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IS VIRTUAL REALITY THE FUTURE OF LIBRARY REFERENCE SERVICES?

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Abstract:

This paper explores the potential of Virtual Reality (VR) to revolutionize library reference services, addressing gaps in engagement and accessibility characteristic of traditional and digital tools. Despite the growing adoption of Virtual Reality (VR) in education and entertainment, its application in library reference services remains underexplored. Traditional digital reference tools lack the depth of engagement and immediacy required for user-centered assistance. This study proposes a Design Thinking framework to bridge this gap, offering immersive, accessible, and interactive VR-based library services. By focusing on immersive user engagement, equitable access, and collaborative knowledge spaces, the study introduces a three-tiered conceptual model for VR integration. The paper identifies critical challenges, including financial constraints, technical accessibility, and staff readiness, offering strategic solutions to overcome these barriers. It highlights VR applications such as immersive exploration of collections, real-time librarian assistance via avatars, and collaborative virtual research spaces. These innovations align with constructivist and sociocultural theories to enhance user interaction and learning. The study contributes to the theoretical discourse by bridging technological innovation with user-centered design, advancing the role of libraries as inclusive, adaptive institutions. It provides actionable insights for leveraging VR to redefine reference services, positioning libraries as leaders in immersive, equitable, and dynamic information access in the digital age.

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Virtual Reality, Library Services, Design Thinking, Immersive Technology, Digital Access, Collaboration

Introduction

Libraries have long been cornerstones of knowledge sharing and cultural preservation, adapting to the evolving needs of their communities over time (Horban et al., 2023). From the tangible confines of traditional book stacks to the limitless expanse of digital repositories, libraries have continually reinvented themselves to stay relevant and accessible. Yet, while digital reference services have greatly expanded access, they often fall short of replicating the depth and personal connection offered by face-to-face consultations.

Virtual Reality (VR) technology presents an exciting opportunity to reimagine library reference services. With its capacity to create immersive and interactive environments, VR addresses some of the limitations of traditional digital tools by fostering deeper engagement and more meaningful connections with information (González-Pérez & Ramírez-Montoya, 2022). In educational settings, VR has been shown to enhance critical thinking and experiential learning, making it a promising tool for transforming how library users interact with resources (Brown et al., 2020). However, despite its potential, the integration of VR into library-specific reference services remains underexplored, with most applications limited to academic teaching and simulations rather than personalized reference interactions (Sarkar, 2023).

The trajectory of library innovation underscores the readiness of libraries to embrace new technologies. Malaysia's u-Pustaka program, for instance, successfully expanded its user base to 1.6 million by leveraging digital repositories to improve access (Adam & Ruzilah, 2020). Similarly, the integration of information and communication technologies (ICT) has normalized the use of digital screens and interactive tools in libraries, creating a foundation for further technological advancements (Pandey, 2022). However, traditional virtual reference services (VRS), such as email and live chat, still fall short in offering the immediacy and personalization users seek. For instance, email-based VRS may result in users waiting for extended periods—sometimes exceeding 24 hours—for replies to their inquiries, which can severely impact the effectiveness of the service (Charbonneau & Vardell, 2022; Garvey, 2021).

Bringing Virtual Reality (VR) into library reference services is an exciting step forward, offering new ways for users to engage with information. However, like any technological advancement, it comes with its own set of challenges. One of the biggest concerns is digital equity—ensuring that everyone, regardless of their background, has access to these immersive experiences. Unfortunately, not all users have the financial means or the necessary technology to fully take advantage of VR-based services. Socioeconomic and geographical barriers often limit access, making it difficult for many individuals to participate in this digital transformation (Mayesti et al., 2024; Lee et al., 2020). While libraries have the potential to bridge this gap by providing access to VR resources, the reality is that many people still lack the necessary hardware or a stable internet connection to make full use of these innovations (Adeyemi et al., 2023; Cook et al., 2019).

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Beyond accessibility, financial constraints pose a significant challenge, particularly for smaller libraries operating on tight budgets. Implementing VR and augmented reality (AR) requires more than just purchasing headsets—it involves investing in software, staff training, and ongoing technical support. Many public libraries are already stretched thin, struggling to balance these costs while meeting the needs of their communities (Adeyemi et al., 2023; Horban et al., 2023). On top of that, there's still a lack of solid research on how effective VR actually is in enhancing library services. Without sufficient data on its impact on user engagement and learning outcomes, libraries may hesitate to fully commit to VR integration (Cook et al., 2019). To make informed decisions, more studies are needed to explore how VR can truly transform the library experience (Valenti et al., 2020; Adetayo et al., 2023).

Even in academic libraries where VR adoption is gaining traction, there is no one-size-fits-all approach to implementation. Some libraries are leading the way, experimenting with VR tools and seeing positive engagement, while others struggle with limited resources and a lack of clear guidelines on how to make the technology sustainable (Suen et al., 2020). Without a strategic roadmap, user experiences can be inconsistent, and the full potential of VR may remain untapped. Experts agree that a well-thought-out approach is crucial to overcoming these barriers and ensuring that VR becomes an integral part of library services, rather than just a short-lived experiment (Saleh et al., 2021; Duan, 2019). To truly make VR work for libraries, administrators and policymakers must take a proactive role in addressing these challenges—balancing innovation with practicality to create a future where immersive technology enhances learning for all.

This study introduces a framework for integrating VR into library reference services, using Design Thinking as its foundation. Design Thinking—a structured, empathy-driven methodology—emphasizes understanding user needs, fostering creativity, and iterative problem-solving (Adeyemi, 2023). By addressing challenges such as accessibility, cost, and staff readiness, this framework provides a clear roadmap for libraries to innovate their reference services and better align with shifting user expectations. Through this conceptual model, libraries are reimagined as immersive knowledge hubs that promote engagement, equity, and discovery in the digital era.

In addition to its practical applications, this paper contributes to the theoretical discourse within library and information science. By merging the principles of Design Thinking with VR, it offers a user-centered framework for modernizing reference services. This integration not only addresses contemporary challenges in accessibility and user engagement but also provides actionable insights for future research and practice, ensuring libraries remain vibrant and inclusive spaces for knowledge exchange.

Literature Review

The role of libraries has continuously evolved in response to technological advancements and changing user expectations. Once centered around traditional reference services and physical collections, libraries have increasingly adopted digital platforms to enhance accessibility and efficiency. However, this shift has often come at the cost of reducing the personalized, interactive nature of face-to-face reference services. As libraries strive to bridge this gap, emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) present new opportunities for creating immersive, engaging, and interactive experiences.

International Journal of Innovation and Industrial Revolution
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This section explores the evolution of reference services in libraries and examines the growing potential of immersive technologies in enhancing information access and user engagement. While VR and AR have been widely adopted in fields such as education and healthcare, their application in library services remains relatively underexplored. By reviewing current literature, this discussion highlights the transformative potential of immersive technologies, the challenges hindering their adoption, and the need for structured, user-centered approaches to integration. Ultimately, this review lays the foundation for understanding how libraries can leverage VR to enrich reference services, enhance accessibility, and redefine user engagement in the digital age.

Evolution of Reference Services in Libraries

Library reference services have evolved significantly, shifting from traditional in-person consultations to digital and chat-based platforms. While this transition has improved accessibility and efficiency, it has often reduced the depth and personalization characteristic of face-to-face interactions (Greene & Groenendyk, 2020). Addressing this gap requires innovative solutions, with immersive technologies like VR offering considerable promise for creating more engaging and interactive experiences (Horban et al., 2023). These technologies offer considerable promise for creating more engaging and interactive experiences that can replicate some of the personal touch lost in digital interactions (Radford et al., 2022).

The integration of VR and Augmented Reality (AR) in education has catalyzed their gradual adoption in academic libraries (González-Pérez & Ramírez-Montoya, 2022). These tools enhance user interaction with library services but remain underexplored in structured library applications (Adeyemi, 2023). Financial constraints further limit their adoption, as larger, well-funded institutions lead the way while smaller libraries face scalability and resource challenges (Dermott, 2023).

The educational potential of VR is well-documented, particularly in enhancing engagement and comprehension in STEM disciplines through immersive environments and experiential activities (Brown et al., 2020; Smith, 2023). Library surveys indicate growing interest in VR and AR technologies, yet their integration into workflows remains limited, raising the question of how these tools can move beyond novelty to become integral to reference services (Cao et al., 2018).

Current initiatives highlight the transformative potential of immersive technologies. For example, AR has successfully improved access to digital content, making it more engaging and inclusive (Rahman et al., 2022; Paramita, 2023). Nevertheless, challenges such as scalability, accessibility, and sustainability persist, hindering broader implementation. While video-based teaching modules reduce errors in instructional contexts, their broader educational impact remains underexplored, limiting direct applicability to immersive learning environments (Angeletaki et al., 2013; Kim, 2024). This highlights the need for further research to assess the real-world applicability of these technologies in library settings (Buchanan et al., 2018).

Hybrid library spaces that blend advanced technologies, collaborative environments, and librarian expertise are reshaping traditional roles. As Warraich et al. (2020) and Urban & Bossaller (2024) suggest, these hubs facilitate innovative forms of scholarly communication, fostering dynamic and collaborative exchanges. High-definition visual platforms—both

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physical and web-based—illustrate the potential for immersive technologies to expand reference services (Deja et al., 2024)

Libraries are also exploring complementary tools such as Linked Data (LD) and the Semantic Web, which enhance information interconnectivity and digital content management (Lyubchak et al., 2022; Lee & Kim, 2022). When integrated with immersive platforms, these technologies can further streamline and enrich user experiences, making reference services more intuitive and accessible.

Integrating immersive technologies into library services presents both opportunities and challenges. VR and AR hold great potential for transforming user engagement and learning experiences, but successful adoption depends on addressing financial, technological, and accessibility barriers. Future research must focus on practical applications and assessing real-world impacts to develop sustainable, inclusive strategies. Libraries stand poised to leverage these innovations, redefining reference services while maintaining their core mission of equitable knowledge dissemination.

VR in Information Access: Lessons from Other Sectors

The role of libraries has continuously evolved in response to technological advancements and changing user expectations. Once centered around traditional reference services and physical collections, libraries have increasingly adopted digital platforms to enhance accessibility and efficiency. However, this shift has often come at the cost of reducing the personalized, interactive nature of face-to-face reference services. As libraries strive to bridge this gap, emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) present new opportunities for creating immersive, engaging, and interactive experiences.

This section explores the evolution of reference services in libraries and examines the growing potential of immersive technologies in enhancing information access and user engagement. While VR and AR have been widely adopted in fields such as education, healthcare, and industry, their application in library services remains relatively underexplored. By reviewing current literature, this discussion highlights the transformative potential of immersive technologies, the challenges hindering their adoption, and the need for structured, user-centered approaches to integration. Ultimately, this review lays the foundation for understanding how libraries can leverage VR to enrich reference services, enhance accessibility, and redefine user engagement in the digital age.

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While the use of immersive technologies in libraries is still in its early stages, other sectors such as education, healthcare, and manufacturing have successfully addressed similar challenges, providing valuable insights for libraries.

Lessons from Education

VR has been widely embraced in education, particularly in STEM disciplines, where immersive environments allow students to engage in hands-on learning experiences that would otherwise be impossible or costly in physical classrooms (Brown et al., 2020; Smith, 2023). Many universities and schools have overcome financial constraints by partnering with technology companies to secure funding, develop VR curriculum tools, and establish shared VR labs (Rahman et al., 2022; Paramita, 2023). Some institutions have adopted a hybrid model, where students access VR resources through centralized university hubs rather than requiring individual ownership of expensive equipment (Adeyemi, 2023).

Additionally, schools have addressed staff training barriers by incorporating VR competency programs for educators. Rather than expecting immediate proficiency, institutions provide step-by-step training and peer mentoring to ensure smooth integration into the learning process (Cao et al., 2018). Libraries facing similar challenges in training staff for VR-based reference services could adopt a similar incremental approach to professional development.

Healthcare and VR

The healthcare sector has leveraged VR to improve accessibility and remote engagement, particularly for patients with mobility challenges or those in rural areas. For example, VR is used in therapeutic settings for pain management and mental health treatment, allowing patients to engage in immersive therapy sessions from home rather than traveling to a clinic (Simons et al., 2022; Ose et al., 2019). These applications demonstrate how VR can break geographical barriers and provide equitable access to services—an important consideration for libraries seeking to expand their reference services to underserved communities.

Healthcare institutions have also dealt with scalability challenges by implementing cloud-based VR solutions, where users can access experiences without needing high-end local hardware (Buchanan et al., 2018). This approach aligns with Linked Data and Semantic Web technologies explored by libraries (Lyubchak et al., 2022; Lee & Kim, 2022), suggesting that libraries could similarly utilize cloud-based VR reference services to reduce infrastructure costs and improve accessibility.

Manufacturing and Training

In industrial and corporate settings, VR is used extensively for workforce training, enabling employees to practice high-risk procedures in safe, simulated environments (Hutson, 2022). Many organizations initially struggled with the high cost of VR equipment and staff reluctance

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Volume 7 Issue 20 (March 2025) PP. 106-134
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to adopt new tools, but they overcame these challenges through gradual implementation—starting with small pilot programs before scaling up (Angeletaki et al., 2013; Kim, 2024).

Libraries could adopt a similar strategy by first testing VR services in specific reference areas—such as virtual research consultations or digital archive exploration—before expanding to broader applications. Furthermore, corporate training programs have demonstrated that hands-on engagement significantly improves learning retention, reinforcing the argument that libraries should use VR not just for access to resources but also for interactive user education and information literacy training (Kristofferson et al., 2022; Mercado, 2023).

VR in Information Access

VR has become a transformative tool across education, healthcare, and library services, creating immersive, interactive environments and enabling real-time collaboration. This technology offers libraries a chance to revolutionize information access and user engagement by facilitating virtual stacks, interactive 3D content, and dynamic workshops, marking a significant departure from traditional methods of information retrieval (Mercado, 2023; Kristofferson et al., 2022).

In education, immersive VR has proven its value, particularly in disciplines like science and mathematics, where abstract concepts benefit from visual, hands-on understanding (Brown et al., 2020). Similarly, surveys in libraries highlight a growing interest in VR and Augmented Reality (AR) tools, emphasizing their potential to transform traditional services (Cao et al., 2018).

Libraries are exploring AR/VR integration to enhance user interaction and expand service offerings. AR has improved digital content access by making resources visually engaging and accessible to diverse audiences, bridging gaps between static and dynamic experiences (Rahman et al., 2022). However, scalability, financial investment, and user training remain significant barriers that must be addressed to ensure sustainability (Rahman et al., 2022).

Although significant advancements have been made in integrating VR into various domains, its theoretical grounding in library-specific contexts remains underexplored. Much of the existing research centers on educational applications or the technical capabilities of VR, often overlooking the distinct needs and challenges inherent to library environments. This paper seeks to bridge these gaps by introducing a conceptual framework rooted in Design Thinking principles.

By prioritizing empathy, creativity, and iterative problem-solving, the proposed framework ensures that VR services are not only innovative but also closely aligned with the needs of library users. It addresses critical barriers such as accessibility, scalability, and user engagement, offering a structured pathway for effective VR integration.

While libraries face significant financial, technological, and user adoption challenges, lessons from education, healthcare, and industry demonstrate that these barriers can be overcome through strategic planning, cloud-based solutions, hybrid access models, incremental adoption, and robust training programs. The success of VR in these sectors highlights the potential for libraries to scale immersive technologies in ways that are practical, sustainable, and inclusive.

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IJIREV
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As intelligent library models evolve, libraries stand poised to lead the integration of immersive technologies, ensuring their continued relevance in a digital society. By embracing these innovations and drawing from other sectors' best practices, libraries can redefine their role as dynamic, indispensable hubs of knowledge for the future.

Methodology

This study employs a conceptual research approach to explore the integration of Virtual Reality (VR) into library reference services. Given that VR adoption in libraries remains in its early stages, a conceptual study allows for the development of a strategic framework that libraries can use to enhance user engagement, accessibility, and service delivery. Instead of conducting empirical experiments or user trials, this research synthesizes insights from existing literature, industry reports, and comparative case studies from other sectors that have successfully implemented immersive technologies.

The research process began with an extensive literature review to examine the current state of VR applications in libraries and to identify challenges that hinder adoption. Previous studies on digital reference services were analyzed to understand gaps in user engagement, accessibility, and interactivity (Greene & Groenendyk, 2020; Charbonneau & Vardell, 2022). Additionally, case studies from education, healthcare, and corporate training sectors were reviewed to explore how VR has been implemented in contexts where accessibility and engagement are critical (Brown et al., 2020; Simons et al., 2022). This cross-sector analysis provided valuable insights into best practices, financial models, and technological scalability, allowing for the development of a library-specific VR framework.

To ensure that the framework was practical and aligned with real-world constraints, a comparative analysis was conducted between library environments and industries that have successfully integrated VR. This involved mapping out common challenges such as financial constraints, technical expertise gaps, and accessibility concerns, and then identifying strategies used in other domains to overcome these barriers (Adeyemi et al., 2023; Ose et al., 2019). For example, educational institutions have addressed VR adoption challenges through cloud-based access models and collaborative funding initiatives, while healthcare has demonstrated how VR can enhance remote accessibility for underserved populations (Rahman et al., 2022; Kristofferson et al., 2022). By synthesizing these strategies, this study formulated a three-tiered framework for VR in library reference services, focusing on immersive user engagement, equitable access, and collaborative knowledge spaces.

The next step in the research process involved conceptualizing library-specific VR applications based on the findings. Several VR-based services were outlined, including virtual reference desks, immersive research spaces, interactive tutorials, and digital archive exploration. These applications were designed to address identified user needs, such as the lack of interactivity in current virtual reference services and the demand for real-time, personalized assistance (Garvey, 2021; Suen et al., 2020). To assess the feasibility and scalability of these services, existing VR implementations in museums, digital learning platforms, and smart library initiatives were reviewed. The assessment considered infrastructure requirements, cost implications, user adoption trends, and potential integration with existing library technologies (Mercado, 2023; Buchanan et al., 2018).

International Journal of Innovation and Industrial Revolution
IJIREV
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The final step in this research process was an evaluation of implementation strategies, where ethical considerations, digital accessibility, and potential barriers to adoption were analyzed. While this study does not involve human participants, it considers critical issues such as data privacy, user training, and inclusivity for individuals with disabilities. The framework recommends that libraries adopt universal design principles, ensuring that VR-based reference services accommodate users regardless of socioeconomic background or technological proficiency (Lyubchak et al., 2022; Lee & Kim, 2022). Additionally, potential concerns such as content development costs and librarian training requirements were addressed through suggested phased implementation models, where libraries can gradually introduce VR services before full-scale adoption.

By following this structured research process—combining literature synthesis, comparative case analysis, conceptual modelling, and feasibility assessment—this study provides a comprehensive roadmap for libraries to integrate VR effectively. Rather than proposing VR as a technological novelty, the framework ensures that library services remain user-centered, inclusive, and sustainable in the digital age.

Proposed Framework: Design Thinking in VR Reference Services

Integrating VR into library reference services represents a forward-thinking initiative. However, implementing such innovation requires a structured, user-focused approach that balances patron needs with the practicalities of VR technology. Design Thinking offers an effective framework for this purpose, providing a systematic and iterative methodology to reimagine reference services in a VR context.

The Design Thinking framework, grounded in principles of empathy, creativity, and iterative problem-solving, offers a powerful foundation for reimagining VR-based reference services. By focusing on the needs and experiences of users, this approach enables libraries to seamlessly integrate technological innovation with practical service delivery. It empowers libraries to design solutions that are not only cutting-edge but also equitable and deeply engaging.

This paper contends that Design Thinking serves as a critical tool for aligning VR initiatives with the diverse needs of library patrons. By emphasizing user-centered design, libraries can overcome challenges related to accessibility while fostering meaningful interactions with their resources and services. In doing so, Design Thinking ensures that VR applications transcend mere novelty, becoming both practical and transformative tools for modern libraries.

As depicted in Figure 1, the Design Thinking framework comprises five stages: Empathize, Define, Ideate, Prototype, and Test. These stages collectively guide libraries in creating VR-enhanced services by emphasizing user needs, fostering creativity, and refining solutions based on feedback. The iterative nature of this process ensures continuous improvement, enabling VR applications to evolve alongside the dynamic needs of library users.

To complement the Design Thinking framework, this paper presents a three-tiered conceptual model for integrating virtual reality (VR) in libraries. The first tier, Immersive User Engagement, emphasizes dynamic and interactive experiences that deepen users' connections with library resources and services. By leveraging VR’s immersive capabilities, libraries can create engaging environments that enhance learning, exploration, and information retention. The second tier, Equitable Access, addresses the barriers posed by physical and digital divides,

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
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ensuring that all users—regardless of their socioeconomic background or technological proficiency—can benefit from VR-based services. By prioritizing inclusivity, libraries can democratize access to advanced digital tools and foster a more diverse learning environment. The final tier, Collaborative Knowledge Spaces, highlights the potential of VR to support interdisciplinary research and collaboration. Through shared virtual environments, users from different fields and locations can interact, exchange ideas, and engage in collective problem-solving. Together, these three components offer libraries a structured approach to enhancing engagement, accessibility, and collaboration, ensuring that VR integration remains innovative, inclusive, and user-centered.

This conceptual model offers a structured approach for libraries to tackle challenges in user engagement, accessibility, and collaboration, ensuring that VR-based services remain both innovative and user-centric.

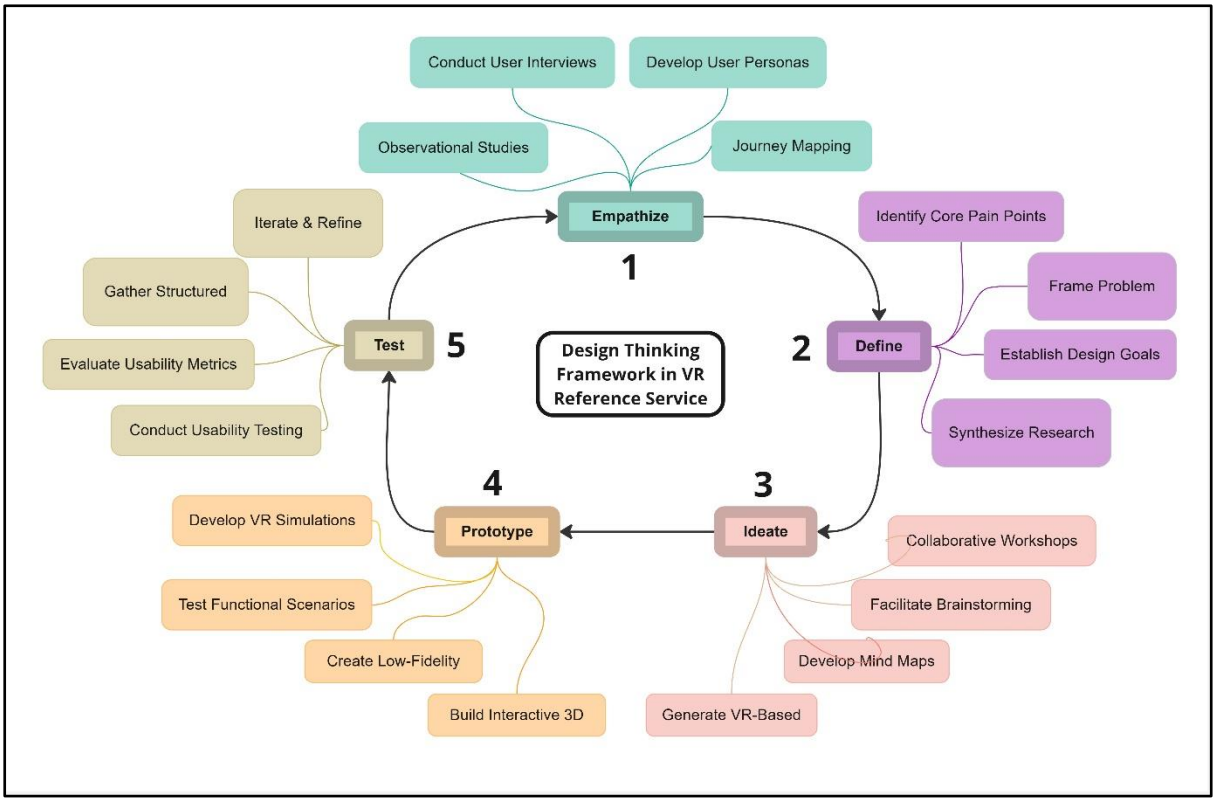

Figure 1: Design Thinking Framework in VR Reference Services

Table 1 presents a detailed summary of the core activities, tools, deliverables, and specific VR applications associated with each stage of the Design Thinking process. It serves as a practical guide for libraries, outlining the essential steps for successful implementation. For instance, during the Empathize stage, librarians gather insights through interviews and observations, identifying potential applications such as virtual reference desks and immersive collections. The Define stage synthesizes these insights into actionable goals, while the Ideate stage generates concepts like collaborative research rooms. Finally, the Prototype and Test stages focus on refining these solutions through iterative feedback to ensure they are effective, practical, and user-friendly.

International Journal of Innovation and Industrial Revolution
IJIREV
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Volume 7 Issue 20 (March 2025) PP. 106-134
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By combining these elements, the model empowers libraries to innovate meaningfully, creating VR services that respond directly to the needs of their communities while fostering deeper engagement and collaboration.

Table 1: Main Activities, Tools, and Deliverables for Each Stage of the Design Thinking Process

Stage	Key Activities	Tools/Methods	Deliverables	Library-Specific VR Applications
Empathize	User interviews, observations	Surveys, journey mapping	User personas, needs summary	Identifying demand for virtual reference desks, 3D collections
Define	Synthesizing data, problem framing	Affinity mapping, framing questions	Problem statements, design goals	Establishing objectives for immersive collections and equitable access
Ideate	Brainstorming, idea generation	Workshops, mind maps	VR service concepts	Proposing collaborative research rooms, interactive tutorials
Prototype	Building and testing prototypes	Mockups, VR simulations	Low-fidelity prototypes	Developing initial designs of VR-enabled reference tools and interactive spaces
Test	Usability testing, feedback	Think-alouds, surveys	Validated, refined designs	Refining virtual navigation tools, accessibility features, and immersive interfaces

Stage 1: Empathize

The Empathize stage in the Design Thinking process lays the groundwork for developing VR reference services by identifying user needs and challenges. This phase emphasizes engaging with patrons to gain meaningful insights into their experiences and expectations. Librarians employ qualitative methods such as interviews, observations, and prototype testing to gather feedback that informs effective solutions (Mercado, 2023).

Interviews are instrumental in uncovering unmet needs and latent frustrations. Open-ended conversations allow users to share explicit challenges, like difficulties navigating academic databases, and implicit desires, such as interactive tools for resource exploration (Radford et al., 2012; Lotbinière-Bassett et al., 2022). For example, graduate students may seek tools to

International Journal of Innovation and Industrial Revolution
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visualize interdisciplinary connections, while first-year students might prefer private virtual consultations to reduce intimidation (Patria, 2023).

Observational studies complement interviews by revealing behaviors and inefficiencies that self-reports may miss. Librarians observing users navigating catalog systems might identify barriers like unclear pathways or unintuitive interfaces (Mulders, 2022; Kitzie et al., 2021). Such insights could guide the design of VR features, like 3D visualizations or instant virtual assistance, that enhance usability and accessibility (Yanti, 2023).

Engaging users with VR prototypes further refines this understanding. Testing early-stage virtual environments helps identify usability barriers and highlight effective features (Boletsis, 2018; Juan et al., 2019). Feedback, whether verbal or nonverbal, reveals critical insights. For instance, students may find navigation tools cumbersome or unexpectedly benefit from enhanced engagement while exploring resources (Freitag & Hämmerle, 2020; Liao & She, 2023). This iterative process ensures that solutions are directly aligned with user needs and preferences (Kim & Hyun, 2022).

The insights from the Empathize stage are essential for guiding the subsequent phases of Design Thinking. By actively listening to users and observing their behaviors, librarians can pinpoint specific pain points and tailor VR tools accordingly (Thoring & Müller, 2011; Kim et al., 2020). For example, users favoring self-paced exploration might benefit from intuitive interfaces, while those needing instructional support could engage with avatar-driven tutorials.

As key user personas emerge—such as graduate researchers needing advanced search tools or undergraduates requiring interactive tutorials—VR services can be customized to address diverse profiles (Bartosh & Anzalone, 2019). This ensures inclusivity and maximizes the utility of VR in reference services.

Beyond data collection, the Empathize stage fosters collaboration between libraries and their patrons, creating a shared vision for the future of reference services. By leveraging insights from interviews, observations, and prototype feedback, libraries can innovate in ways that are both user-centered and technologically feasible. This process reimagines how libraries engage and support patrons, setting a benchmark for accessible, dynamic, and intuitive VR-based reference services (Kim & Hyun, 2022).

Stage 2: Define

The Define stage bridges understanding user needs and creating actionable solutions. Building on insights from the Empathize phase, this step identifies the critical challenges and unmet needs that VR-based reference services can address. It prioritizes the development of precise problem statements and clear design goals to align solutions with user expectations and institutional objectives (Lotbinière-Bassett et al., 2022; Patria, 2023).

This process begins with a detailed analysis of data from interviews, observations, and prototype testing, focusing on recurring themes and patterns (Mulders, 2022). Common issues include limited access to physical archives for remote learners, barriers to collaborative research, and a need for more intuitive methods to explore library collections. These findings highlight opportunities for VR innovation.

International Journal of Innovation and Industrial Revolution
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DOI 10.35631/IJIREV.720007

One pressing issue is providing equitable access to archives for remote learners. Traditional services often fail to replicate the spatial experience of browsing physical stacks or interacting with rare materials, leaving users disconnected from essential resources (Yanti, 2023; Kitzie et al., 2021). Addressing this gap requires immersive VR tools that enable users to browse virtual stacks, interact with 3D models of rare artifacts, and engage in interactive research activities. Projects like the British Library's "Turning the Pages" demonstrate how digitized manuscripts can offer engaging, immersive experiences. Expanding such initiatives into VR could enhance accessibility while fostering deeper user engagement.

Another challenge lies in facilitating collaborative research and consultations. Traditional reference tools often lack the functionality to support real-time, multi-user engagement, which can hinder interdisciplinary projects (Freitag & Hämmerle, 2020; Liao & She, 2023). VR can overcome these limitations by enabling researchers and librarians to collaborate in shared virtual spaces. These environments could support simultaneous annotation, 3D data visualization, and real-time communication, aligning with Vygotsky's sociocultural theory, which emphasizes the role of interaction in knowledge-building.

Table 2: VR Use Case Matrix

Use Case	Target User Group	Benefit	Challenges
Virtual Reference Desks	Remote learners	Personalized guidance	Avatar responsiveness
Interactive Tutorials	Undergraduate students	Improved information literacy	Content development costs
Collaborative Research Rooms	Multidisciplinary teams	Enhanced teamwork	VR hardware compatibility
Data Visualization Tools	STEM researchers	Deeper insight into complex data	High computational requirements

To prioritize VR applications, Table 2 compares use cases, highlighting target user groups, benefits, and implementation challenges. For instance, virtual reference desks can provide remote learners with personalized guidance but require responsive avatars. Interactive tutorials enhance information literacy for undergraduates but necessitate significant content development investment. Collaborative research rooms benefit multidisciplinary teams but may face hardware compatibility issues. Data visualization tools offer deeper insights for STEM researchers but come with high computational demands.

The Define stage culminates in actionable design goals tailored to these challenges. Goals might include developing accessible, device-agnostic VR environments, creating realistic immersive experiences that replicate physical interactions, integrating collaborative tools, and ensuring scalability. Success metrics, such as user engagement rates, collaboration effectiveness, and accessibility impact, further guide evaluation and refinement.

By synthesizing insights and defining clear objectives, the Define stage lays a strategic foundation for subsequent phases. It ensures that VR solutions address real-world challenges, positioning libraries to innovate reference services and create engaging, user-centered experiences in the digital age.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Stage 3: Ideate

The Ideation stage is a crucial point in the Design Thinking process, fostering creativity and interdisciplinary collaboration to develop innovative solutions. For libraries implementing VR reference services, this phase provides an opportunity to rethink traditional methods and explore concepts that address evolving user needs. Through brainstorming, design workshops, and open-ended discussions, libraries generate diverse ideas that harness VR's potential to revolutionize the reference experience (Sarkar, 2019; Adewojo, 2023).

A standout concept is the virtual reference desk, where librarian avatars provide real-time, immersive assistance. These VR environments replicate traditional library interactions, such as browsing stacks, consulting rare collections, and seeking guidance. Unlike static digital tools, VR reference desks offer an interactive dimension, bridging physical engagement and digital convenience (Adewojo, 2023). Users who find standard online services impersonal may find the lifelike presence of librarian avatars more approachable, fostering deeper connections with library resources.

Expanding this approach, interactive VR tutorials and workshops can enhance skills like research, information literacy, and database navigation. These experiences replace passive learning with dynamic participation in simulated scenarios. For example, a user learning complex search queries could navigate a responsive VR tutorial, receiving tailored feedback. Grounded in Kolb's experiential learning theory, this approach emphasizes hands-on engagement, making learning more intuitive and impactful (Adewojo, 2023).

Collaboration is another key focus. Virtual research rooms in VR enable geographically dispersed users to meet and share resources, annotate documents, and visualize complex data collectively. Librarians can facilitate these sessions, guiding discussions and optimizing resource use (Freitag & Hämmerle, 2020). This aligns with Vygotsky's sociocultural theory, which underscores the importance of interaction in learning and problem-solving. Compared to video conferencing, virtual research rooms offer a richer, more engaging alternative, encouraging interdisciplinary collaboration.

Additionally, libraries can integrate VR-based data visualization tools, allowing users to explore complex datasets in immersive, 3D environments. For instance, researchers analyzing geographic information could overlay variables like population density and environmental patterns on a 3D map, uncovering insights static tools might miss. Similarly, digital humanities scholars could spatially visualize linguistic or textual patterns, gaining fresh perspectives on data relationships. These tools align with cognitive load theory by minimizing extraneous demands and enabling users to focus on analysis and discovery.

The Ideation stage thus serves as a foundation for innovation, generating ideas like virtual reference desks, interactive tutorials, collaborative research spaces, and data visualization tools. These concepts reimagine reference services to prioritize accessibility, engagement, and collaboration. This phase thrives on interdisciplinary collaboration, ensuring solutions are both visionary and practical. The resulting ideas guide prototyping and testing, positioning libraries to leverage VR for transformative knowledge access and discovery.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972 IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Stage 4: Prototype

The Prototype stage of Design Thinking transforms conceptual ideas into testable, tangible forms, bridging innovation and practical application. This stage allows library teams to experiment with VR-based reference services and collect actionable user feedback. Prototypes, such as interactive mockups and simulations, provide early iterations of VR services, which evolve through iterative testing and refinement (Boletsis et al., 2017; Alayón, 2023).

One promising prototype is the virtual reference desk, reimagining traditional in-person consultations in a VR environment. Librarian avatars interact with users in real-time, providing research support, answering questions, and facilitating resource access. Users can virtually browse digital stacks, examine 3D models of rare materials, and engage in personalized discussions. This approach addresses the impersonal nature of conventional digital reference tools, creating a dynamic, engaging experience. Initial testing can evaluate navigation preferences, avatar responsiveness, and the overall realism of the environment.

Another innovative prototype involves interactive VR tutorials and workshops, designed to improve research skills, information literacy, and database navigation. Unlike traditional, passive tutorials, VR-based learning emphasizes active engagement in hands-on scenarios. For instance, users might simulate advanced database searches, receiving real-time feedback as they refine queries. Grounded in Kolb's experiential learning theory, this approach enhances comprehension and retention by situating users in interactive problem-solving contexts (Kolb, 1984). Testing can refine these tools, ensuring they balance instructional depth with usability while delivering impactful learning outcomes.

Collaborative virtual research rooms represent another area for prototyping. These immersive spaces allow users to share, annotate, and visualize resources in real-time, fostering teamwork across dispersed or interdisciplinary groups. Librarian avatars can guide discussions, provide research support, and ensure effective resource use. To differentiate from video conferencing tools, prototypes might include voice communication, interactive 3D visualizations, and customizable layouts. Early user testing can identify desired features, such as privacy settings or integration with external databases (Fortune et al., 2022).

Prototypes can also focus on VR-based data visualization and analysis tools, enabling researchers to explore complex datasets in three dimensions. For example, climate scientists could overlay environmental data on a 3D map, revealing patterns through layered visualizations, while humanities scholars might examine linguistic trends spatially. These tools offer capabilities beyond traditional interfaces, and testing ensures their alignment with diverse research workflows, supporting innovative knowledge discovery.

Prototyping is inherently iterative, minimizing risks by incorporating user feedback to refine designs. Testing with real users uncovers limitations, validates assumptions, and highlights areas for improvement (Mummah et al., 2016). For instance, early tests might reveal a need for more intuitive navigation tools in virtual reference desks or additional accessibility features in collaborative research rooms. Feedback from these tests drives subsequent iterations, aligning VR services with user expectations and library objectives (Lee & Park, 2021).

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

This iterative process fosters co-creation, involving users in shaping solutions they will ultimately use. Engaging users throughout prototyping ensures VR services are both technologically sophisticated and intuitive, building trust and encouraging adoption. Collaborative refinement enhances the likelihood of successful implementation and user satisfaction.

Ultimately, the Prototype stage is vital for redefining library reference services through VR innovation. By developing and testing virtual reference desks, interactive tutorials, collaborative research rooms, and data visualization tools, libraries can create solutions that address user challenges while enhancing accessibility, engagement, and collaboration. This process ensures VR services transcend novelty, becoming transformative tools that empower users and reimagine the reference experience. Through thoughtful experimentation, libraries can lead technological advancement and provide immersive, user-centered information access for the future.

Stage 5: Test

The Test stage of Design Thinking finalizes the iterative process by rigorously evaluating VR reference service prototypes to ensure their effectiveness, functionality, and alignment with user needs. This stage validates design concepts, identifies limitations, and informs refinements through systematic usability and user experience (UX) testing, creating robust, user-centered solutions (Yi et al., 2022; Lie et al., 2023).

Usability testing lies at the heart of this stage, offering quantitative and qualitative insights into user interactions with VR services. Metrics such as task completion rates, error frequencies, and time spent on tasks reveal system efficiency and functionality (Oliveira et al., 2016). For instance, testing might involve users navigating virtual stacks, consulting librarian avatars, or collaborating in research rooms. These scenarios simulate real-world applications, enabling library teams to identify and address performance gaps (Horban et al., 2023).

Testing also uncovers pain points like navigation challenges, system lag, or accessibility issues. For example, users with disabilities may encounter difficulties without assistive features such as screen reader compatibility, gesture inputs, or voice commands. Designing tests that prioritize universal accessibility ensures VR services are inclusive and meet diverse user needs.

UX evaluations are equally crucial, examining emotional and cognitive impacts, including immersion, presence, and user satisfaction. Techniques such as think-aloud protocols, where participants verbalize their thoughts during tasks, provide valuable insights into decision-making and frustrations. A user might initially struggle with VR navigation but later express enthusiasm for realistic 3D interactions. Tools like post-task interviews and the System Usability Scale (SUS) add depth to the assessment, fostering a nuanced understanding of user engagement (Touloudi et al., 2022).

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Table 3: Journey Map Stages in VR Testing

Stage	Action	Key Touchpoints	Emotions	Pain Points	Opportunities
Entering VR	Put on headset, enter virtual space	Interface, controls	Curious, excited	Complex controls	Simplify onboarding, UI
Searching	Locate materials in virtual stacks	Search bar, 3D models	Interested, unsure	Unclear tools, results	Enhance filters, searches
Librarian Help	Consult librarian avatar	Avatar, prompts	Engaged, frustrated	Slow avatar response	Improve speed, accuracy
Collaborating	Join virtual research session	Shared tools, room	Collaborative	Limited tools	Add voice chat, annotations
Task Completion	Finalize resource use	Feedback, support	Accomplished	Delayed response times	Speed responses, refine avatars
Exiting	Exit VR environment, feedback.	Exit screen, survey	Reflective	Confusing process	Simplify exit, guidance.

Journey maps help libraries visualize user experiences, emotions, and challenges across touchpoints. For example (Table 3), a graduate student may initially struggle with navigation but later benefit from avatar support and collaborative tools. Such mapping ensures that every interaction stage offers opportunities for enhancement.

The iterative nature of testing ensures consistent improvements. For instance, user feedback on slow avatar responses could drive updates to speech recognition algorithms, followed by further testing to validate improvements. This cycle reduces development risks and aligns VR services with evolving user expectations (Pallavicini et al., 2019). Testing also enables experimentation with user-suggested features, like customizable research spaces or database integrations, ensuring responsiveness to real-world needs.

Engaging users in feedback sessions fosters ownership and collaboration, allowing patrons to see their input reflected in the final design. Transparent communication about changes, such as test findings and implemented updates, builds trust and encourages engagement (Solmaz et al., 2023). Testing diverse user groups, including students, researchers, and general patrons, ensures VR services are adaptable and relevant to varying demographics and disciplines.

Insights from testing drive the successful deployment of VR reference services. For example, intuitive navigation tools may emerge as essential for virtual reference desks, while robust

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
communication features could enhance collaborative research rooms. Addressing these needs boosts user satisfaction and increases adoption likelihood.

The Test stage solidifies the impact of VR services by refining designs based on systematic evaluations. This process ensures the final product is functional, engaging, and user-focused, setting a new benchmark for library reference services. By harnessing VR's immersive capabilities, libraries can enhance accessibility, foster collaboration, and revolutionize knowledge discovery, cementing their role as leaders in digital innovation.

VR in Action: Enhancing Reference Services

The integration of VR into library reference services marks a transformative advancement in how users access, explore, and interact with information. By creating immersive and dynamic environments, VR surpasses traditional digital tools, making library services more engaging, collaborative, and accessible (Cook et al., 2019; Holappa et al., 2018). This section explores VR's applications in enhancing reference services, focusing on immersive collections, real-time assistance, and collaborative research spaces.

Immersive Exploration of Virtual Library Collections

One of VR's most impactful uses is facilitating immersive navigation of digital library collections. Users can explore virtual stacks, interact with 3D models, and engage with multimedia resources, replicating—and often surpassing—the experience of a physical library (Alfaro, 2023). This is particularly beneficial for remote learners or those without access to physical facilities. Virtual recreations of historical archives, rare manuscripts, and scientific specimens allow for detailed exploration without risking damage to originals.

Beyond replicating physical browsing, VR introduces opportunities for data visualization and analysis. Users can manipulate complex datasets, overlay information layers, and explore data in three dimensions, enhancing critical analysis and research. For disciplines like data science and environmental studies, VR offers dynamic tools unavailable in static interfaces. Grounded in constructivist learning theories emphasizing active engagement, these immersive environments foster deeper understanding and knowledge construction.

Examples like the British Library's "Turning the Pages" project highlight the potential of digitization, with VR taking this concept further. Platforms such as Oculus and HTC Vive allow users to virtually "walk" through library spaces, blending realism with innovation.

Real-Time Assistance with Librarian Avatars

Virtual reference desks staffed by librarian avatars provide another transformative application of VR. These immersive environments replicate face-to-face consultations, offering real-time guidance, resource navigation, and database support. Unlike impersonal digital tools like email or chat, VR fosters presence and interactive engagement, enhancing the user experience (Sarkar, 2019).

For example, a graduate student conducting interdisciplinary research might use an avatar-guided session to receive tailored assistance, document annotations, or collaborative dataset exploration. These dynamic interactions address the shortcomings of conventional reference services, which often feel transactional and lack personalization.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Frameworks such as Vygotsky's sociocultural theory support the value of collaborative, socially interactive environments for learning. By situating consultations within shared VR spaces, libraries enable meaningful exchanges that enhance cognitive development and knowledge transfer.

Collaborative Virtual Research Spaces

Collaboration is central to academic research, and VR redefines how teams work together. Virtual research rooms allow users to share resources, annotate documents, and collaboratively explore complex data (Tea et al., 2021). These spaces are particularly valuable for interdisciplinary or geographically dispersed teams, enabling real-time brainstorming and co-creation.

For instance, environmental scientists might overlay climate data and land use patterns in a VR space, facilitating informed discussions and decision-making. Similarly, students working on group projects could engage with shared 3D models, annotate materials, or simulate experiments. Librarian avatars can guide sessions, ensuring effective use of library resources.

VR's interactive and social capabilities foster active, collaborative learning. Compared to static video conferencing tools, VR research rooms provide visually rich, immersive environments that encourage deep interaction with content and peers. Features like voice communication, shared annotations, and customizable workspaces significantly enhance teamwork and innovation.

The adoption of VR in library reference services addresses the limitations of current tools while creating new opportunities for engagement and access. Immersive exploration of collections, real-time avatar assistance, and collaborative research spaces establish a dynamic and inclusive environment for knowledge discovery (Cook et al., 2019; Holappa et al., 2018). These innovations enhance user satisfaction and broaden accessibility for diverse groups, including remote learners and interdisciplinary researchers.

To meet the demands of a digital age, libraries must continue researching, experimenting, and incorporating user feedback to refine VR services. By embracing VR strategically, libraries can redefine the reference experience, offering engaging, equitable, and interactive pathways to knowledge. This approach strengthens libraries' roles as facilitators of information while positioning them as leaders in leveraging technology to transform learning and research.

Challenges and Solutions in Implementing VR Reference Services in Libraries

Integrating VR technology into library reference services offers transformative potential but also introduces significant challenges, including financial constraints, accessibility issues, and staff preparedness. Addressing these challenges through strategic solutions and collaborative partnerships enables libraries to enhance user engagement and redefine information access (Greene & Groenendyk, 2020; Horban et al., 2023).

High Costs and Expertise Requirements

The cost of VR technology—covering headsets, motion controllers, and high-performance systems—poses significant hurdles for libraries, especially those with limited budgets (Greene & Groenendyk, 2020). Maintenance and upgrades further strain resources, while insufficient technical expertise among staff complicates implementation and support (Lee et al., 2020).

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Libraries can mitigate financial challenges through collaborative funding and resource-sharing models. Partnerships with universities, schools, and community organizations can co-fund VR facilities, making technology accessible to broader audiences while distributing costs (Holappa et al., 2018). Additionally, libraries can seek grants, negotiate discounts, or solicit donations from technology providers (Frost et al., 2020).

Staff training is equally crucial. Comprehensive programs blending technical instruction with hands-on experience can equip librarians to manage and integrate VR systems effectively. Collaborations with IT professionals ensure ongoing support, fostering a culture of continuous learning (Lee et al., 2020).

Ensuring Inclusivity and Accessibility

Despite its immersive potential, VR can exclude users with disabilities or those unfamiliar with advanced technology. For example, visually impaired patrons may face navigation challenges, and individuals with sensory sensitivities might find VR environments overwhelming (Kulikauskienė, 2019; Jacinto & Kappler, 2022).

To address these issues, libraries should adopt inclusive design principles and provide alternative formats like 2D simulations or pre-recorded walkthroughs, ensuring engagement without requiring specialized equipment (Alfaro, 2023). Collaborating with accessibility experts can help develop VR systems that meet universal usability standards (Floegel, 2019).

Hybrid models combining VR and traditional reference tools can further expand accessibility. Additionally, user training initiatives can help patrons unfamiliar with VR gain the confidence and skills needed to navigate the technology effectively (Raharja et al., 2021).

Developing Staff Competencies and Fostering Adoption

Successful VR integration depends heavily on staff readiness. Resistance often stems from unfamiliarity or uncertainty about VR's alignment with library goals (Lee et al., 2020). Targeted training, participatory development, and clear communication about VR's value are vital for overcoming these challenges.

Professional development initiatives, including workshops simulating VR-based consultations, can familiarize librarians with user needs and their roles as facilitators. These programs highlight VR's potential to enhance research and engagement (Cook et al., 2019). Involving staff in the design and testing of VR services fosters collaboration and ownership, while success stories and case studies demonstrate VR's benefits in improving access, supporting research, and fostering digital literacy (Thoring & Müller, 2011; Kim et al., 2020).

While challenges in implementing VR reference services exist, they are surmountable through strategic planning and innovation. Collaborative funding, inclusive design, and robust training programs are critical to success. By addressing financial barriers, ensuring accessibility, and preparing staff, libraries can adopt VR technology effectively.

Ultimately, VR positions libraries as leaders in innovation and user-centered design. Immersive, engaging, and inclusive reference services allow libraries to meet the evolving needs of patrons, reinforcing their role as dynamic knowledge hubs. Thoughtful planning and

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
collaboration can fully realize VR's potential to transform information access and interaction in the digital age.

Industry Impact and Future Directions of VR in Library Reference Services

The integration of VR in library reference services is reshaping information access, enabling enhanced interactivity, accessibility, and innovation. This section explores the broader implications of VR for libraries and outlines key directions to ensure its sustained impact, focusing on hybrid service models, developer collaborations, virtual literacy, and educational partnerships.

Hybrid Models for Enhanced User Engagement

VR facilitates a hybrid model that bridges physical and virtual library services, providing flexible, inclusive experiences for diverse user groups (Cowan, 2023). Remote users can access virtual stacks, interact with 3D models, or consult librarian avatars in real time, while on-site patrons can enrich their library visits with immersive VR tools in dedicated labs.

For instance, a remote researcher might explore rare manuscripts via high-fidelity 3D models, while a local student participates in collaborative VR workshops. This dual approach ensures equitable access for underserved or geographically dispersed populations while fostering a seamless connection between physical and digital offerings (Suen et al., 2020). By blending VR with traditional methods, libraries align with constructivist learning theories, emphasizing contextual, multi-modal engagement that enhances knowledge retention.

Collaborative Partnerships with Developers

Successful VR implementation requires partnerships with developers to design tailored solutions that integrate seamlessly into library workflows. Such collaborations ensure that VR tools align with user needs and institutional goals, providing scalable and sustainable applications (Gunadi, 2023).

For example, developers can create immersive search engines that visualize search results spatially, helping users identify patterns and connections. Libraries might also integrate VR tools with learning management platforms to embed immersive resources directly into academic curricula. These partnerships are vital for system updates, troubleshooting, and scaling (Breen et al., 2022). Co-designing applications with librarians and patrons ensures usability and fosters ownership, aligning with participatory design principles that prioritize end-user involvement.

Hosting Virtual Literacy Workshops

The effectiveness of VR in libraries hinges on patrons' digital literacy. Virtual literacy initiatives address barriers like unfamiliarity with hardware, navigation difficulties, and apprehension about new technologies (Hurrell & Baker, 2020). Libraries can offer workshops tailored to various skill levels, from basic VR navigation to advanced collaborative research and data visualization.

For example, workshops might simulate a research process, guiding users through locating resources, annotating documents, and sharing findings in a VR environment. Such sessions build user competence while positioning libraries as leaders in fostering essential 21st-century

International Journal of Innovation and Industrial Revolution
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IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
skills. Tailoring workshops to specific audiences, such as students or researchers, ensures relevance and inclusivity (Yerden et al., 2022).

Forging Partnerships with Educational Institutions

Partnering with educational institutions amplifies VR's potential in libraries. Collaborations with schools, universities, and research centers allow libraries to pool resources, share expertise, and develop innovative learning tools (Hahn, 2018). For example, a library could co-develop VR labs with a university's computer science department, benefiting public and academic users.

These partnerships integrate VR into curricula, offering immersive simulations, virtual science labs, and interactive research tools that enrich teaching and learning. Libraries also support joint research on VR's pedagogical benefits, contributing to evidence on immersive learning technologies. Engaging with schools through tailored VR experiences for K–12 students, such as virtual field trips or storytelling, fosters early engagement with library resources and inspires lifelong learning.

The adoption of VR in library reference services represents a transformative shift in how users access and interact with information. Hybrid models that blend physical and virtual experiences, collaborations with developers for tailored solutions, and virtual literacy initiatives ensure that VR enhances accessibility and user engagement. Educational partnerships further embed VR into learning, broadening its reach and impact.

As libraries explore VR's potential, they have the opportunity to shape the future of information access and knowledge creation. By aligning technological innovation with evolving community needs, libraries strengthen their role as adaptive institutions bridging the digital divide. Through sustained experimentation, research, and user-centered approaches, VR can redefine library services, offering immersive, inclusive, and collaborative experiences that meet the demands of a rapidly changing digital landscape.

Theoretical Contributions

This paper contributes to the evolving discourse in library and information science by integrating Design Thinking with VR to reimagine reference services. While existing research largely emphasizes the technical and educational aspects of VR, this study shifts focus to its potential for user-centered, library-specific applications.

By incorporating the iterative and empathetic principles of Design Thinking, the proposed framework bridges the gap between innovation and practical service delivery. It positions libraries as dynamic facilitators of knowledge, emphasizing inclusivity, engagement, and accessibility while aligning VR applications with the diverse needs of their users.

Additionally, this study extends theoretical boundaries by linking immersive technologies with social and cognitive theories, such as constructivist learning and sociocultural collaboration. These insights lay a foundation for future research to refine VR's integration into libraries, advancing both theoretical understanding and real-world impact.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Conclusion

The integration of VR into library reference services marks a transformative shift in how users access, engage with, and explore information. As libraries evolve to meet the needs of diverse, tech-savvy communities, VR bridges traditional services with innovative, immersive experiences, redefining libraries as inclusive hubs for discovery and collaboration.

VR addresses limitations of traditional digital tools through features like virtual reference desks with responsive avatars, collaborative research spaces, and immersive tutorials that enhance engagement and connectivity. These innovations tackle challenges such as remote access barriers, constrained physical collections, and the lack of real-time interactivity in existing platforms.

However, realizing VR's potential requires addressing challenges in inclusivity and accessibility. Libraries must ensure VR accommodates diverse user needs, including those with disabilities or limited technological familiarity, through universal design principles, alternative formats like desktop simulations, and hybrid service models. Partnerships and shared access initiatives are critical to bridging the digital divide and fostering equity.

Equipping library staff with technical and pedagogical training is equally essential for successful VR adoption. Skilled librarians bridge advanced technologies with user needs, ensuring seamless implementation and building trust with patrons who may approach VR with skepticism.

Ultimately, VR reimagines libraries as future-ready, inclusive institutions. By blending innovation with accessibility, libraries can lead the charge in democratizing immersive technologies. Thoughtful planning and collaborations with developers and educators will solidify libraries' roles as accessible, equitable, and engaging spaces, expanding the boundaries of information access and exploration in the digital age.

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References

Adam Zulkarnain Saleng & Ruzilah Ehsan (2020). Perkhidmatan Digital PNM Semasa Pandemik COVID-19. Sekitar Perpustakaan, 51, 15-23.

Adewojo, A. A., & Dunmade, A. O. (2023). Special libraries' odyssey into the 3D realm. Library Hi Tech News, 41(5), 11-14. https://doi.org/10.1108/lhtn-09-2023-0172

Adeyemi, I. O., Sulaiman, K. A., Abdulsalam, Z. M., & Issa, A. O. (2023). Virtual and augmented reality as predictors of users' intention to use Lagos state public library, Lagos state, Nigeria. The Electronic Library, 41(5), 682-699. https://doi.org/10.1108/el-03-2023-0075

Alayón, P. C. (2023). The use of design thinking method in applied research to integrate the library in distance learning platforms with a learning object. E-Ciencias De La Información. https://doi.org/10.15517/eci.v13i2.54022

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Allman-Farinelli, M., Ijaz, K., Tran, H., Pallotta, H., Ramos, S., Liu, J., … & Calvo, R. A. (2019). A virtual reality food court to study meal choices in youth: Design and assessment of usability. JMIR Formative Research, 3(1), e12456. https://doi.org/10.2196/12456

Alpala, L. O., Quiroga-Parra, D. J., Torres, J. C., & Peluffo-Ordóñez, D. H. (2022). Smart factory using virtual reality and online multi-user: towards a metaverse for experimental frameworks. Applied Sciences, 12(12), 6258. https://doi.org/10.3390/app12126258

Angeletaki, A., Carrozzino, M., & Johansen, S. O. (2013). Implementation of 3D tools and immersive experience interaction for supporting learning in a library-archive environment: Visions and challenges. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-5/W2, 37-41. https://doi.org/10.5194/isprsarchives-xl-5-w2-37-2013

Asfarian, A., Nurhadryani, Y., Ardiansyah, F., Hermadi, I., & Ramadhan, D. A. (2022). From immersive to metaverse: The gap of learning and technology in agriculture education application. Jurnal Ilmu Komputer Dan Agri-Informatika, 9(2), 127-136. https://doi.org/10.29244/jika.9.2.127-136

Bartosh, A., & Anzalone, P. (2019). Experimental applications of virtual reality in design education. ACADIA Proceedings, 458-467. https://doi.org/10.52842/conf.acadia.2019.458

Boletsis, C. (2018). Virtual reality for prototyping service journeys. Multimodal Technologies and Interaction, 2(2), 14. https://doi.org/10.3390/mti2020014

Boletsis, C., Karahasanovic, A., & Fjuk, A. (2017). Virtual bodystorming: Utilizing virtual reality for prototyping in service design. Lecture Notes in Computer Science, 279-288. https://doi.org/10.1007/978-3-319-60922-5_22

Breen, M., Waters, J., & O'Shea, L. (2022). Taking a lead on digital literacy for students—a case study from the library at the university of limerick. New Review of Academic Librarianship, 29(1), 11-32. https://doi.org/10.1080/13614533.2022.2039243

Brown, C. S., Cunningham, C. D., Lee, W. T., & Puscas, L. (2020). Development of a surgical video atlas for resident education: 3-year experience. OTO Open, 4(3). https://doi.org/10.1177/2473974x20939067

Buchanan, S., Jardine, C., & Ruthven, I. (2018). Information Behaviors in Disadvantaged and Dependent Circumstances and the Role of Information Intermediaries. Journal of the Association for Information Science and Technology, 70(2), 117-129. https://doi.org/10.1002/asi.24110

Charbonneau, D. H. and Vardell, E. (2022). The impact of covid-19 on reference services: a national survey of academic health sciences librarians. Journal of the Medical Library Association, 110(1). https://doi.org/10.5195/jmla.2022.1322

Cao, G., Liang, M., & Li, X. (2018). How to make the library smart? The conceptualization of the smart library. The Electronic Library, 36(5), 811-825. https://doi.org/10.1108/el-11-2017-0248

Christina Purnama Yanti, I. G., Sudipa, I. G., & Aditama, P. W. (2023). Design thinking testing of AR/VR application for Bali's lontar prasi preservation. Jurnal Multidisiplin Madani, 3(9), 1956-1963. https://doi.org/10.55927/mudima.v3i9.5744

Cook, M., Lischer-Katz, Z., Hall, N., Hardesty, J. L., Johnson, J., McDonald, R. H., … & Carlisle, T. (2019). Challenges and strategies for educational virtual reality. Information Technology and Libraries, 38(4), 25-48. https://doi.org/10.6017/ital.v38i4.11075

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
Cowan, P. and Farrell, R. (2023). Using virtual reality to support retrieval practice in blended learning: an interdisciplinary professional development collaboration between novice and expert teachers. Digital, 3(3), 251-272. https://doi.org/10.3390/digital3030016

De Sarkar, T. (2023). Augmented reality applications and the future library. Library Hi Tech News, 40(9), 7-11. https://doi.org/10.1108/lhtn-07-2023-0129

Deja, M., Bobkowski, P., Huvila, I., & Mierzecka, A. (2024). Empowering Through Digital Skills: A Case of Alumni in the Business Services Sector. Journal of the Association for Information Science and Technology, 75(11), 1288-1303. https://doi.org/10.1002/asi.24890

Floegel, D. (2019). "A good intention gone awry": Queering makerspaces to support queer creators. Proceedings of the Association for Information Science and Technology, 56(1), 395-398. https://doi.org/10.1002/pra2.36

Fortune, J., Burke, J. G., Dillon, C., Cen, S. D. R., O'Toole, S., Enright, A., … & Ryan, J. M. (2022). Co-designing resources to support the transition from child to adult health services for young people with cerebral palsy: A design thinking approach. Frontiers in Rehabilitation Sciences, 3. https://doi.org/10.3389/fresc.2022.976580

Freitag, M., & Hämmerle, O. (2020). Agile guideline for development of smart services in manufacturing enterprises with support of artificial intelligence. IFIP Advances in Information and Communication Technology, 645-652. https://doi.org/10.1007/978-3-030-57993-7_73

Frost, M., Goates, M. C., Cheng, S. H., & Johnston, J. (2020). Virtual reality. Information Technology and Libraries, 39(1). https://doi.org/10.6017/ital.v39i1.11369

Garvey, M. (2021). Virtual reference amid covid-19 campus closure: a case study and assessment. Reference Services Review, 49(2), 132-150. https://doi.org/10.1108/rsr-01-2021-0005

Greene, D., & Groenendyk, M. (2020). An environmental scan of virtual and augmented reality services in academic libraries. Library Hi Tech, 39(1), 37-47. https://doi.org/10.1108/lht-08-2019-0166

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of education 4.0 in 21st century skills frameworks: Systematic review. Sustainability, 14(3), 1493. https://doi.org/10.3390/su14031493

Gunadi, Z. Z. I., Prijana, & Sias, J. N. (2023). Academic library collaboration to optimize library services. Record and Library Journal, 9(2), 283-292. https://doi.org/10.20473/rlj.v9-i2.2023.283-292

Hahn, J. (2018). Virtual reality learning environments. Information and Learning Science, 119(11), 652-661. https://doi.org/10.1108/ils-07-2018-0069

Holappa, H., Ylipulli, J., Rautiainen, S., Minyaev, I., Pouke, M., & Ojala, T. (2018). VR application for technology education in a public library. Proceedings of the 17th International Conference on Mobile and Ubiquitous Multimedia, 521-527. https://doi.org/10.1145/3282894.3289719

Horban, Y., Gaisynuik, N., Dolbenko, T., Karakoz, O., Kobyzhcha, N., & Kulish, Y. (2023). The media space of a modern library in the context of its organizing by virtual and augmented reality technologies. International Journal of Information and Education Technology, 13(4), 718-723. https://doi.org/10.18178/ijiet.2023.13.4.1858

Hurrell, C. and Baker, J. (2020). Immersive learning: applications of virtual reality for undergraduate education. College &Amp; Undergraduate Libraries, 27(2-4), 197-209. https://doi.org/10.1080/10691316.2020.1796879

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
Hutson, J. H. (2022). Social virtual reality: Neurodivergence and inclusivity in the metaverse. Societies, 12(4), 102. https://doi.org/10.3390/soc12040102

Jacinto, R. F., & Kappler, E. (2022). A discussion on accessibility, inclusivity, cultural design considerations, and health & safety advisories for virtual reality head mounted displays. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 66(1), 1706-1710. https://doi.org/10.1177/1071181322661200

Juan, Y., Chi, H., & Chen, H. (2019). Virtual reality-based decision support model for interior design and decoration of an office building. Engineering, Construction and Architectural Management, 28(1), 229-245. https://doi.org/10.1108/ecam-03-2019-0138

Kim, H., & Hyun, K. H. (2022). Understanding design experience in virtual reality for interior design process. CAADRIA Proceedings. https://doi.org/10.52842/conf.caadria.2022.1.059

Kim, J., Hong, L., & Evans, S. (2024). Toward Measuring Data Literacy for Higher Education: Developing and Validating a Data Literacy Self-Efficacy Scale. Journal of the Association for Information Science and Technology, 75(8), 916-931. https://doi.org/10.1002/asi.24934

Kim, K. H., & Kim, D. H. (2023). Improved balance, gait, and lower limb motor function in a 58-year-old man with right hemiplegic traumatic brain injury following virtual reality-based real-time feedback physical therapy. American Journal of Case Reports, 24. https://doi.org/10.12659/ajcr.938803

Kristofferson, K., Daniels, M., & Morales, A. C. (2022). Using virtual reality to increase charitable donations. Marketing Letters, 33(1), 75-87. https://doi.org/10.1007/s11002-021-09601-8

Kulikauskienė, K. (2019). The concept of socially inclusive library in changing society. Socialiniai Tyrimai, 42(1), 67-78. https://doi.org/10.21277/st.v42i1.265

Lee, H., & Park, J. E. (2021). Designing a new empathy-oriented prototyping toolkit for the design thinking process: Creativity and design sensibility. International Journal of Art & Design Education, 40(2), 324-341. https://doi.org/10.1111/jade.12345

Lee, K. J., King, W., Dahya, N., & Lee, J. H. (2020). Librarian perspectives on the role of virtual reality in public libraries. Proceedings of the Association for Information Science and Technology, 57(1). https://doi.org/10.1002/pra2.254

Lee, U., & Kim, H. (2022). UTAUT in metaverse: An “ifland” case. Journal of Theoretical and Applied Electronic Commerce Research, 17(2), 613-635. https://doi.org/10.3390/jtaer17020032

Lie, S. S., Helle, N., Sletteland, N. V., Vikman, M. D., & Bonsaksen, T. (2023). Implementation of virtual reality in health professions education: Scoping review. JMIR Medical Education, 9, e41589. https://doi.org/10.2196/41589

Lotbinière-Bassett, M. d., Batista, A. V., Lai, C., Chemaly, T. E., Dort, J. C., Blevins, N. H., … & Lui, J. T. (2022). The user experience design of a novel microscope within SurgiSim, a virtual reality surgical simulator. International Journal of Computer Assisted Radiology and Surgery, 18(1), 85-93. https://doi.org/10.1007/s11548-022-02727-8

Lyubchak, V., Zuban, Y. O., & Artyukhov, A. (2022). Immersive learning technology for ensuring quality education: Ukrainian university case. CTE Workshop Proceedings, 9, 336-354. https://doi.org/10.55056/cte.124

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Mc Dermott, G., Byrne, A., McLaughlin, R., O'Connor, N., & Griselain, S. (2023). Exploring the use of immersive technologies to enhance the student experience. Ubiquity Proceedings. https://doi.org/10.5334/uproc.98

Mercado, F. P., & Catapan, M. F. (2023). The impact of virtual reality in service design research. Blucher Design Proceedings, 405-410. https://doi.org/10.5151/ead2023-2sao-02short-02fuad-pumarejo-mercado-et-al

Mulders, M. (2022). Vocational training in virtual reality: A case study using the 4C/ID model. Multimodal Technologies and Interaction, 6(7), 49. https://doi.org/10.3390/mti6070049

Mummah, S., Robinson, T. N., King, A. C., Gardner, C. D., & Sutton, S. (2016). IDEAS (Integrate, Design, Assess, and Share): A framework and toolkit of strategies for the development of more effective digital interventions to change health behavior. Journal of Medical Internet Research, 18(12), e317. https://doi.org/10.2196/jmir.5927

Ose, S. O., Færevik, H., Kaasbøll, J., Lindgren, M., Thaulow, K., Antonsen, S., … & Burkeland, O. (2019). Exploring the potential for use of virtual reality technology in the treatment of severe mental illness among adults in mid-Norway: Collaborative research between clinicians and researchers. JMIR Formative Research, 3(2), e13633. https://doi.org/10.2196/13633

Pallavicini, F., Pepe, A., & Minissi, M. E. (2019). Gaming in virtual reality: What changes in terms of usability, emotional response and sense of presence compared to non-immersive video games? Simulation & Gaming, 50(2), 136-159. https://doi.org/10.1177/1046878119831420

Paramita, M. L., Kasinidou, M., Kleanthous, S., Rosso, P., Kuflik, T., & Hopfgartner, F. (2023). Towards Improving User Awareness of Search Engine Biases: A Participatory Design Approach. Journal of the Association for Information Science and Technology, 75(5), 581-599. https://doi.org/10.1002/asi.24826

Patria, A. S., Martadi, M., Kristiana, N., & Anggalih, N. N. (2023). Integrating design thinking process and service learning project into packaging design lesson plan at vocational graphic design study program. Advances in Social Science, Education and Humanities Research, 900-909. https://doi.org/10.2991/978-2-38476-152-4_87

Radford, M. L., Connaway, L. S., & Shah, C. (2012). Convergence and synergy: Social Q&A meets virtual reference services. Proceedings of the American Society for Information Science and Technology, 49(1), 1-8. https://doi.org/10.1002/meet.14504901111

Radford, M. L., Costello, L., & Montague, K. (2022). “Death of Social Encounters”: Investigating Covid-19's Initial Impact on Virtual Reference Services in Academic Libraries. Journal of the Association for Information Science and Technology, 73(11), 1594-1607. https://doi.org/10.1002/asi.24698

Raharja, S., Bustari, M., & Fadhli, R. (2021). Exploration of School Library Services for Students with Disabilities. KnE Social Sciences, 6(2), 604–611. https://doi.org/10.18502/kss.v6i2.10018

Rahman, M. H., Ahmad, A., & Zakaria, S. (2022). A literature review on digital content management: Trends and future challenges. Digital Library Perspectives, 39(1), 97-110. https://doi.org/10.1108/dlp-03-2022-0024

Rojas Alfaro, R. (2023). A virtual reality exploration of library services: Affordances and perceptions. International Robotics & Automation Journal, 9(3), 115-112. https://doi.org/10.15406/iratj.2023.09.00273

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007

Sarkar, T. D. (2019). Library in 3D virtual world: A critical review. VINE Journal of Information and Knowledge Management Systems, 49(2), 213-228. https://doi.org/10.1108/vjikms-07-2018-0059

Schöne, B., Kisker, J., Sylvester, R. S., Radtke, E. L., & Gruber, T. (2021). Library for universal virtual reality experiments (LUVRE): A standardized immersive 3D/360° picture and video database for VR-based research. Current Psychology, 42(7), 5366-5384. https://doi.org/10.1007/s12144-021-01841-1

Schwebel, D. C., Severson, J., & He, Y. (2016). Using smartphone technology to deliver a virtual pedestrian environment: Usability and validation. Virtual Reality, 21(3), 145-152. https://doi.org/10.1007/s10055-016-0304-x

Simons, L. E., Hess, C. W., Choate, E. S., Orden, A. R. V., Tremblay-McGaw, A. G., Menéndez, M., … & Koeppen, K. (2022). Virtual reality–augmented physiotherapy for chronic pain in youth: Protocol for a randomized controlled trial enhanced with a single-case experimental design. JMIR Research Protocols, 11(12), e40705. https://doi.org/10.2196/40705

Smith, L. C. (2023). Reviews and Reviewing: Approaches to Research Synthesis. An Annual Review of Information Science and Technology (ARIST) paper. Journal of the Association for Information Science and Technology, 75(3), 245-267. https://doi.org/10.1002/asi.24851

Solmaz, S., Kester, L., & Gerven, T. V. (2023). An immersive virtual reality learning environment with CFD simulations: Unveiling the virtual garage concept. Education and Information Technologies, 29(2), 1455-1488. https://doi.org/10.1007/s10639-023-11747-z

Suen, R. L. T., Chiu, D. K., & Tang, J. K. T. (2020). Virtual reality services in academic libraries: deployment experience in hong kong. The Electronic Library, 38(4), 843-858. https://doi.org/10.1108/el-05-2020-0116

Tea, S., Panuwatwanich, K., Ruthankoon, R., & Kaewmoracharoen, M. (2021). Multiuser immersive virtual reality application for real-time remote collaboration to enhance design review process in the social distancing era. Journal of Engineering, Design and Technology, 20(1), 281-298. https://doi.org/10.1108/jedt-12-2020-0500

Thoring, K., & Müller, R. (2011). Understanding the creative mechanisms of design thinking. Procedings of the Second Conference on Creativity and Innovation in Design, 137-147. https://doi.org/10.1145/2079216.2079236

Touloudi, E., Hassandra, M., Galanis, E., Goudas, M., & Theodorakis, Y. (2022). Applicability of an immersive virtual reality exercise training system for office workers during working hours. Sports, 10(7), 104. https://doi.org/10.3390/sports10070104

Urban, A. and Bossaller, J. S. (2024). Exploring Enigmas: Information Seeking After Exposure to Virtual Reality Awe Elicitors. Journal of the Association for Information Science and Technology, 75(7), 789-806. https://doi.org/10.1002/asi.24882

Voinescu, A., Morgan, P. L., Alford, C., & Caleb-Solly, P. (2020). The utility of psychological measures in evaluating perceived usability of automated vehicle interfaces – A study with older adults. Transportation Research Part F: Traffic Psychology and Behaviour, 72, 244-263. https://doi.org/10.1016/j.trf.2020.05.003

Warraich, N. F., Rorissa, A., & Rasool, T. (2020). An in-depth qualitative study of Pakistani academic library professionals' conceptions of linked data technology. Information Discovery and Delivery, 49(4), 280-286. https://doi.org/10.1108/idd-03-2020-0029

Yerden, X., Gil-García, J. R., Gascó-Hernández, M., & Burke, G. B. (2022). Public libraries' perceptions of future collaborations for the development of smart cities and

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 20 (March 2025) PP. 106-134
DOI 10.35631/IJIREV.720007
communities: Understanding influential factors. Proceedings of the Annual Hawaii International Conference on System Sciences. https://doi.org/10.24251/hicss.2022.336

Yi, Y. J., Hwang, B., & Kim, D. (2022). A model for mobile curation services in academic libraries. The Electronic Library, 40(1/2), 99-117. https://doi.org/10.1108/el-09-2021-0178