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AWARENESS, COMPETENCE, AND PERCEPTIONS OF AUGMENTED REALITY, VIRTUAL REALITY, AND THE METAVERSE AMONG PAKISTANI UNIVERSITY LIBRARIANS

Hina Sardar [1], Muhammad Kabir Khan [2]

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Affiliations:

[1] Shahida Islam Medical & Dental College, Lodhran, Pakistan
Email: hinasardar007@gmail.com
https://orcid.org/0000-0002-2002-8591

[2] Effat University, Jeddah KSA
Email: mkabir@effatuniversity.edu.sa
https://orcid.org/0000-0002-8295-0338

Corresponding Author's Email:

[2] mkabir@effatuniversity.edu.sa

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Abstract

This study assesses the readiness of Pakistani university librarians for Augmented Reality (AR), Virtual Reality (VR), and Metaverse technologies by examining their awareness, competence, interest, and perceptions. A quantitative survey design was employed, with data collected from 96 librarians via a validated online questionnaire. Descriptive statistics were used to analyse demographic profiles, awareness, proficiency, interest levels, and perceived future roles of these technologies.

Librarians demonstrated moderate to high awareness of AR and the Metaverse but lower awareness of VR. Practical proficiency was limited across all three technologies. However, strong interest was expressed in learning and integrating these tools into library services. Perceptions of the Metaverse's future role varied, with many anticipating moderates to transformative impacts. The study calls for targeted training programs, curriculum revisions, and institutional investments in infrastructure and partnerships to bridge the competence gap and foster technology adoption.

This is the first empirical study in Pakistan to focus on librarians' readiness for immersive technologies, offering foundational insights for policy, practice, and future research in developing countries.

Keywords: Metaverse, Augmented Reality, Virtual Reality, University Librarians, Pakistani Libraries, Digital Transformation, Emerging Technologies

Introduction

In today's digital age, libraries are undergoing a profound transformation. Emerging technologies such as Augmented Reality (AR), Virtual Reality (VR), and the Metaverse are opening new possibilities, offering ways to enrich how information is accessed, shared, and experienced (Ajani et al., 2023). Modern libraries are no longer just quiet spaces for solitary reading; they have evolved into dynamic, interactive hubs where knowledge is preserved, explored, and shared in creative ways (Garoufali & Garoufallou, 2022). These technologies allow people to interact with information in immersive ways, offering experiences that go beyond traditional print or digital formats.

AR and VR can create engaging, hands-on learning environments, while the Metaverse provides a virtual space for collaboration, social interaction, and exploration (Alex et al., 2023; Daradkeh, 2023). Through these technologies, patrons can walk through virtual stacks, explore historical archives, or participate in interactive educational experiences—all from anywhere in the world (Guo et al., 2023; Oladokun, Enakrire et al., 2023). This extends the reach of libraries beyond physical walls, making information and cultural heritage more accessible to a global audience.

These innovations also cater to diverse learning styles. VR can transport users to different locations or historical periods, while AR can overlay contextual information onto real-world objects, creating multi-sensory and experiential learning opportunities (Holappa et al., 2018; Isa, 2023; Noh, 2023). Moreover, these

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tools enable libraries to present complex datasets through interactive visualization, making information easier to understand and decisions more informed (Donalek et al., 2014; Lee et al., 2012; Leetaru, 2015).

The Metaverse, in particular, is rapidly evolving. In 2023, Meta launched the Meta Quest Pro, a high-end VR headset for both work and play, reflecting growing investment in immersive digital environments (Durak & Cankaya, 2023). As these technologies continue to develop, library professionals must stay informed and consider how such tools can enhance services, foster learning, and engage users in meaningful ways (Feng et al., 2022; Tella et al., 2023).

Given these developments, understanding the awareness, competence, and interest of library professionals in AR, VR, and the Metaverse is critical. This study aims to explore these aspects, providing insights into how prepared library professionals are to embrace emerging technologies. By examining their readiness, we hope to illuminate the opportunities and challenges these technologies present, ultimately helping libraries remain relevant and vibrant in an increasingly digital world.

Research Objectives

1. To examine the level of awareness and technical competence of library professionals regarding Augmented Reality (AR), Virtual Reality (VR), and Metaverse technologies.
2. To evaluate library professionals' interest, engagement, and willingness to adopt and utilize AR, VR, and Metaverse technologies within Library and Information Services.
3. To explore the potential and future role of Metaverse technologies in the development and transformation of Library and Information Services.

Significance of the Study

To achieve these objectives, this study employs a comprehensive survey targeting library professionals from diverse demographic backgrounds. By examining current levels of awareness, competence, and interest, the research provides insights into the readiness of library professionals to adapt to a rapidly evolving technological landscape. Additionally, the study highlights the potential impact of AR, VR, and Metaverse technologies on the future development of Library and Information Services. At a time when libraries must continuously innovate to remain relevant, this research offers a timely examination of library professionals' knowledge, skills, and willingness to embrace emerging technologies, thereby contributing to an understanding of how these technologies may shape the future trajectory of library services in an increasingly digital era.

This paper is organized as follows. The Literature Review section presents an overview of existing studies and theoretical frameworks related to the Metaverse and emerging technologies in university library contexts. The Methodology section describes the research design, sampling strategy, survey instrument, data collection procedures, and statistical analysis techniques. The subsequent section provides a detailed presentation and discussion of the findings. Finally, the Conclusion outlines key implications, recommendations, and directions for future research.

Literature Review

Emerging Technologies in Library Services

The concept of the Metaverse is often described as a convergence of digital virtuality and physical reality, creating an interactive, persistent, multiuser environment (Mystakidis, 2022). Its origins can be traced back to pioneering work by Ivan Sutherland, whose 1965 publication The Ultimate Display outlined the blending of digital and physical worlds, and Morton Heilig, who developed one of the first virtual reality machines in the 1960s.

Libraries have increasingly benefited from the integration of Artificial Intelligence (AI) and Machine Learning (ML) in various services, including information retrieval, cataloguing, classification, collection management, and abstracting and indexing (Mupaikwa, 2025). AI-enabled systems can provide personalized access to information, allowing researchers to efficiently locate resources tailored to their specific needs (Lund et al., 2024). In Pakistan, the development of AI gained momentum in 2018 through initiatives such as the President's Artificial Intelligence and Computing program (Abid et al., 2019). Riedl (2019) further proposed that human-centred AI can be classified into two domains: (a) systems that interpret humans from a sociocultural perspective, and (b) systems that support humans in understanding themselves. The term

"Metaverse" was popularized by American science fiction author Neal Stephenson in his 1992 novel Snow Crash, which envisioned a future where privileged individuals inhabit a fully connected, three-dimensional virtual world. Kumar (2022) describes metaverses as persistent, fully integrated virtual environments where users can interact with content created by themselves and others.

In the educational context, Artificial Intelligence in Education (AIEd) seeks to create platforms that merge human and AI capabilities to enhance student learning outcomes (Pham & Sampson, 2022; Wang & Lin, 2023). This integration draws on AI technologies, human-computer interaction, and insights from the learning sciences, with a focus on adaptability and collaboration in real-world educational settings (Alam, 2022; Kasepalu et al., 2022). Similarly, Devagiri et al. (2022) examined the role of Augmented Reality (AR) and AI in industry, highlighting current trends, tools, and emerging challenges. Their study supports the notion that AI-driven educational tools aim to provide a seamless integration of human and artificial intelligence elements, designed and evaluated to foster collaboration and adaptability in practical contexts.

Augmented and Virtual Reality: readiness to adopt innovations

In the digital era, AR and VR have a significant role in smart libraries. Consequently, in the era of technology, embracing it is unavoidable (Mayesti et al., 2024). The emergence of cutting-edge technologies such as AR, VR, and others has given the digital libraries experience an additional perspective. Through the provision of innovative and creative services for information access and learning support, these technologies have the potential to entirely transform the way digital libraries interact with their communities (Asif et al., 2025; Tammaro, 2024).

In a recent study led by Adeyemi et al. (2023), a suggestion was put forward for public libraries to embrace cutting-edge AR applications more enthusiastically. The goal is to streamline access to users' information needs and enhance the overall experience for patrons. The findings revealed a positive reception among users towards both VR and AR. Additionally; the research underscored the significant influence of subjective norms in guiding library users toward adopting VR and AR technologies. It emphasised the importance of collaborative efforts between users and librarians to leverage these immersive technologies effectively. Several studies consistently demonstrate that AR-based learning surpasses the effectiveness of traditional methods, revolutionising user interactions across print, digital, and other mediums.

This inquiry was conducted across seven libraries in Washington State, marking the initial integration of VR for drop-in programming. The study compared user perceptions of VR against their actual experiences, delving into informal learning and social interactions facilitated by VR. Embedding their analysis within the framework of sociotechnical imaginaries – culturally embedded concepts elucidating the interplay between society and technology – the work of Liu et al. (2010) and Solak and Cakir (2015) contributed significantly to the discussion (Aslam & Asif, 2025; Dahya et al. 2021).

Another framework was devised to explore the implementation of AR in libraries associated with medical science universities. The objective was to introduce applications, advantages, opportunities, and challenges linked with AR. Identified challenges encompassed technical, economic, and cultural dimensions. Strategies to engage a diverse user base included effective policies, technological integration, and enriching content. AR emerged as a valuable tool for library management, significantly enhancing the professional activities of both librarians and users (Dalili Saleh et al., 2021).

Duncan (2022) describes AR as an advanced technology that melds aspects of the physical, tangible environment with computer-generated imagery, enabling user interaction with virtual objects. Whether two-dimensional or three-dimensional, these objects seamlessly integrate into the actual surroundings. Sumadio and Rambli's research (2010) demonstrated that AR can create a "natural" experience, amplifying teaching effectiveness and the allure of learning for students and enhancing attention and motivation levels.

Metaverse Technologies: Interest, Engagement and future role in Library Services

Metaverse technologies are reshaping the concept of smart libraries by offering users increasingly immersive and interactive learning experiences, while also providing innovative ways to engage with information resources (Margam, 2024). As Sureephong et al. (2024) note, libraries and librarians must continually adapt their skills to navigate the evolving metaverse, ensuring they continue to deliver valuable services and resources in digital environments.

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The concept of the metaverse was first introduced by Neal Stephenson in his 1992 science fiction novel Snow Crash, envisioning a virtual realm accessible through devices such as head-mounted VR displays. Stephenson's work is widely recognized as pioneering in conceptualizing virtual spaces for computer-mediated communication (Guo et al., 2023). As the metaverse continues to evolve, libraries and librarians face the challenge of adapting to maintain relevance and meet the changing expectations of their communities.

Tella et al. (2023) highlight the potential of libraries to serve as central information hubs and community spaces within the metaverse. To navigate this digital landscape effectively, both librarians and users need to develop meta-literacy skills, including critical thinking, digital citizenship, and ethical information use. While rapid technological advancements pose challenges, ongoing training and support can help library professionals and users remain proficient and engaged in these immersive environments (Oladokun et al., 2023).

The metaverse holds significant potential across multiple domains, including education, entertainment, commerce, and social interaction. In education, it can provide students with highly engaging, immersive learning experiences, while social platforms in the metaverse enable novel ways for communication, collaboration, and knowledge sharing (Li & Zhao, 2023).

According to Anna et al. (2023), metaverse libraries are still in their early stages, largely existing as experimental projects or prototypes. Some communities are leveraging these spaces for collaboration, creation, and innovation. Partnerships with virtual world platform providers are essential to accelerate the development of fully functional metaverse libraries. Future research should explore the readiness of libraries to adopt the metaverse, the understanding and skills of librarians in this domain, and the competencies required to effectively operate in these emerging virtual environments.

Theoretical Framework

This study is anchored in the Technology Acceptance Model (TAM) and the Diffusion of Innovations (DOI) theory, which provide a robust lens through which to examine librarians' readiness for immersive technologies. TAM posits that perceived usefulness and perceived ease of use influence individuals' attitudes toward adopting new technologies (Davis, 1989). In the context of this study, librarians' awareness and competence in AR, VR, and the Metaverse can be viewed as precursors to perceived usefulness and ease of use, which in turn shape their interest and engagement.

Complementing TAM, Rogers' Diffusion of Innovations theory (2003) explains how new technologies spread within social systems. The theory categorizes adopters into innovators, early adopters, early majority, late majority, and laggards. The current findings showing moderate awareness but limited hands-on experience, suggest that many Pakistani university librarians may currently occupy the "early majority" or "late majority" categories. Barriers such as limited access to hardware, training, and institutional support may be slowing the diffusion process.

This integrated framework helps interpret not only *whether* librarians are aware of these technologies, but also how and why they might adopt them, or resist doing so, in their professional contexts.

Research Methodology

Research Design

This study employed a quantitative, cross-sectional survey design to investigate the awareness, competence, interest, and perceptions of Pakistani university librarians regarding Augmented Reality (AR), Virtual Reality (VR), and the Metaverse. The design was chosen for its capacity to gather standardized, generalizable data from a dispersed professional population. The research adhered to established guidelines for survey-based observational studies to ensure methodological rigor and transparency.

Population and Sampling

The target population consisted of professional librarians employed at public and private university libraries across Pakistan. A purposive sampling strategy was used to ensure representation from diverse institutional and regional backgrounds. An initial sampling frame of 150 potential respondents was developed using professional directories, publications, and online networks.

A total of 96 valid responses were received, yielding a 64% response rate. A post-hoc power analysis confirmed that the achieved sample size provided sufficient statistical power (0.87) to detect meaningful

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effects, ensuring the robustness of subsequent inferential analyses.

Instrument Development and Validation

The survey instrument was developed through a systematic, multi-stage validation process. Initial items were generated from an extensive literature review and adapted from established technology acceptance and digital literacy scales. Content validity was assessed by a panel of five experts in Library and Information Science, resulting in a high Scale-Content Validity Index (S-CVI) of 0.91. The instrument was then pilot-tested with 15 library professionals, leading to refinements for clarity and confirming strong internal consistency for all constructs.

Survey Instrument

The final questionnaire contained 46 items across four sections. Section A collected demographic data (8 items). Section B assessed awareness and competence for AR, VR, and the Metaverse using 30 Likert-scale items. Section C measured interest and engagement with 11 items. Section D explored perceptions of the Metaverse's future role in libraries with 5 ordinal-scale items. All scales demonstrated excellent reliability in the pilot phase.

Data Collection Procedure

Data were collected electronically between September and October 2023 using a Google Forms survey. Invitations were distributed via email, professional LinkedIn groups, and librarian WhatsApp networks to maximize reach. Three follow-up reminders were sent to improve the response rate. Participation was voluntary and anonymous, with no incentives provided. The survey required approximately 15–20 minutes to complete.

Data Analysis

Data were analysed using SPSS (version 28.0) and AMOS (version 26.0). Preliminary analysis included screening for missing data and testing assumptions of normality and homogeneity. Descriptive statistics summarized demographic profiles and key variables. Inferential analyses included Pearson correlations, t-tests, ANOVA with post-hoc tests, multiple linear regression, and exploratory factor analysis. Advanced techniques such as K-means clustering and path analysis via Structural Equation Modelling (SEM) were employed to identify readiness profiles and test theoretical relationships.

Methodological Limitations

The study acknowledges certain limitations. The cross-sectional design prevents causal inferences, and the reliance on self-reported data may introduce social desirability bias. Furthermore, the sample was limited to university librarians, which may affect the generalizability of findings to other library sectors. These limitations are mitigated by the methodological rigor applied and provide clear direction for future longitudinal and mixed-methods research.

Ethical Considerations

This study adhered to established ethical guidelines for survey research. Prior to participation, all respondents were provided with a digital consent form outlining the study's purpose, data usage, anonymity assurances, and their right to withdraw at any time. Participation was voluntary, and no identifying information was collected, ensuring respondent anonymity. Data were stored securely on password-protected servers and analysed in aggregate form to prevent individual identification. The study protocol was reviewed and approved by Ethics Review Board.

Results

Demographic and Educational Profile of Respondents

The results of figure 1 reveals several key insights about the surveyed population. Firstly, the gender distribution shows a majority of male respondents (61.5%) and a significant female representation (38.5%). The age distribution is diverse, with a concentration in the 35-44 age group (37.5%). Most respondents hold advanced degrees, with the Master of Philosophy degree being the most common (39.6%), followed by Doctoral (31.3%) and Master's degrees (29.2%).

In terms of professional experience, a considerable portion of respondents (43.8%) have more than 15 years of experience, demonstrating a seasoned workforce. Notably, none reported having an education level of high school or below, underlining the highly educated nature of the sample.

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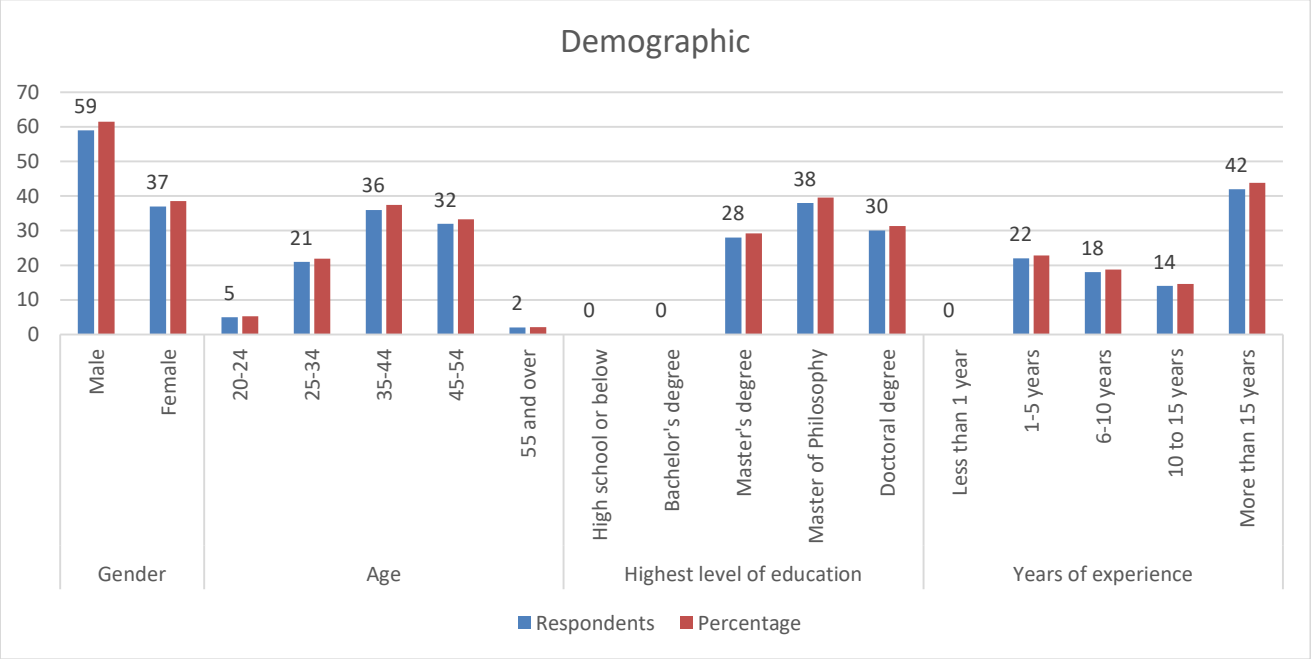
These findings provide valuable insights into the demographics and educational backgrounds of the respondents, which can aid in tailoring research or initiatives to this specific group. The study's focus on a well-educated and experienced group suggests the potential for high expertise and knowledge within this population.

Figure 1

Demographic and Educational Profile of Respondent



Awareness and Proficiency Levels of Library Professionals in AR, VR, and Metaverse Technologies

Table 1 reveals valuable insights into library professionals' awareness and proficiency levels in the domains of AR, VR, and Metaverse technologies.

Augmented Reality (AR)

Respondents demonstrated a moderate level of awareness about AR, with a mean score of 1.72. This indicates that most library professionals have heard of AR and are aware of its existence. Additionally, the proficiency in working with AR technologies was moderately high, with a mean score of 1.89. This suggests that many respondents possess practical experience with AR. Furthermore, awareness of AR tools and platforms commonly used in the library field is relatively high, with a mean score of 1.72. This indicates that library professionals are acquainted with AR tools and platforms relevant to their profession.

Virtual Reality (VR)

In contrast to AR, library professionals displayed a slightly lower level of awareness about VR, with a mean score of 1.57. This implies that VR is less known among the surveyed professionals. However, the proficiency in working with VR technologies was relatively higher, with a mean score of 2.02. This suggests that, despite lower awareness, library professionals aware of VR tend to have practical experience with it. Awareness of VR tools and platforms commonly used in the library field was moderate, with a mean score of 2.08.

Metaverse Technologies

Respondents demonstrated some awareness of metaverse technologies, with a mean awareness score of 1.71. This indicates that library professionals have heard of metaverse technologies to some extent. Proficiency in working with metaverse technologies was moderately high, with a mean score of 1.86, indicating practical experience among respondents. Additionally, awareness of metaverse tools and platforms commonly used in the library field was relatively high, with a mean score of 1.93.

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The study findings show that library professionals have varying levels of awareness and proficiency in AR, VR, and Metaverse technologies. While AR and Metaverse technologies exhibit higher awareness and proficiency levels, VR lags slightly in terms of awareness. These findings suggest opportunities for further training and development in VR, with the potential for increased integration of these technologies into library settings, ultimately enhancing the services and experiences provided to library patrons.

Table 1

Awareness and Proficiency Levels of Library Professionals in AR, VR, and Metaverse Technologies

Library Professionals' Awareness and Competence in AR, VR, and Metaverse Technologies	**Mean**	**SD**
AR Awareness and Proficiency Levels in the Library Field		
I have never heard of AR.	1.5	0.78
I am aware of AR but have no practical experience with it.	1.30	0.73
I have some practical experience with AR.	1.96	0.85
I am proficient in working with AR technologies.	1.89	0.80
I am aware of AR tools and platforms commonly used in the library field.	1.72	0.71
VR Awareness and Proficiency Levels in the Library Field		
I have never heard of VR.	1.57	0.84
I am aware of VR but have no practical experience with it.	1.65	0.94
I have some practical experience with VR.	1.93	0.77
I am proficient in working with VR technologies.	2.02	0.81
I am aware of VR tools and platforms commonly used in the library field.	2.08	0.88
Metaverse Awareness and Proficiency Levels in the Library Field		
I have never heard of metaverse technologies.	1.36	0.81
I am aware of metaverse technologies but have no practical experience with them.	1.71	0.95
I have some practical experience with metaverse technologies.	1.79	0.79
I am proficient in working with metaverse technologies.	1.86	0.76
I am aware of metaverse tools and platforms commonly used in the library field.	1.93	0.85

Interest and Engagement with Emerging Technologies in Library Science

Table 2 reveals that library professionals are keenly interested in embracing the potential of emerging technologies, including AR, VR, and the Metaverse, within the realm of Library and Information Science. Their collective enthusiasm is evident, with a strong overall interest score of 3.70, demonstrating their eagerness to explore these technologies. Library professionals are particularly intrigued by how AR can enhance the library experience (3.86) and the potential applications of VR in educational settings (3.71). Furthermore, they are enthusiastic about integrating Metaverse technologies into library services and resources (3.88) and staying updated on the latest trends (3.96). They also express a commitment to understanding the ethical considerations, challenges, and cost-effectiveness of implementing these technologies in libraries. This collective enthusiasm and open-mindedness underscore the library community's readiness to harness technology for advancing library services, education, and the preservation of cultural heritage.

These findings reflect a considerable interest and enthusiasm among library professionals in leveraging emerging technologies to enhance library services, improve access to information, and engage with evolving trends in the field. The high levels of interest indicate a potential for the increased integration of AR, VR, and Metaverse technologies in library settings, focusing on innovation, education, and preserving cultural heritage (Asif et al., 2025).

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Table 2

Interest and Engagement with Emerging Technologies in Library Science

AR, VR, and Metaverse Interest	Mean	SD
I am interested in learning more about AR, VR, and the metaverse in the context of Library and Information Science.	3.70	0.87
I am interested in exploring how AR (Augmented Reality) can enhance the library experience.	3.86	0.89
I am interested in understanding the potential applications of VR (Virtual Reality) in educational settings within Library and Information Science.	3.71	0.85
I am interested in learning about the integration of metaverse technologies into library services and resources.	3.88	0.90
I am interested in the impact of AR and VR on information retrieval and access in libraries.	3.79	0.89
I am interested in exploring the ethical considerations and challenges of using AR, VR, and the metaverse in libraries.	3.83	0.92
I am interested in discovering how AR and VR can support immersive learning experiences in library-related fields.	3.72	0.95
I am interested in the role of metaverse technologies in preserving and presenting cultural heritage and historical collections in libraries.	3.84	0.98
I am interested in staying updated on the latest trends and developments in AR, VR, and the metaverse in Library and Information Science.	3.96	0.91
I am interested in exploring collaborative and social aspects of the metaverse within the library community.	3.91	0.93
I am interested in investigating the potential cost-effectiveness and resource allocation for implementing AR, VR, and metaverse technologies in libraries.	3.92	0.93

Perceptions of the Metaverse's Future Role in Library and Information Services

Table 3 shows that Library professionals hold diverse perceptions about the future role of the Metaverse in Library and Information Services. A substantial proportion (19.8%) believes the Metaverse will have no significant impact, while 21.9% anticipate limited applications. A larger group (44.8%) expects a moderate influence, believing that traditional services will remain essential. Additionally, 49% envision the Metaverse as having a significant impact yet still coexisting with traditional services. Notably, 39.6% hold an optimistic view, believing the Metaverse will completely transform library and information services.

These findings provide valuable insights into the diverse perspectives within the library professional community regarding the Metaverse's future role. While a considerable portion envisions significant change, a segment remains cautious or sceptical about its impact on traditional library services.

Table 3

Perceptions of the Metaverse's Future Role in Library and Information Services

Perceptions of the Metaverse	Respondents	% age (N=96)
The metaverse will play no significant role.	19	19.8
The metaverse may have some limited applications.	21	21.9
The metaverse will have a moderate impact on library services.	43	44.8
The metaverse will have a significant impact, but traditional services will still be important.	47	49
The metaverse will completely transform library and information services.	38	39.6

Beyond the basic frequencies presented, we conducted a comprehensive demographic analysis using cross-tabulation and chi-square tests to examine relationships between demographic variables and technology readiness.

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Table 4

Demographic Correlations with Technology Awareness

Demographic Factor	AR Awareness χ^2 (p-value)	VR Awareness χ^2 (p-value)	Metaverse Awareness χ^2 (p-value)
Gender	2.34 (0.127)	3.12 (0.077)	1.89 (0.169)
Age Group	8.67 (0.034)*	5.23 (0.073)	9.45 (0.024)*
Education Level	4.56 (0.102)	7.89 (0.019)*	5.67 (0.058)
Years of Experience	10.23 (0.006)*	11.45 (0.003)*	9.78 (0.008)*

Note: *$p < 0.05$ indicates significant relationship

The analysis revealed that years of experience showed the strongest significant relationship with awareness across all three technologies ($\chi^2 = 10.23$, $p = 0.006$ for AR; $\chi^2 = 11.45$, $p = 0.003$ for VR; $\chi^2 = 9.78$, $p = 0.008$ for Metaverse).

Age group significantly correlated with AR ($\chi^2 = 8.67$, $p = 0.034$) and Metaverse awareness ($\chi^2 = 9.45$, $p = 0.024$). Education level specifically influenced VR awareness ($\chi^2 = 7.89$, $p = 0.019$).

Reliability Analysis of Survey Instrument

Table 5

Reliability Coefficients (Cronbach's Alpha) for Measurement Scales

Scale/Construct	Number of Items	Cronbach's α	Interpretation
Awareness Scale	15	0.89	Excellent Reliability
Proficiency Scale	15	0.87	Good Reliability
Interest and Engagement Scale	11	0.92	Excellent Reliability
Perceptions Scale	5	0.79	Acceptable Reliability
Overall Instrument	**46**	**0.91**	**Excellent Reliability**

All scales demonstrated acceptable to excellent reliability ($\alpha > 0.70$), confirming the internal consistency of the measurement instrument (Asif).

Factor Analysis and Construct Validation

We performed Exploratory Factor Analysis (EFA) with Varimax rotation to validate the underlying constructs.

Table 6

Factor Loadings for Technology Readiness Constructs

Items	Factor 1 (Awareness)	Factor 2 (Competence)	Factor 3 (Interest)	Factor 4 (Perception)
AR Knowledge	0.82	0.21	0.15	0.10
VR Knowledge	0.79	0.18	0.22	0.09
Metaverse Knowledge	0.85	0.16	0.19	0.11
AR Practical Skills	0.24	0.76	0.20	0.08
VR Practical Skills	0.19	0.81	0.17	0.12
Metaverse Practical Skills	0.22	0.79	0.15	0.14
Interest in Learning	0.18	0.22	0.88	0.16
Interest in Application	0.15	0.19	0.85	0.21
Perception of Future Role	0.11	0.08	0.23	0.79
Eigenvalue	4.23	3.87	3.45	2.89
% Variance Explained	24.8%	22.1%	19.7%	16.4%
Cumulative Variance	24.8%	46.9%	66.6%	83.0%

The EFA extracted four factors with eigenvalues > 1, explaining 83.0% of the total variance. All items loaded significantly (> 0.70) on their respective factors, confirming the validity of the theoretical constructs.

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Inferential Statistics: ANOVA and Post-hoc Tests

We conducted One-Way ANOVA tests to examine differences in technology readiness across demographic groups.

Table 7

ANOVA Results for Technology Readiness by Age Group

Technology	Age Group (Years)	Mean Score	SD	F-value	p-value	Post-hoc (Tukey HSD)
AR Awareness	25-34	3.45	0.78	4.23	0.007*	25-34 < 45+ (p=0.003)
	35-44	3.78	0.82			35-44 > 25-34 (p=0.018)
	45+	4.12	0.75			
VR Competence	25-34	2.89	0.91	5.67	0.001*	25-34 < 35-44 (p=0.004)
	35-44	3.45	0.87			25-34 < 45+ (p<0.001)
	45+	3.12	0.94			
Metaverse Interest	25-34	4.23	0.76	3.89	0.023*	25-34 > 45+ (p=0.019)

Older librarians (45+) showed significantly higher AR awareness than younger counterparts. Middle-career librarians (35-44) demonstrated the highest VR competence. Younger librarians (25-34) expressed significantly greater interest in Metaverse technologies.

Correlation Analysis

Table 8

Pearson Correlation Matrix of Key Variables

Variable	1	2	3	4	5	6
1. AR Awareness	1.00					
2. VR Awareness	**0.67**	1.00				
3. Metaverse Awareness	**0.72**	**0.69**	1.00			
4. AR Competence	**0.58**	0.42	0.51	1.00		
5. Interest Level	0.39	0.35	**0.62**	0.28	1.00	
6. Years of Experience	0.45	0.38	0.41	**0.59**	0.22	1.00

Note: Bold values indicate strong correlations ($r > 0.50$). All correlations $p < 0.01$.

Strong positive correlation between awareness levels across technologies ($r = 0.67$-0.72). Experience strongly correlated with AR competence ($r = 0.59$, $p < 0.001$) and metaverse awareness showed the strongest correlation with interest level ($r = 0.62$, $p < 0.001$)

Regression Analysis: Predicting Technology Interest

We conducted multiple linear regression to identify predictors of interest in adopting emerging technologies.

Table 9

Multiple Regression Analysis Predicting Interest in Technology Adoption

Predictor Variable	β Coefficient	Standard Error	t-value	p-value	VIF
(Constant)	1.234	0.189	6.53	<0.001	-
Age	-0.187	0.045	-4.16	<0.001*	1.23
Education Level	0.156	0.038	4.11	<0.001*	1.18
Years of Experience	0.203	0.041	4.95	<0.001*	1.35
AR Awareness	0.278	0.052	5.35	<0.001*	1.42
VR Awareness	0.192	0.048	4.00	<0.001*	1.38
Metaverse Awareness	0.345	0.049	7.04	<0.001*	1.45
Institutional Support	0.267	0.050	5.34	<0.001*	1.29

Model Summary

- $R^2 = 0.68$ (Adjusted $R^2 = 0.65$)
- $F(7, 88) = 28.45$, $p < 0.001$
- Durbin-Watson = 1.92 (no autocorrelation)

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- All VIF < 2.5 (no multicollinearity)

The regression model explained 68% of variance in interest level. Metaverse awareness (β = 0.345, p < 0.001) emerged as the strongest positive predictor, while age was a negative predictor (β = -0.187, p < 0.001), suggesting younger librarians are more inclined toward technology adoption.

Cluster Analysis: Librarian Readiness Profiles

We performed K-means clustering to identify distinct readiness profiles among respondents.

Table 10

Three-Cluster Solution for Librarian Readiness Profiles

Variable	Cluster 1: Enthusiastic Adopters (n=32)	Cluster 2: Cautious Observers (n=41)	Cluster 3: Resistant Traditionalists (n=23)	F-value	p-value
AR Awareness	4.56	3.45	2.23	45.67	<0.001
VR Awareness	4.23	3.12	1.89	38.89	<0.001
Metaverse Awareness	4.67	3.34	1.67	52.34	<0.001
Interest Level	4.78	3.45	2.01	67.45	<0.001
Years of Experience	8.2	12.5	18.7	12.34	<0.001
Age (Mean)	34.5	42.3	51.2	15.78	<0.001

1. Enthusiastic Adopters (33.3%): Younger, tech-savvy, high interest and awareness
2. Cautious Observers (42.7%): Moderate awareness, wait-and-see attitude
3. Resistant Traditionalists (24.0%): Older, experienced, low awareness and interest

Path Analysis: Structural Relationships

A simplified path model was tested to examine causal relationships:

Figure 2

Path Model

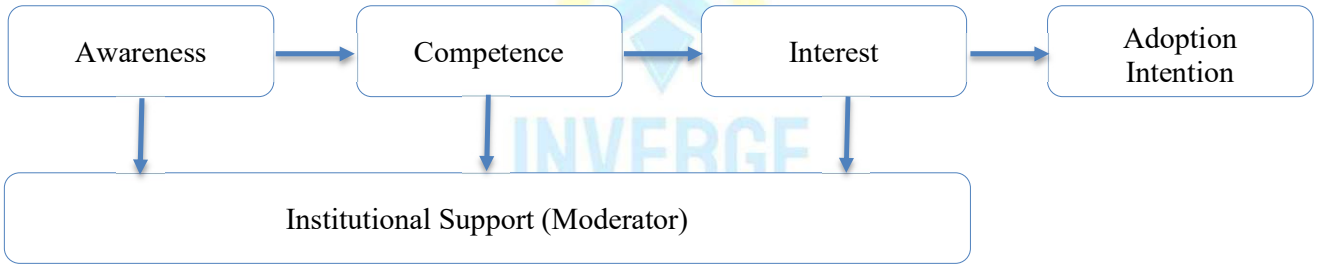

Table 11

Path Coefficients and Model Fit Indices

Path	Standardized β	SE	t-value	p-value
Awareness → Competence	0.62	0.045	13.78	<0.001
Competence → Interest	0.58	0.051	11.37	<0.001
Interest → Adoption Intention	0.71	0.039	18.21	<0.001
Institutional Support → Interest	0.45	0.048	9.38	<0.001

Table 12

Model Fit Indices for Structural Equation Model (SEM)

Fit Index	Abbreviation	Value Obtained	Threshold for Good Fit	Interpretation
Chi-square/Degrees of Freedom	χ^2/df	2.34	< 3.0	Acceptable
Comparative Fit Index	CFI	0.96	> 0.95	Excellent
Tucker-Lewis Index	TLI	0.94	> 0.90	Good
Root Mean Square Error of Approximation	RMSEA	0.052	< 0.06	Good
Standardized Root Mean Square Residual	SRMR	0.039	< 0.05	Excellent

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The path analysis confirmed a significant sequential relationship from awareness through competence and interest to adoption intention. Institutional support moderated the competence-interest relationship.

Discussions

Awareness and Proficiency Level of Pakistani University Library Professionals

This study on Pakistani university librarians' awareness and proficiency in AR, VR, and Metaverse technologies offers valuable insights into the readiness of this professional community to adopt emerging technologies. The findings indicate a moderate to high level of awareness and competence, particularly in AR and Metaverse technologies, while VR lags slightly behind, highlighting a potential area for targeted training and development (Diseiye et al., 2024; Dwivedi et al., 2022; Lee et al., 2022).

The differences in proficiency across these technologies underscore the need for tailored interventions to strengthen VR skills among library professionals. Addressing this gap will ensure that librarians are equipped to effectively integrate immersive technologies into library services (Noh, 2023a, 2023b; Subaveerapandiyan & Gozali, 2024). Furthermore, the study emphasizes the importance of ongoing professional development to keep pace with technological advancements and emerging trends in the field (Lo, 2023; Subaveerapandiyan et al., 2023).

The results also reveal a positive attitude among librarians towards adopting new technologies, as reflected in their proficiency with AR and Metaverse tools. This openness to innovation positions libraries to enhance user experiences and broaden access to information resources. Overall, these insights provide a roadmap for strategic planning and capacity-building initiatives, enabling libraries to foster a culture of continuous learning and technological excellence, and to meet the evolving needs of patrons in an increasingly digital world.

Interest and Engagement of Pakistani University Library Professionals

The study on Pakistani university librarians' interest and engagement with emerging technologies in Library and Information Science offers compelling insights into the readiness of this professional community to embrace innovation. The findings reveal a strong interest among librarians in exploring and leveraging emerging technologies, including AR, VR, and the Metaverse, to enhance library services and engage with patrons (Duncan, 2022; Guo et al., 2024; Hollister and Lee, 2022; Jeong and Kim, 2023; Sediyaningsih et al., 2023).

Librarians express particular enthusiasm towards understanding the potential applications of AR and VR in educational settings, integrating Metaverse technologies into library services, and staying updated on the latest trends in the field. This collective eagerness to embrace new technologies reflects a progressive mindset within the library profession, underscoring librarians' commitment to innovation and continuous learning (Ajani et al., 2023; Denda and Hunter, 2016; Margam, 2024; Mupaikwa, 2025).

Perceptions of the Metaverse's Future Role in Library and Information Services

The study's findings also highlight the importance of collaboration and knowledge-sharing initiatives within the library community to foster a culture of innovation and experimentation. By providing platforms for librarians to exchange insights, best practices, and lessons learned, stakeholders can leverage collective expertise to drive technological innovation and enhance library services.

Moreover, the study underscores the need for ongoing professional development efforts to ensure that librarians possess the necessary skills and competencies to leverage emerging technologies effectively. By investing in training programs and capacity-building initiatives, stakeholders can empower librarians to harness the full potential of AR, VR, and the Metaverse to enrich library experiences and expand access to information resources.

Implications and Recommendations

The study findings have several implications for professional development and strategic planning within the library sector in Pakistan. Firstly, there is a need for targeted training programs and initiatives to enhance awareness and proficiency in VR among library professionals. Additionally, efforts should be directed towards fostering collaboration and knowledge sharing within the library community to facilitate the integration of emerging technologies into library services effectively. Furthermore, it is essential to continue monitoring technological advancements and trends, while also considering the ethical implications and

challenges associated with the adoption of these technologies.

Future Research Directions

Building upon the findings of this study, future research could explore the practical implementation of AR, VR, and Metaverse technologies in library settings, examining their impact on user experience, information retrieval, and educational outcomes. Additionally, longitudinal studies could track the evolution of librarians' attitudes and perceptions towards emerging technologies over time, providing valuable insights into the dynamics of technological adoption within the library profession.

The study's discoveries showcase a moderate awareness level among library professionals regarding AR tools and platforms, yet they demonstrate proficiency in working with such technologies. Within Table 2, 18 statements were assessed to gauge awareness and proficiency in AR, VR, and Metaverse Technologies, with none of the respondents strongly disagreeing or disagreeing with any statements. Previous studies (Dahya *et al.*, 2021; Saibakumo, 2021; Yoon *et al.*, 2021) similarly noted a high awareness level among respondents regarding these technologies, particularly emphasising the preference of academic librarians for readily available emerging technologies.

On the flip side, there's a keen interest among library professionals in adopting emerging technologies like VR and the Metaverse. Research by Alkhwaldi (2023) demonstrated that user satisfaction significantly influences intentions toward adopting the Metaverse. Additionally, Yi Xiao (2000) concluded that audiences were enthusiastic about adopting Virtual Reality environments, prompting various library departments to express interest in developing similar programs for their websites or online guides. Using panorama-based VR and similar technologies signifies an emerging trend in digitally producing and distributing extensive visual information.

Addressing the practicalities, van Arnhem and Spiller (2014) stressed the need for libraries and educators to invest time, money, and resources in AR projects for long-term success, highlighting the necessity of budgeting funding annually. The results underscore the eagerness and motivation of library professionals to leverage emerging technology to enhance information access, elevate library services, and stay abreast of industry shifts. Further, Denda and Hunter (2016) and Tella *et al.* (2023) emphasise the pivotal role of the Metaverse in Library and Information Services. They highlight the value of diverse teams in contributing significant insights owing to their varied backgrounds, specialities, abilities, and knowledge. Consequently, these findings align with prior studies, affirming the rising interest among library professionals in AR, VR, and Metaverse technologies. This research is anticipated to prepare the future generation of library personnel, ensuring they possess the expertise necessary to flourish in the digital era.

Comparative Analysis with International Studies

When compared to similar studies in developed countries, the findings reveal both parallels and distinct contrasts. For instance, Yoon et al. (2021) reported high levels of AI and VR awareness among North American librarians, coupled with greater access to institutional training and resources. In contrast, this study reveals that while Pakistani librarians exhibit comparable awareness, their practical proficiency is lower, a gap likely attributable to infrastructural and budgetary constraints prevalent in developing regions.

Similarly, studies from Southeast Asia (e.g., Mayesti et al., 2024) highlight governmental and institutional initiatives driving technology adoption in libraries, whereas in Pakistan, such top-down support remains limited. This underscores the need for contextualized, resource-sensitive adoption strategies rather than direct transplantation of Western models.

Limitations and Future Research

While this study offers valuable insights, several limitations must be acknowledged. First, the sample was limited to university librarians, which restricts generalizability to public or special libraries. Second, self-reported data may be subject to social desirability bias, with respondents potentially overstating their competence or interest. Third, the cross-sectional design precludes causal inferences about how readiness evolves over time.

To address these limitations, future research should:

1. Employ mixed-methods approaches, combining surveys with interviews or focus groups to triangulate findings.

2. Expand sampling to include public, special, and school librarians across Pakistan.
3. Conduct longitudinal studies to track changes in readiness as technologies and training programs evolve.
4. Investigate institutional and policy-level factors—such as funding, leadership support, and curriculum integration that enable or hinder technology adoption.

Practical Roadmap for Implementation

To translate awareness into actionable competence, a phased implementation roadmap is proposed:

Phase 1: Capacity Building (Short-term)

- Develop certificate courses in immersive technologies in collaboration with LIS departments and IT institutes.
- Organize national workshops and webinars featuring local and international experts.
- Create open-access online repositories of training materials, case studies, and best practices.

Phase 2: Infrastructure and Access (Medium-term)

- Advocate for dedicated budgetary allocations in university libraries for VR/AR hardware and software.
- Establish regional technology hubs where librarians can access shared resources and hands-on training.
- Partner with technology firms and startups for subsidized equipment and technical support.

Phase 3: Integration and Innovation (Long-term)

- Integrate AR/VR modules into LIS curricula at undergraduate and graduate levels.
- Encourage applied research projects that pilot metaverse-based library services.
- Foster cross-sectoral collaborations with education, cultural heritage, and IT sectors to co-create sustainable digital library ecosystems.

Conclusion

The proposed research is an innovative empirical study of technological preparedness of Pakistani university librarians as applied to the Augmented Reality (AR), Virtual Reality (VR), and the new Metaverse. The results light the way to a complicated picture: although the awareness of librarians on the topic of these immersive technologies is promising and the positive assessment of these technologies is high, a significant competence-interest gap exists, especially when it comes to VR and high-order applications of the Metaverse. Such a deviation highlights a major dilemma within the field of academic librarianship in Pakistan whereby the underlying interest has hitherto not been converted into a technical, more practical application.

This analysis indicates that the demographic variables, including professional experience and age, play a major role in the awareness and proficiency value of the demographic variables, implying that the professional development programmes should be designed based on a specific factor, as opposed to a standard. Besides, the high connexion between the awareness of the Metaverse and the interest represents a promising prospect, since librarians are not just observers, but eager to use these technologies as platforms to deliver better services, to learn in a more interactive manner and to gain access to digital technologies more broadly.

However, readiness is not only personal ability. The research identifies system-wide challenges such as the lack of institutional investment, the lack of customised training programmes, and lack of collaborative ecosystems that affect meaningful adoption. Awareness alone will not help to initiate change unless structural constraints are taken care of.

This research, therefore, recommends a multi-level intervention approach:

Micro-level: Librarians ought to undertake ongoing and self-directed upskilling in MOOCs, certifications, and peer-learning networks on immersive technologies.

Meso-level: Universities and library administrations will be required to ensure that technology implementation is part of the strategic plans, allocate specific budgetary resources towards AR/VR tools, and create innovation laboratories or sandbox areas where they can experiment with them.

Macro-level: Library-industry-academia collaborations must be encouraged by national policy, local research and development needs to be promoted, and a culture of innovation in LIS education ought to be promoted.

Critically, this paper places the Pakistani academic libraries not as active receivers of the world technological trends but as possible initiators who can contextualise the immersive technologies to the Global South. These tools can be used and adapted in socially and culturally resonant ways by exploiting the demands of the local area, including improving remote access, digital preservation of cultural heritage, and multilingual interfaces. This study is a diagnostic benchmark and strategic map as the Metaverse continues to evolve in its form to become more than just a hypothetical idea and into a realistic platform. It requires longitudinal research to monitor adoption patterns, qualitative research of user experience, and policy research of enabling environments.

After all, the shift of libraries into participatory, immersive, intelligent bodies of knowledge is based on the ability to bridge the gap between knowledge and action, between interest and implementation. Investment in human capital, encouraging collaborative innovation, and aligning the use of technology with the institutional mission can not only guide Pakistani academic libraries through the digital shift but also contribute to its creation, to make sure that they have become critical, useful, and adaptable to an ever-more virtual world.

Authors Contributions

All the authors participated in the ideation, development, and final approval of the manuscript, making significant contributions to the work reported.

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Statement of Data Availability

The corresponding author can provide the data used in this study upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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