

# Augmented Reality Trends and Popularity in Libraries: A Systematic Review

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## ABSTRACT

Augmented Reality (AR) is emerging as a pivotal technology in education and library services, offering personalised and interactive learning experiences. This research investigates the advancements in AR applications for dynamic library services and the challenges associated with their implementation. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method, the study analyses scholarly publications from databases including EBSCO, IEEE Explore, Emerald, Taylor & Francis, and Google Scholar. The review reveals that integrating AR into library systems enhances access to information resources, improves maritime capabilities, and bolsters user education. AR facilitates remote access to interactive resources and models, extending educational opportunities beyond the physical confines of libraries. However, significant challenges exist, such as the lack of integrated applications and inadequate technological infrastructure. Despite AR's growing popularity and potential in education, there is a scarcity of research on its adoption in libraries and strategic planning for AR-centred library services.

**Keywords:** Augmented reality (AR); Virtual reality (VR); Trends; ICT; Libraries; Systematic review

## 1. INTRODUCTION

Augmented Reality (AR) is a rapidly expanding technology that integrates digital information with the real world, significantly enhancing user experience and engagement<sup>1-2</sup>. Its broad applications span healthcare, education, retail, military, and industrial sectors<sup>3-4</sup>. In healthcare, AR has improved surgical precision by offering surgeons a three-dimensional view of anatomical structures<sup>5-6</sup>. In education, AR has revolutionised learning by promoting engagement, experiential learning, and personalised education<sup>7-8</sup>. AR delivers immersive experiences through non-immersive, semi-immersive, and immersive systems, utilising devices ranging from smartphones to Head-Mounted Displays (HMDs)<sup>9-10</sup>. For instance, AR applications in furniture shopping allow users to visualise how items fit in their spaces before purchase<sup>11</sup>. Integration of Mixed Reality (MR) technology is essential for implementing digital twins, which blend real and virtual worlds<sup>12</sup>. AR enhances user perception and interaction by overlaying virtual data, such as graphics, text, or audio, onto real-world objects<sup>13</sup>. As technology advances, AR's potential to bridge the digital and physical realms continues to grow<sup>14</sup>.

In libraries, AR is an innovative tool that enhances user experiences by integrating digital content with

the physical environment<sup>15-16</sup>. It can animate historical documents, provide virtual tours, and assist in locating books, making learning more interactive and engaging<sup>17</sup>. This research is crucial as it explores how AR can modernise library services, making them more engaging, and addressing gaps in current library technology.

## 2. METHODOLOGY

### 2.1 Study Design

This research was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach<sup>18</sup>, a standardised method for conducting systematic reviews and meta-analyses. The study focused on identifying and evaluating scholarly articles related to the application of Augmented Reality (AR) in library services over the last twenty years.

### 2.2 Data Sources and Search Strategy

To gather relevant literature, the researchers utilised multiple academic databases, including EBSCO, IEEE Explorer, Emerald, Taylor & Francis, and Google Scholar. The search strategy involved the application of Boolean logic<sup>19</sup>, employing the operators AND, OR, and NOT to refine the search. The specific search query was (((Augmented Reality)) OR (AR)) AND (Libraries)). The search was conducted from December 2023 to

January 2024. Only articles published in English and directly related to the use of AR in library settings were included in the analysis.

The PRISMA checklist was used as a guideline to ensure the systematic review's comprehensiveness and transparency.

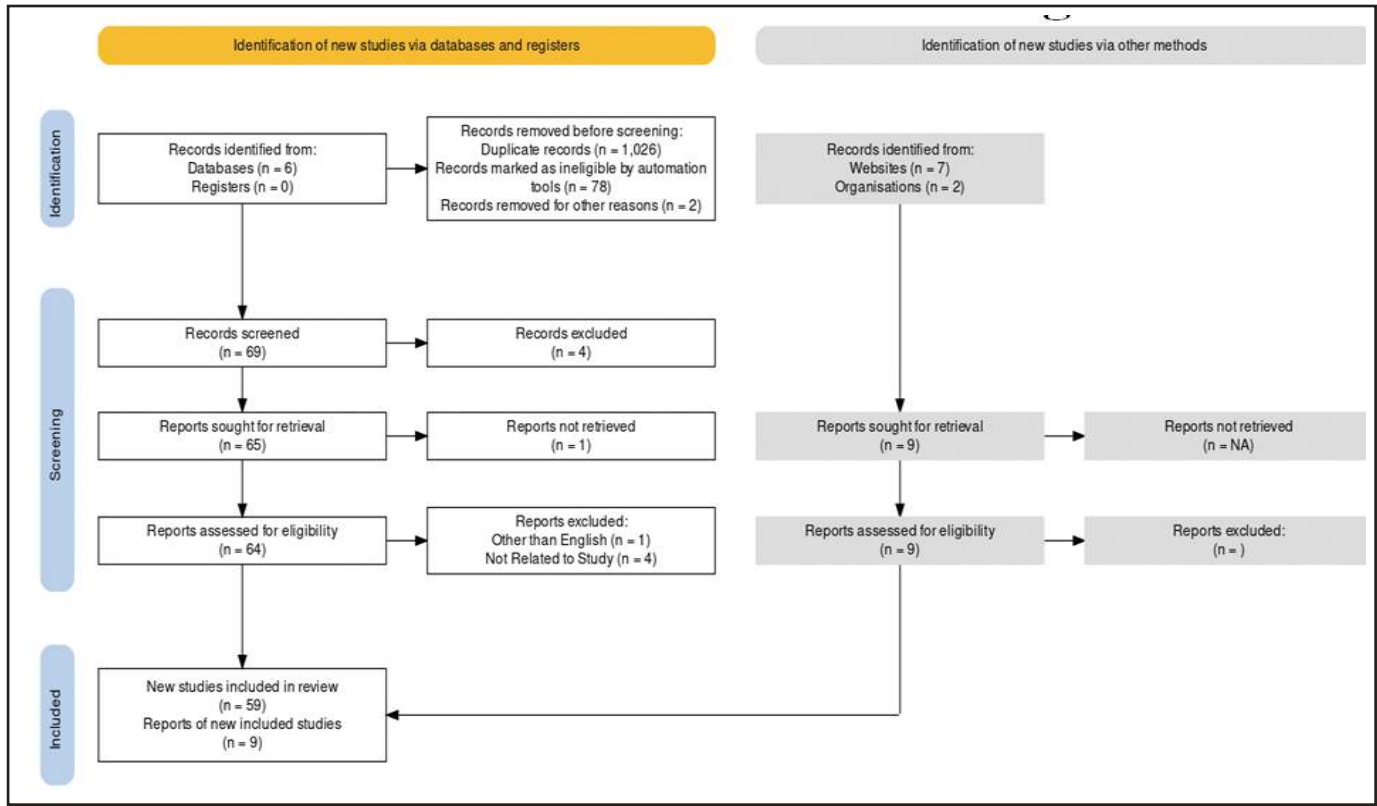


Figure 1. PRISMA-Flow chart<sup>18</sup>.

### 2.3 Inclusion and Exclusion Criteria

*The inclusion criteria for the study were:*

- Publications that explicitly discuss the application of AR in libraries.
- Articles published in English.
- Studies published within the last twenty years.

*Publications were excluded if they:*

- Did not have a clear focus on AR in libraries.
- Those were not available in English.
- Were opinion pieces or lacked empirical data.

### 2.4 Data Extraction and Analysis

The selected AR publications were critically evaluated for their relevance to library services. Data were extracted from these articles, focusing on the implementation of AR, its impact on library services, and the factors hindering its implementation. Additionally, institutional and organisational websites were consulted to define and clarify technical terms, providing a comprehensive understanding of the concepts discussed in the literature.

### 2.5 Quality Assessment

The quality of the selected studies was assessed based on their methodological rigour, the relevance of the findings to the objectives, and the clarity of the reported outcomes.

## 3. AUGMENTED REALITY IN LIBRARIES

The use of Augmented Reality (AR) technology is becoming increasingly prevalent in libraries to enrich user experiences and engagement<sup>20-21</sup>. Its integration serves several purposes, such as providing access to information resources and facilitating user education and navigation. This technology has proven effective in enhancing library service systems and marketing initiatives, enhancing the reputation of institutions as innovative and interactive spaces<sup>22</sup>. The adoption of AR aligns with the broader trend of incorporating AR and

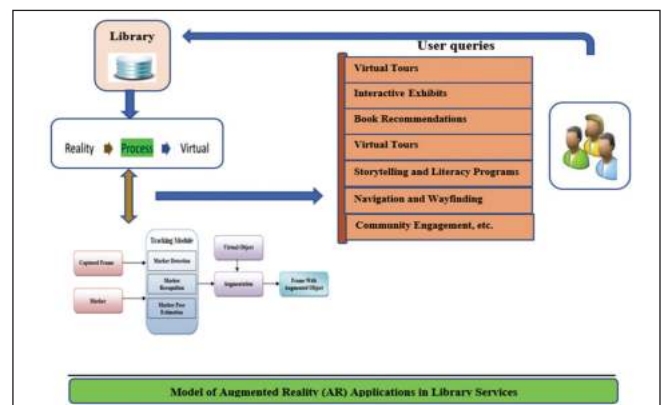


Figure 2.

VR technologies in service delivery, which has been observed since early 2018<sup>23-24</sup>. AR has been leveraged to create interactive storybooks in education, improving children's learning experiences by merging physical books with virtual models. Additionally, for Generation Z, AR provides interactive learning media that aids in accessing and utilising library collections<sup>25-26</sup>. Its applications include creating interactive OPAC brochures, showcasing collections, and assisting users in locating books on shelves<sup>27</sup>. The advantages of AR in libraries include its cost-effective implementation, compatibility with existing technologies, and the promotion of interactive services<sup>28</sup>. AR transforms libraries into media-rich environments catering to diverse information needs, from education to travel planning. This transformation is facilitated by AR's ability to blend the virtual and real worlds, creating a novel information space<sup>29</sup>. While AR offers significant benefits in enhancing library services, careful planning is vital to ensure equitable access and successful integration<sup>30-31</sup>.

### 3.1 AR in Academic Libraries

AR applications in libraries provide diverse services, such as augmenting physical book stacks, facilitating navigation, and offering digital information overlaid on the physical environment<sup>32</sup>. For specific groups, like Generation Z users, AR enhances learning experiences through interactive storybooks and provides access to library collections. Its cost-effective implementation and compatibility with existing technologies transform libraries into dynamic information spaces, promoting highly interactive services. Two prominent AR types in academic settings are markerless AR, which uses location data, and marked AR, which utilises two-dimensional barcodes to connect to information resources<sup>33-21</sup>. While AR's potential to enhance academic achievement and student engagement is well-recognised, its adoption varies across institutions. Some academic libraries have introduced AR technologies like the Oculus Rift and HTC Vive for in-library use<sup>34</sup>. The integration of AR in academic libraries not only enhances user experiences but also bolsters the institutions' reputations as innovative and tech-friendly environments<sup>35-36</sup>. AR's ability to create immersive and engaging environments can profoundly impact student learning and engagement, making it an invaluable tool for future educational strategies.

### 3.2 AR in Public Libraries

AR has the potential to enhance a range of public library services, including reader advisory, reference services, and indoor navigation, particularly benefiting younger patrons. It can support various functions such as information filtering, 3-D visualisation, and promoting user education through interactive learning materials<sup>37</sup>. Additionally, AR can cater to diverse user groups, such as the elderly, by offering tailored information services that address their specific needs<sup>38</sup>.

AR's ability to provide personalised and engaging experiences in public libraries is invaluable. Nonetheless, with thoughtful implementation and support, AR can transform public libraries into inclusive, modern information hubs<sup>39-40</sup>.

### 3.3 AR in National Libraries

National libraries, as repositories of a nation's cultural heritage and knowledge, have the potential to leverage AR for innovative services. AR can enhance the communication of exhibits, improve navigation, and support educational programs<sup>41</sup>. For instance, AR can create immersive experiences that allow users to engage with rare collections or historical documents in a virtual setting, thus preserving the actual artifacts while making them accessible<sup>42</sup>. Additionally, AR can assist in navigating expansive national library spaces, helping users locate materials and resources more efficiently. Adopting AR can help national libraries stay relevant in the digital age, attract new users, and fulfil their cultural and educational roles more effectively. AR offers national libraries a powerful tool for engaging users with their cultural heritage and improving access to resources.

## 4. APPLICATION OF AR TECHNOLOGY IN LIBRARY SERVICES

AR technology offers thrilling possibilities for pretty library services. Some of the way's libraries can leverage AR are:

### 4.1 Virtual Tours

AR allows patrons to explore library spaces and services dynamically. The virtual tours can be particularly beneficial for orienting new users to the library, showcasing facilities, and promoting information literacy<sup>43</sup>.

### 4.2 Interactive Exhibits

Libraries can use AR to construct immersive exhibitions in which users can learn about many different subjects through interesting digital content made on real objects or exhibits. These exhibits can include navigation aids, access to extended textual and audio-visual information, and interactive learning experiences<sup>44</sup>.

### 4.3 Book Recommendations

AR apps can provide personalised book recommendations based on a user's interests, consenting them to discover new books and authors interactively<sup>45</sup>.

### 4.4 Storytelling and Literacy Programs

AR books can bring characters to life or provide interactive elements that encourage children to engage with stories. AR has been progressively combined into library services, particularly in storytelling and literacy programs, as it has the potential to transform the way literacy is taught and experienced, making it more interactive and aligned with the digital communication landscape<sup>46</sup>.

#### 4.5 Navigation and Wayfinding

The expansion of a customised AR navigation app for libraries will bolster cognitive abilities by integrating iBeacon technology with an app system to establish an indoor positioning system. AR is likely to alleviate cognitive strain and amplify wayfinding performance, empowering users to navigate complex library layouts more efficiently<sup>47</sup>.

#### 4.6 Community Engagement

AR has the latent to create interactive practices that encourage community engagement. Examples include scavenger hunts or interactive displays that prompt users to contribute content<sup>48</sup>.

#### 4.7 Digital Archives and Special Collections

AR is increasingly used in libraries to improve user engagement and access to valuable materials, allowing for interactive experiences without handling fragile items, particularly beneficial for rare books and manuscripts<sup>49</sup>.

#### 4.8 Collaborative Spaces

AR can enable collaborative workspaces in the library, allowing users to share digital content, annotate documents, or work together on projects in a virtual environment<sup>50-51</sup>.

#### 4.9 Historical Reconstructions

Libraries with historical collections can use AR to create virtual reconstructions of historical events or locations, providing users with a unique perspective on the past<sup>52</sup>. It enables users to interact with digital enhancements overlaid on the physical world, providing a unique way to experience historical content<sup>53</sup>.

#### 4.10 Interactive Library Displays

IFLA firmly believes that the integration of AR and ChatGPT technology grips huge latent for attractive user experiences. With the incorporation of chatbots into AR apps, users can expect more personalised and engaging interactions with virtual elements<sup>54</sup>. Incorporating visual cues also promises to make interactions with digital avatars feel more natural and enjoyable. Moreover, the University of Illinois Urbana-Champaign is actively developing a mobile application using optical character recognition (OCR) to scan text documents and provide customised recommendations based on the scanned content<sup>55-56</sup>.

#### 4.11 Current Awareness Services (CAS) and Selective Dissemination of Information (SDI) Services

The SDI service and the CAS are two academic library facilities accessible to researchers at the University of Bahrain and these services are AR-based. The AR system allows researchers to receive rapid help and comprehend their needs while also functioning as an effective personal learning tool<sup>57</sup>. A prototype for

an AR system is developed to provide scholars with current information about available library items and how to use them. The University of Houston Library has an AR-based SDI and CAS services system called the 'ARLib'. This system uses the QR code linked to AR content to deliver information about the CAS and SDI services. This system creates accounts in the 'Aurasma' studio, creates brochures with QR codes, and distributes them so that patterns can access information via the HP reveal program<sup>58</sup>.

### 5. ETHICAL AND PRIVACY CONCERNS

#### 5.1 Data Privacy and Security in AR Applications

When developing AR applications, it is crucial to prioritize user data collection and storage and ensure its security. Transparency and consent are essential, and libraries must seek explicit consent from users before gathering personal information. Libraries need to balance providing tailored AR services with respecting user autonomy and privacy, addressing the digital divide for equitable access, and managing intellectual property and copyright concerns when using digital content.

#### 5.2 User Diversity and Accessibility

When designing AR applications, it is crucial to consider users with disabilities. This means integrating features like audio descriptions, text-to-speech options, and screen reader compatibility for those with visual and hearing impairments. Additionally, alternative input methods should be provided to address the needs of users with physical disabilities.

### 6. FACTORS HINDERING THE IMPLEMENTATION OF AR IN LIBRARIES

While AR technology offers benefits such as improved user education and interactivity, its adoption in libraries faces several obstacles. These include infrastructural, budgetary, cultural, and technical issues. Ethical concerns related to privacy, data security, and digital citizenship also arise<sup>59-60</sup>. A significant barrier to AR implementation is the lack of integrated applications and limited technological support<sup>61</sup>. Budgetary constraints further complicate adoption, as the costs associated with AR technologies can be prohibitive, particularly in settings with tight budgets, like medical libraries<sup>62</sup>. Additionally, cultural resistance from users and staff may impede the adoption of AR, necessitating extensive training and professional development for librarians to effectively utilise the technology<sup>56</sup>. Despite the growing interest in AR and its educational potential, research on its implementation in libraries is still limited. However, existing literature suggests that AR has the potential to significantly enhance the library experience, which can help attract and retain users<sup>63-64</sup>. While AR has promising benefits for libraries, its successful adoption requires overcoming privacy concerns, budget limitations, and cultural resistance, along with proper training and integration.

## 7. MAJOR FINDINGS AND SUGGESTIONS

### 7.1 Major Findings

Augmented Reality (AR) technology significantly enhances user experience in libraries by offering interactive access to information and improved navigation. In academic libraries, AR facilitates access to physical book collections, navigation, and digital resources. Public libraries use AR to enhance services like reader advisory, reference services, and indoor wayfinding. National libraries leverage AR for interactive exhibits, enhanced navigation, and educational programs. AR also supports virtual tours, book recommendations, storytelling, and scavenger hunts. It improves engagement with digital archives while safeguarding delicate items. Effective AR implementation requires staff training and continuous user feedback. Implementing Augmented Reality (AR) in libraries faces several challenges that hinder its effectiveness and adoption. Cost is a primary barrier as AR technology requires significant financial investment in both hardware and software, which many libraries cannot afford. Additionally, technical expertise is essential for the deployment and maintenance of AR systems, but libraries often lack staff with the necessary skills. Another challenge is integration with existing systems. Libraries already use various technologies and integrating AR smoothly with these systems can be complex and time-consuming. Content creation is also a significant hurdle as it requires specialised knowledge and resources to develop AR applications that are both engaging and educational. Patrons may need time to adapt to new technology, and without proper training and outreach, they might not fully utilize AR features. Furthermore, privacy concerns related to data collection and user tracking in AR environments could deter adoption. Finally, technical limitations such as the need for high-speed internet and advanced hardware can restrict access, especially in under-resourced libraries. Addressing these factors requires careful planning and investment to ensure successful AR implementation.

### 7.2 Suggestions

Promoting AR technology in libraries is crucial for raising awareness and generating interest among patrons. To achieve this, stakeholders must collaborate to develop affordable, user-friendly, and secure AR systems<sup>59</sup>. Library professionals should receive adequate training and support to effectively utilise this technology. Effective AR implementation necessitates careful consideration of staff training, technological infrastructure, and the creation of suitable AR components<sup>65</sup>. Librarians can enhance AR adoption by setting up interactive AR demonstrations and exhibits within the library to showcase its potential applications<sup>66</sup>. Partnering with schools, universities, and local organisations can facilitate joint AR events and projects, thereby reaching a broader audience. Utilising social media platforms to promote AR initiatives through videos, photos, and testimonials can also generate interest and engagement<sup>67</sup>. Additionally, featuring AR projects

and events on the library's website and in newsletters helps keep patrons informed and involved. Libraries should consider collaborating with AR developers and companies to create AR experiences tailored to their collections and services. Offering incentives or rewards, such as discounts on library services or exclusive access to AR content, can encourage participation. Gathering feedback from patrons is essential for assessing interest and refining future AR initiatives<sup>68</sup>. These strategies collectively contribute to the successful integration of AR into library services.

## 8. CONCLUSION

Libraries are abandoning their image as dusty archives and embracing Augmented Reality (AR). The implementation of Augmented Reality (AR) in libraries holds significant promise for enhancing user engagement and expanding learning opportunities. AR can bring exhibits to life by overlaying digital information on physical displays, allowing for compelling exploration. AR navigation apps can help visually challenged customers navigate the library, while audio descriptions and text-to-speech functions can help them learn. AR promotes inclusivity, allowing everyone to engage in the library experience. Regardless of the challenges, AR's potential is apparent. Libraries that embrace modern technology can turn into vibrant learning centers, attracting new generations and reviving their goal to connect people with knowledge and instill a love of learning. AR provides a unique chance to connect the physical and digital worlds, resulting in a truly dynamic and engaging library experience for everyone.

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