated technologies. Libraries have to train, maintain manuals and offer support to users. There is the issue of accessibility and inclusivity. AR and VR services are supposed to assist users with varying capacities. Certain users might experience discomfort or motion sickness with the VR. Libraries ought to offer other options of access. Another challenge is content development. Production of good AR and VR content needs experience and work. Privacy of data is also an issue. Libraries need to ensure the security of user data and observe the security protocols. Through proper planning, libraries would be able to overcome such

issues in order to utilize AR and VR.

FUTURE DIRECTIONS

VR and AR are transforming the service delivery of libraries. Libraries will employ new approaches in future to enhance learning, access, and interactivity with users. These technologies help in expanding libraries, and this is shown in the following directions and recommendations.

8.1 Embarkation of Metaverse for Collaborative Learning: Libraries can embark on metaverse environments to facilitate collaborative learning. Virtual spaces enable real-time interaction between people in various locations. It can be used to create a common 3D space where students and researchers can collaborate. They can explore the past and learn virtually through experiments, as well as make use of digital objects with ease. This system has eliminated geographical limits and promotes learning worldwide. It also enhances cultural knowledge and teamwork amongst the users. Libraries in the present day are developing an increased curiosity in the metaverse, which is a virtual environment where individuals are capable of interacting with one another and with the digital resources in real-time. It integrates both the physical and digital experiences into a single platform. Libraries are developing virtual reading rooms whereby the user can access books and journals anywhere. They are also coming up with virtual reference desks where the user can communicate with the librarians using avatars. These services offer real-time help and advice. Collaborative spaces are also being developed in the metaverse by libraries. These social media platforms will enable users to collaborate and attend events as well as participate in discussions. Access is also enhanced through the metaverse. It assists libraries in offering services to clients who are not able to access physical premises. Studies indicate that AR and VR systems are advancing to reach full immersion. The systems constitute the foundation of the metaverse and contribute to enhanced library services. Immersive technologies in libraries and education are also emerging as a separate field of study.

8.2 Creation of Custom VR Learning: Libraries are to create their own VR learning materials that are aligned

with academic courses. They would be able to liaise with teachers and experts on subjects and create substantial learning content. These can be virtual tours of historical locations, science simulations, and language learning. It is this type of content that will make learning interesting. It will also facilitate formal education when it is correlated with the curriculum standards.

8.3 Expansion of Remote Access: Libraries must enlarge the remote access to VR and AR services. These resources are supposed to be made available in digital form so that users can access them from the comfort of their homes. Remote access will facilitate equal learning among the users. It will also promote lifelong learning among the various age groups and regions.

8.4 Collaboration with Technology Companies: Libraries are supposed to establish a proper working relationship with technology companies. Such partnerships will assist in embracing the new VR and AR devices. The quality of library services can be enhanced through joint research and pilot projects. In order to make systems user-friendly and sustainable, technology partners can be utilized to help libraries. This level of cooperation is going to guarantee sustained innovation within the library settings.

CONCLUSION

Where AR can be used to make the real world more real, VR provides a complete immersion in a digital environment. VR provides new opportunities in libraries regarding teaching, learning, orientation, collaboration, and professional development. VR and AR are changing the library services in a significant way. They enhance accessibility more effectively as they facilitate the needs of various users. Learning is more active and effective with the help of these technologies. They assist libraries in integrating hardcopy collections with online materials. The libraries will be able to adapt to evolving user expectations by embracing VR and AR. They enhance services and user experience. These steps will help libraries to play pervasive role in the future of global education.



Figure 1. Visual Marker (Baumgartner-Kiradi, Haberler & Zeiller, 2024)

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