

Digital Preservation Training Needs in Cultural Heritage Institutions: a Systematic Review and Conceptual Framework

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Abstract

Digital preservation may enable long term access, recurring value, use, and reuse of cultural heritage digitized and digital born resources. Amongst other factors, the success and sustainability of digital preservation practices hinge on how cultural heritage institutions address practitioners' training needs, particularly in countries like Saudi Arabia where digital preservation is a relatively new area. Addressing these needs requires relevant formal and informal training, policies and collaboration with appropriate stakeholders. Increasingly more advanced approaches have been implemented to support digital preservation efforts for heterogeneous and complex cultural heritage resources. Extant studies provide insights into digital preservation training needs at international and national level. However, findings from previous work highlighted inconsistencies, challenges, and knowledge gaps attributable to the use of different methodologies, adoption of different terminologies, and examining digital preservation in varied contexts and maturity levels. This systematic review explores the current state of digital preservation training for librarians and archivists, both internationally and in Saudi Arabia, reviewing 117 studies to identify knowledge gaps and help develop a conceptual framework for improving practitioners' skills in digital preservation.

Keywords— Digital preservation, cultural heritage institutions, preservation specialists, training, skill, policies, collaboration, advanced technologies.

I. INTRODUCTION

Digital preservation is about “maintaining the semantic meaning of the digital object and its content, about maintaining its provenance and authenticity, about retaining its ‘interrelatedness’, and about securing information about the context of its creation and use” [1]. Cultural heritage institutions worldwide are making efforts to build sustainable digital preservation practices[2]. However, success in such practices is subject to how cultural heritage institutions adapt to specialists' training needs. Addressing preservation specialists' needs necessitates a strategic approach that factors in diverse approaches towards skill enhancement, enabling policy frameworks and collaboration among others. Moreover, advanced technologies such as artificial intelligence and machine learning have become inevitable tools in digital preservation practices, reducing manual labour while enhancing

efficiency. This paper critically reviews digital preservation training needs in the international community as well as in Saudi Arabia, a nation in its early stage in digital preservation activities. Such detailed analysis provides informative content towards the development of a strategic framework for the resolution of preservationists' training needs and creating sustainable digital preservation practice in the future.

II. METHODOLOGY

This systematic review explores the current state of training programs in digital preservation for librarians and archivists internationally and in Saudi Arabia, analysing 117 articles to identify knowledge gaps and develop a conceptual framework for enhancing practitioners' skills and competencies to support digital preservation practices. The study adopts a Systematic Review (SR) integrated with Grounded Theory (GT) ‘to generate, identify, and trace a phenomenon’s major concepts, which together constitute its theoretical framework [3] This methodology includes the following conceptual framework building stages: a) mapping selected data sources; b) reviewing the literature and categorizing the selected data; c) identifying and naming the concepts; d) deconstructing and categorizing the concepts; e) integrating the concepts; f) synthesis, resynthesis, and making it all make sense; g) validating the conceptual framework; and h) rethinking the conceptual framework [3]

To ensure transparency and replicability, the study adopts the PRISMA framework (Figure 1)[4] providing a structured, evidence-based roadmap for data collection and article selection, thereby reducing bias and enhancing research integrity [5][6].

A. Identifying Relevant Studies

1. Databases

A cross-disciplinary search involved scholarly databases representing a relevant source for digital preservation research: IEEE Xplore, Elsevier, ERIC, Web of Science, Scopus, and JSTOR ProQuest. These databases enabled the retrieval of interdisciplinary studies covering skills and competences, technologies, education and training, policy and strategy, as well as security and risk management. This enriched the review with diverse perspectives on training needs in digital preservation.

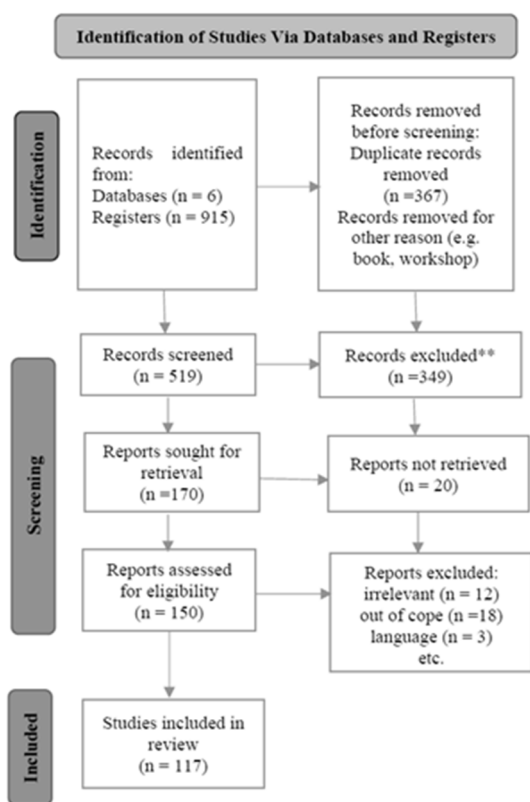


Figure 1: PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart.

2. Search Strategy

The next step was keyword search within the selected database to identify relevant papers. Literature employs various terms inconsistently to describe digital preservation training, reflecting the interdisciplinary nature of the field. To ensure comprehensive coverage the search terms were derived from similar studies that examined training needs in digital preservation. Five main concepts were identified for this study. The search query was structured around key themes outlined in Table 1 below.

Concepts	Terms
Skills development	["soft skills" OR "technical skills" OR "metadata standards" OR "storage techniques" OR "file format" OR "AI" OR "ML" OR "software skills" OR "hardware" OR "technologies skills"]
Training	["educational technology" OR "training resources" OR "training platforms" OR "simulation" OR "VR" OR "3D" OR "pedagogy" OR "learning styles" OR "MOOCs" OR "community of practice" OR "knowledge sharing" OR "formal learning" OR "informal learning"]
Collaboration	["collaboration" AND "information resource" OR "information system" OR "knowledge sharing"]
Policies	["regulations" OR "national vision" OR "Vision 2030" OR "digital preservation policies" OR "legislation" OR "collaboration" OR "risk management" OR "security"]

Technology	["AI" OR "ML" OR "software tools" OR "hardware" OR "digital preservation technologies" OR "metadata" OR "file format" OR "digital storage"]
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Table 1: General search queries for the review, excluding truncation, wildcards, and other database-specific rules.

B. Study Selection

The aim of this step was to establish and evaluate inclusion and exclusion criteria as shown in Table 2 below. In systematic review methods, inclusion and exclusion criteria based on a specific research question are developed to ensure consistency in decision-making which would be used to systematically select and reject articles for review. The development process began with a collection of criteria that aligned with the target article type: training needs for digital preservation. While the initial list of criteria was considered preliminary and open to refinement as the review progressed, no further changes were made to the criteria once established. The most important criteria relate to the articles' research topic and scope.

Inclusion Criteria	<ol style="list-style-type: none"> 1. Research examining digital preservation training needs in cultural heritage institutions. 2. Studies involving training programs, methods, and technologies used to enhance digital preservation practices. 3. Original research published in peer-reviewed journals and full-length conference papers. 4. Research papers addressing raising awareness, improving knowledge, enhancing skills, and promoting knowledge sharing. 5. Studies published since 2000.
Exclusion Criteria	<ol style="list-style-type: none"> 1. Papers not specifically investigating digital preservation training or capacity building. 2. Articles that focus solely on technology without discussing the training aspects needed for implementation. 3. Dissertations, review articles, conference abstracts. 4. Publications not in the English language

Table 2. List of Inclusion Criteria/Exclusion Criteria

III. ANALYSIS AND DISCUSSION OF FINDINGS

Key interrelated dimensions explored in the systematic review suggest how each component contributes to the overall competency development of digital preservation specialists (Table 3). At the core are training methods, acting as a conduit between skills (technical/soft) and the enablers - collaborations, policies, and technologies. Policy frameworks and collaborative models function as both inputs and feedback loops, informing how training evolves and what competencies are prioritized. Advanced technologies sit on the outer edge, driving change across all other dimensions.

In line with [3] concepts were then identified, categorised, integrated, analysed, and internally validated into a Digital Preservation Training Needs Conceptual Framework (Figure 2). This framework illustrates the dynamic interrelationships between six core elements—Training Methods, Technical Skills, Soft Skills, Collaborations, Policy Frameworks, and Advanced Technologies—and how knowledge gaps guide their integration. Within this ecosystem, identified knowledge gaps serve as the catalyst for a continuous loop of improvement,

adaptation, and sustainable digital preservation outcomes. Formal and informal training methods develop technical and soft skills, while being shaped by collaborative models, policy frameworks, and the pressures of advanced technologies.

The following sections reflect the result of the conceptual framework building process.

Dimension	Subcomponents	Interrelationships
Training Methods	Formal (degrees, certifications, workshops); Informal (CoPs, self-learning, peer support)	Vehicles for delivering both technical and soft skills; effectiveness shaped by institutional policy frameworks.
Technical Skills	Metadata management; AI literacy; Digital asset handling; Software & hardware expertise	Foundation for applying advanced technologies; defined by formal training and influenced by policy priorities.
Soft Skills	Communication; Collaboration; Cultural competence; Negotiation	Essential for collaborative models; required to advocate for resources and cross-cultural knowledge exchange.
Collaborations	Institutional partnerships; National/international networks; Communities of Practice (CoPs)	Enable informal learning; optimize resources and facilitate policy harmonization and skills transfer.
Policy Frameworks	National standards- Institutional strategies- Risk management- Compliance (e.g., ISO 16363)	Establish mandates for skills development and training; shape curriculum and assessment criteria.
Advanced Technologies	AI; Digitization robotics; Data analytics; Smart storage systems	Drive new training needs; require technical upskilling and adaptive formal curricula supported by policy mandates.

Table 3. Competency development of digital preservation specialists identified in the review.

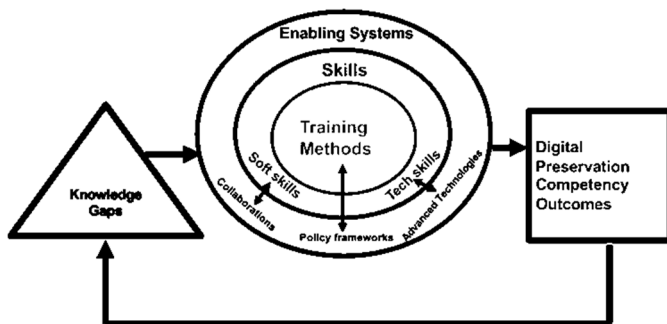


Figure 2: Digital Preservation Training Needs Conceptual Framework

A. Training Methods

Digital preservation training encompasses different methodologies that entail both formal and informal learning

formats. Formal training is typically offered through systematic education programs, certification programs, and well-structured workshops, while informal training is achieved through communities of practice, learning from colleagues, and self-learning[7][8]. Both approaches have been prevalent in the field of digital preservation, offering complementary benefits for organisations and practitioners. Education and training programs constitute the backbone of effective digital preservation practice. Digital preservation training as discussed by [9] equips archivists, librarians, and information technology professionals with the essential skills enhancing their individual performance as well as organizational productivity. In Saudi Arabia, formal training has been employed to enhance preservation specialists’ skills as cultural heritage institutions like King Salman bin Abdul Aziz Centre for Historical Materials has partnered with institutions like the US Library of Congress and Naif Arab University for Security Sciences to provide training programs on digital preservation [10]. Moreover, informal learning has emerged as a valuable complement to formal education.[11] argues that Communities of Practice (CoP) facilitate peer-to-peer learning and experiential knowledge sharing. CoPs in Australia and New Zealand have played a key role in uniting governmental agencies, libraries, and cultural institutions in addressing preservation concerns. However, cultural heritage institutions are confronted with the issues of inadequate training programs, lack of standardization and failing to stay at par with the evolving digital preservation training needs. These issues necessitate a systematic approach to address training needs, explored by the DigCurV project (<http://schreibman.eu/digcurv/>). DigCurV project represents a significant European initiative that links formal and informal training approaches by its systematic vocational curriculum for digital curators working in libraries, archives, and museums [12]. This model demonstrates how standardized training practices can be adapted to different cultural environments with the same professional outcomes, addressing the need for both formal education and hands-on experience in digital preservation.

B. Skills

Skills are key success drivers in career contexts, which are acquired abilities employed for specific tasks. Both technical and soft competencies play significant roles in digital preservation, providing a balance of specialized know-how and interpersonal skills needed to succeed with preservation plans [13]. Computer literacy, indexing, classification, cataloguing, scanning, manuscript restoration and metadata among others are key essential skills which preservation specialist should possess. For instance, computer literacy is a crucial skill that enables preservation specialists to use technological tools required for digital asset management [14]. As digital preservation entails information structures, metadata management is a vital competency which enables future usability and interoperability of preserved information. [15] noted that metadata management offers indispensable contextual information aiding long-term preservation planning.

Practitioners may benefit from Artificial Intelligence (AI) competencies as these technologies could help to carry out digital preservation [16], and the future of AI for cultural heritage organizations has a high potential[17]. However,

integration of AI in digital preservation practices necessitates preservation specialists to have prior knowledge of data analysis, programming like Python or R, and domain-specific expertise to comprehend artificial intelligence algorithms [18]. Institutional readiness is also a crucial component for AI adoption because organizational preparedness, systematic competencies mapping, and established development opportunities are where professionals acquire adaptability to new technologies as essential factors that supplement manual output while increasing efficiency of preservation [19].

Beyond technical skills and competencies, the preservation environment is characterized by collaboration endeavours and interactions of different stakeholders, which means that soft skills are equally crucial. Soft skills encompass interpersonal skills, linguistic competencies and teamwork among others [20]. Persuasive communication according to [21], is a key digital preservation skill through which professionals are enabled to negotiate well for resources and partner with other parties. On top of that, in today's globalized world defined by cultural diversity and collaboration of preservation stakeholders in different endeavours, cultural competency is a vital skill which preservation specialists should possess. [20] recognized cultural capabilities as necessary skills in knowledge transfer and participation in global preservation programs. However, a number of cultural heritage institutions suffer from skill shortages, a critical issue primarily attributable to ineffective training programs, resource constraints, and lack standardization of preservation practices [22]. The issue of skill deficiency facing cultural heritage institutions in the global scale is also evident in Saudi Arabia, where preservation specialists lack essential technical and soft skills [14][15][21][30]. Addressing these skill gaps calls for a well-structured assessment methodology like the Digital Preservation Competency Framework advocated by [23] This framework provides a formal structure of five broad competency areas and twenty-eight elements of skills that digital preservation specialists need to develop proficiency for effective digital preservation practice. The provision of a rapid assessment model within the framework enables institutions to benchmark themselves against their digital preservation capability and identify specific skills gaps within staff. By employing this framework, cultural heritage institutions internationally and in Saudi Arabia may evaluate and enhance technical and soft skills required for their digital preservation endeavours.

C. Collaboration

Collaborating is a vital aspect of digital preservation, involving multiple actors within and outside an organization, joining forces and expertise to address preservation challenges. Collaboration in digital preservation may occur through events (e.g. seminars, workshops, conferences), formal and informal networks and projects which enable knowledge flow and skill uptake by preservation specialists. Collaboration enhances sharing of resources and knowledge, standards creation, and overall sustainability of digital preservation programs [24]. The Digital Preservation Coalition (DPC) was established in 2002 in the UK as a digital preservation community, providing a platform for meaningful and sustained professional exchange both nationally and internationally. The UK DCC was created as a consortium in 2004 and jointly funded by JISC and the UK

E-Science programme. The European Commission has funded several key collaborative digital preservation research projects since the early 2000, including but not limited to Electronic Resource Preservation and Access Network of Excellence (ERPANET), Digital Preservation Europe (DPE), Preservation and Long-term Access through Networked Services (Planets), and Living Web Archives (Liwa). A study conducted by [25] on three specialist libraries of Germany showed how knowledge is made more accessible by collaboration amongst preservation practitioners. Joint initiatives have been conducted in Saudi Arabia with collaboration amongst the national institution DARAH and the US Library of Congress, creating knowledge exchange channels for preservation specialist [10]. Collaborative programs address the needs of specialists by sharing resources and solving problems as a group so that institutions can overcome technical and financial limitations [24]. The Chinese National Digital Preservation Program[26] illustrates how government-library community collaboration may preserve digital scholarly materials through certified archiving networks and contractual participation.

D. Policy Frameworks

Supportive and facilitating policies provide a foundation for digital preservation skill development, establishing structured approaches to professional competency building. Strategic policies addressing resource planning, training needs assessment, competency standards, and institutional collaborations ensure that preservation professionals are equipped with relevant skills while institutions attain viable preservation capabilities [27]. As noted, comprehensive policies like the ones used in the Library of Congress enable the staff to act appropriately at all stages in the preservation process, from acquisition to long-term storage. Policies play a key role in minimizing risks associated with digital preservation practices. According to [28] the presence of policies helps organizations minimize the risk of loss or corruption of content and ensure compliance with international standards. Policy frameworks directly affect training methods in that they dictate competencies that are required and offer channels for continuous professional development. The National Diet Library of Japan is an example of this approach: its extensive training programs are founded upon national priorities that promote skills development in the application of modern preservation methods [29]. However, many cultural heritage institutions globally still lack clear and well-structured digital preservation policies, which hinders the development of standardized training programs. Specifically, in Saudi Arabia where digital preservation is at its early stage, key policies are yet to be developed. Hence, as recommended by [30], establishing key digital preservation policies will make cultural heritage institutions in Saudi Arabia improve their preservation practices and become compliant with global standards like ISO 16363 for digital repositories.

E. Advanced Technologies

AI and its applications may change the course of digital preservation [16], although AI literacy, ethics, and other aspects require attention. Cultural heritage institutions globally are gradually embracing these technologies to supplement core functions such as metadata generation, content analysis, information extraction, detection and correction of errors, and

independent classification and recognition of digital artefacts [31][32]. AI has been applied in Belgium to enhance searchability of digitised collections of historical newspapers by reducing labour intensive annotation and enhancing better corpora creation for cultural heritage study [33]. [34],[35] studied the application of smart record archive robots in Chinese cultural institutions for navigation, recording, and record checking, creating a sustainable operational model by collective means like robotic arms and infrared heat imaging devices. [36] showed that machine learning model applied to book classification by using UDC numbers registered more than 90% accuracy evaluating a corpus of 200,000 units, demonstrating the capability of machine learning to make historic text more accessible even amidst linguistic challenges of ancient times. Despite the strong potential of advanced technologies in revolutionizing digital preservation practices, cultural heritage institutions in Saudi Arabia lag behind global standards as they are yet to adopt such technologies- an issue largely attributable to limited awareness and lack of professional expertise [14][15][21][30]. However, as noted by [37], AI adoption has begun among neighbouring United Arab Emirates libraries. This suggests a gradual diffusion within the Arab world, which may revolutionize preservation practice in cultural heritage institutions in the Gulf region. As advocated by [38], cultural heritage institutions need well-structured training programs tailored on utilisation of such advanced technologies in digital preservation.

F. Knowledge Gaps and Directions for Future Studies

Previous studies on digital preservation on a global scale and in Saudi Arabia have shown great progress in providing a better comprehension of training needs, and useful insights on essential skills, skill enhancement, the role of policy frameworks in preservation practices, and the importance of advanced technologies in digital preservation. However, key knowledge gaps still exist.

Knowledge Gaps	Directions for Future Studies
1. Limited understanding of how technical and soft skills synergistically function in real-world digital preservation environments.	Conduct longitudinal case studies examining skill integration patterns across diverse preservation projects, to develop competency frameworks that optimize technical and soft skill synergies.
2. Insufficient evidence on how formal training programs maintain relevance and effectiveness within rapidly evolving technological landscapes.	Develop adaptive assessment frameworks that continuously evaluate training program responsiveness to emerging preservation methodologies and technologies.
3. Lack of robust mechanisms to measure and authenticate competencies acquired through communities of	Design blockchain-based credentialing systems that capture and verify skills development through peer-

practice and informal learning networks.	to-peer learning and practice-based experiences.
4. Need of a fine-grained understanding of optimal collaborative frameworks tailored to diverse cultural and institutional contexts.	Investigate cross-cultural collaboration frameworks through comparative studies across different cultural contexts to identify universally effective partnership models.
5. Limited research on contextual and sustainable implementation of advanced AI preservation technologies beyond controlled experimental environments.	Implement and assess the sustainability of large-scale field studies that evaluate advanced AI preservation technologies within real-life institutional workflows.
6. Insufficient guidance for implementing training-specific policies within broader preservation frameworks.	Develop policy implementation toolkits that provide step-by-step guidance for integrating training requirements into institutional preservation governance structures.

Table 4: Knowledge Gaps and Directions for Future Studies

G. New Perspectives

Our findings provide an alternate perspective to digital preservation training needs, by noting the complementary nature of the formal and informal learning approaches rather than perceiving them as competitive methodologies. This integrated strategy illustrates how education curricula may complement experiential learning, suggesting that competency development in preservation happens along a continuum of activities and not as discrete interventions. Moreover, soft skills have been identified as core competencies upon which technical expertise can be effectively deployed, challenging traditional perspectives that prioritize technical knowledge. Such perspective offers fresh insights into how institutions can strategically utilize collaboration, which entails not only technical transfer of knowledge but also the cultural translation of preservation and organizational processes across institutional stakeholders.

IV. Conclusion

To safeguard long term preservation of cultural heritage, training needs of preservation specialists must be adequately addressed. The success and sustainability of digital preservation efforts calls for cultural heritage institutions to enhance preservation specialists' technical and soft skills, as preservation endeavours demand both specialized know-how and interpersonal competencies. Developing relevant digital preservation policies is necessary to support skill acquisition, and collaboration is an empowering support pillar that enhances skill development through the sharing of knowledge within and beyond institutional boundaries. Through effective training programs, enabling policies, and collaborative approaches, cultural heritage institutions will have more means to preserve their assets and ensure that "we pass our information heritage to future generations in viable form" [1].

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