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The development of E-Archives Learning 2.0: An innovative instructional medium for vocational high school students

Agung Kuswantoro[1]
Muhamad Nukha Murtadlo[2]
Arif Wahyu Wirawan[3]


(✉ Corresponding Author)

[1,2,3]*Semarang State University, Indonesia.*
[1]*Email: agungbinmadik@mail.unnes.ac.id*
[2]*Email: nukhamurtadlo@mail.unnes.ac.id*
[3]*Email: arifwahyu@mail.unnes.ac.id*

Abstract

This study aims to develop and evaluate the effectiveness of E-Archives Learning 2.0 as an integrated, intuitive, and adaptable instructional medium for digital archiving. Using a Research and Development (R&D) design, the study was conducted through stages of needs analysis, prototype development, expert validation, and multi-stage field trials. A mixed-methods approach was applied, combining qualitative data from interviews and focus groups with quantitative data from surveys and assessments. Results show a significant improvement in participants' proficiency, with mean scores increasing from 86 to 94 ($p < 0.05$) and a large effect size (Cohen's $d = 1.39$). The learning media achieved a success index of 95%, with digital archiving comprehension at 81.97%, user competency at 82.87%, and technology use effectiveness at 87.75%. Challenges include technological infrastructure (77.10%) and the need for advanced technical training (70.11%). Overall, findings indicate E-Archives Learning 2.0 effectively enhances digital archiving competencies and has potential as a sustainable platform-based learning model, supported by infrastructure improvements and systematic human resource development. The study contributes empirical evidence on developing and evaluating an integrated digital archiving learning system, linking media effectiveness, user competency, infrastructure readiness, and training needs within vocational education, extending research by connecting instructional design outcomes with institutional capacity.

Keywords: Digital archive, E-Archives learning 2.0, Learning media, Vocational.

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Contents

Contribution of this paper to the literature
This study develops E-Archives Learning 2.0 as a vocational-context instructional medium that integrates interactive digital archiving practice with structured learning activities, offering a more applied alternative to conventional archive instruction that is often theoretical, static, and less aligned with students' workplace-oriented competencies.

1. Introduction

The rapid development of information technology has significantly influenced technological progress across various fields (Darusman, 2022). The Industrial Revolution 4.0 has ushered the world into a new phase in which activities are interconnected through algorithmic language embedded in digital machines (Permana, Wibawa, & Nabila, 2021). These developments have triggered fundamental changes, reflected in a shift in the role of humans from direct dominance to greater reliance on the digital environment, accelerated technological advancement, and the emergence of the Internet of Things (IoT) as a key driving factor (Prawiyogi & Anwar, 2023).

Education constitutes the primary foundation for building civilization and producing an intelligent, competitive, and morally grounded generation. In the contemporary digital era, the education sector is experiencing substantial transformation. Digitalization presents not only challenges but also considerable opportunities, requiring adaptation in learning methods, the competencies being developed, and the roles assumed by teachers and students. As a result, education in the digital era assumes an increasingly critical role in preparing younger generations to navigate a world that is progressively interconnected and driven by technology (Jayanti, Setyowibowo, & Widarti, 2023).

As digital developments continue to permeate various aspects of life, the education sector is required to keep pace with these changes. The application of technology enables the development of enhanced capabilities within educational processes. Within this context, information technology functions not merely as a means of accessing learning materials but also as a catalyst for the development of more advanced learning strategies, including those related to archival management and archival learning. In archival management, the urgency of transformation is evident in the shift from manual practices to more systematic management approaches (Hayat, Sanusi, & Khuzaini, 2021). This urgency arises from the fact that most documents are now produced in digital form, necessitating digital storage systems. Accordingly, when archival management is implemented digitally, archival education and training must also be introduced and conducted through digital means (Sholahuddin, 2021). To date, a gap persists between institutions formally engaged in archival management and community organizations that also conduct archival activities. This gap largely arises from differences in the archival management methods applied by each organization. In principle, archival management practices are similar; however, the main distinction lies in the use of information technology systems, as many organizations continue to manage archives manually (Faridah, 2020). Archival institutions that routinely handle archival processes generally employ technology-based management systems. By contrast, many other institutions and community organizations, including educational institutions, still rely on manual archival practices. Vocational high schools specializing in Office Management and Business Services are expected to produce graduates capable of managing archives effectively and professionally (Siregar, 2022).

Archives are defined as records of activities or sources of information in various forms created by institutions, organizations, or individuals in the course of their activities (Juniati & Nurdiansyah, 2023). These records may take the form of letters, documents, deeds, charters, books, and other materials that function as valid evidence of specific actions or decisions. Alongside technological advancement, archives may also exist in digital, video, or audio formats (Ningsih, 2023). Given the continuously increasing volume of archives and the intensity of their creation and receipt, effective archive management, commonly referred to as an archiving system is essential to ensure proper organization and use (Budi & Priska Lestari, 2022). According to the Law of the Republic of Indonesia Number 43 of 2009 concerning Archives, archival management is required to ensure the availability of authentic and reliable archives, safeguard state interests and citizens' civil rights, and streamline the national archival system. Such management must be implemented in accordance with established principles, rules, and standards to support a reliable national archival framework. In response to the challenges of globalization, the realization of good and clean governance, and the improvement of public service quality, archival management across state institutions, regional governments, educational institutions, companies, political organizations, community organizations, and individuals must be integrated within a comprehensive national archival management system. Based on this explanation, archival management must be able to respond to the challenges and developments of digitalization, which increasingly emphasize effectiveness and efficiency. Accordingly, archival governance within organizations needs to be continuously evaluated and further developed into a digitally systematized management framework to achieve these objectives. Preliminary empirical data supporting this condition are presented in Table 1.

Table 1. Conditions of archival learning at vocational high schools offering office management and business services program.

No.	Aspects	Manual	System	Obstacles
1	Introduction of archival learning	90%	10%	Limited resources
2	Practical archival learning	90%	10%	Limited resources
3	Archival management in work units	80%	20%	Limited to compliance with government regulations, while the remainder of archival processes remain manual.
4	Archival management personnel capability	70%	30%	System utilization generally limited to younger personnel.

Source: Processed data (2025).

Based on the conditions presented in Table 1, the mapping of 13 vocational high schools offering Office Management and Business Services programs in Semarang City indicates that most learning and archival processes in these institutions are still conducted manually. Although these schools recognize the importance of digitalizing archival management, the primary constraint remains the limited availability of facilities and supporting infrastructure. Additionally, the operation of digital archiving systems is generally more feasible for relatively younger personnel, given its close association with computer-related competencies.

Electronic archive refers to computer-based archive storage systems. When developed using internet-based technologies, such systems can be operated online, making them particularly suitable for large organizations. The fundamental principle underlying computer- and internet-based electronic archiving systems positions computers as the foundation of internet-based filing. Consequently, prior to designing an internet-based filing system, a thorough understanding of computer-based filing systems is essential. Conceptually, archivists are also required to be familiar with conventional filing system theory when designing an electronic archiving system. An electronic filing system consists of three main components: virtual cabinets, virtual folders, and archive sheets in the form of digital files (Permadani & Waluyo, 2021). Sugiarto and Wahyono (2005) explain that the distinction between conventional and electronic filing lies in the form of the cabinets, folders, and archives used. In conventional filing, cabinets take the form of physical shelves or filing cabinets, whereas in electronic filing, they are realized as databases. Similarly, folders in conventional archiving are physical folders used to store archive sheets, while in electronic archiving, they take the form of digital folders designed to store documents. Archives in conventional systems typically consist of letters or printed documents; by contrast, in electronic archiving systems, these materials are converted into digital files, images, or text formats. Based on the results of research observations, several key problems were identified, including the absence of a digital platform–based archival learning model, the need for archival learning media that are affordable, user-friendly, and flexible, and the increasing demand among educators and students for digital platform–based archival learning media (Jaya, 2020).

The planning stage of this research involved synthesizing the existing factual model of E-Archives Learning, an application currently used for learning and implementing E-Archives, developing a hypothetical model for a digital archival learning platform, and testing the feasibility and effectiveness of the proposed platform model.

The development of information technology in the modern era has profoundly influenced nearly all aspects of life, such that very few daily activities are carried out without technological support (Ambarwati & Adianti, 2022). In line with this rapid advancement, archival management within institutions must likewise be directed toward digital systems. This transformation is intended to enhance the effectiveness and efficiency of archival management processes. Accordingly, the development of archival learning media becomes essential, particularly for activities such as creating and managing e-mail, recording incoming and outgoing correspondence, storing archives based on classification or storage codes, managing archive loans and returns, and compiling statistics on incoming and outgoing mail (Bawono, 2022). Through the literature review, it was found that similar studies conducted across various research settings have generally focused on measuring the effectiveness of digital systems in archival management. With reference to the primary focus of this study, namely, the development of a digital archival learning platform the next critical issue to be examined concerns how such a platform model can be effectively implemented. This approach is expected to promote greater coherence among existing studies, particularly in generating sustainable solutions to current challenges in the implementation of archival learning media models.

Several streams of previous research are summarized in the following table. Through this mapping, this study seeks to position the current research within the broader development of digital archival science. The table also functions as a basis for identifying research gaps that have not been extensively explored in earlier studies.

Table 2. Past research.

No.	Year	Title	Researchers	Findings
1	2019	*Digital Data Archives as Knowledge Infrastructures: Mediating Data Sharing and Reuse*	Borgman, Scharnhorst, and Golshan (2019)	Borgman et al. (2019) demonstrated that the success of digital repositories depends not only on technological infrastructure but also on governance structures, access policies, and normative practices within the academic community. This view broadens the understanding of archiving beyond data storage by framing digital archives as complex socio-technical systems.
2	2020	*Digital Sources and Digital Archives: Historical Evidence in the Digital Age.*	Owens and Padilla (2021)	Owens and Padilla (2021) revisited the concept of historical evidence in the context of digital archives, which are inherently vulnerable to manipulation and format degradation. They emphasized the importance of digital provenance, understood as authentic digital traces, as the foundation of scientific validity in historical research relying on digital data. Their work provides a conceptual basis for developing standards to ensure the authenticity and reliability of electronic archives.
3	2022	*How Can We Make Born-Digital and Digitised Archives More Accessible? Identifying Obstacles and Solutions.*	Jaillant (2022)	Jaillant (2022) identified key barriers to digital archive accessibility, including metadata heterogeneity, copyright restrictions, and limited user technical competence. Drawing on a survey of archives and digital libraries in Europe, the study recommends strengthening cross-institutional collaboration and adopting open metadata standards. These findings are particularly relevant to archival management approaches emphasizing openness and long-term preservation.
4	2024	*Are Users of Digital Archives Ready for the AI Era? Obstacles to the Application of Computational Research Methods and New Opportunities.*	Jaillant and Aske (2024)	Jaillant and Aske (2024) highlighted challenges associated with integrating artificial intelligence (AI) into digital archives, particularly regarding user digital literacy and institutional readiness. Their research revealed a gap between AI's technological potential and the practical capacity of archive users, underscoring the need to develop AI-related competencies and design archival interfaces that support ethical and collaborative data exploration.
5	2024	*Reassembling Digital Archives—Strategies for Counter-Archiving.*	Blanke (2024)	Blanke (2024) argued that digital archives function not only as new modes of storage but also as arenas of power that shape collective memory. He introduced the concept of *counter-archiving* as a strategy to dismantle historical bias by reorganizing digital archives to better include marginalized narratives. This perspective underscores the need for critical examination of algorithms and data representation in managing digitized archives.

Source: Processed data (2025).

Based on Table 2, the development of digital archives over the past decade reflects a paradigm shift from the mere storage of electronic documents toward the reconceptualization of archives as knowledge infrastructure. Borgman et al. (2019) emphasize that digital archives function as socio-technical systems that mediate the sharing and reuse of scientific data, with governance and access policies positioned as key determinants of repository sustainability. Owens and Padilla (2021) further highlight the importance of maintaining digital provenance, understood as authentic digital traces, as the foundation of scientific validity in an era in which digital data are easily altered and may lose their original context. Jaillant (2022) adds that digitization initiatives and the implementation of open access are frequently constrained by metadata limitations, copyright issues, and insufficient user technical competence, thereby necessitating the adoption of open metadata standards and strengthened inter-institutional collaboration. In addition, Blanke (2024) advances a counter-archiving approach aimed at promoting greater inclusivity of marginalized narratives while drawing attention to the need for critical scrutiny of algorithmic bias in digital representation systems. Conversely, Jaillant and Aske (2024) argue that user readiness for integrating artificial intelligence (AI) into digital archives remains relatively low, highlighting the need to enhance AI literacy and to design ethical and collaborative archival interfaces. Collectively, these findings indicate that archive digitization represents not only a technological shift but also an epistemological and social transformation that requires careful consideration of inclusivity, authenticity, and knowledge accessibility.

Through this comprehensive literature review, this research offers novelty by proposing the use of a digital archival learning platform as a medium for disseminating insights and practices to other organizations and institutions. This approach is intended to foster a holistic understanding of digital archiving and to encourage an integrated transformation of archival management toward technology-assisted practices. The integration referred to in this study involves the development of a digital platform that is accessible to both educators and students, thereby enabling archives to optimally support learning in archiving and office management.

2. Method

This research employed a research and development (R&D) approach. According to Borg and Gall (1989), the R&D approach is intended to produce a specific product and to test its effectiveness through a series of systematic development stages. This approach was selected because it aligns with the focus of this study, namely the development of digital-based archival learning media, which is expected to strengthen the support capacity of Semarang State University (UNNES) as a center for the dissemination of archival knowledge and expertise. Accordingly, this research not only generated technological innovation in the form of a digital archival information system but also contributed directly to improving the quality of learning and institutional knowledge management within the university and its partner institutions.

The participants in this study consisted of 200 students recruited from several vocational high schools in Semarang, Central Java. The selection of these institutions was based on their implementation of the Office Management and Business Services curriculum, which directly aligns with the digital archiving competencies being tested. The sample included students from grade XI, aged between 16 and 18 years, thereby providing a representative demographic of vocational learners in an urban educational setting. By involving these specific institutions, the study ensured transparency and offered a contextualized understanding of how the E-Archives Learning 2.0 performed within the Indonesian vocational education framework.

In general, this research was conducted through three main stages: a preliminary study and needs analysis, the design and development of digital information system–based archival learning media, and the testing, validation, and evaluation of the effectiveness of the developed media. The overall research process is illustrated in the following Figure 1.

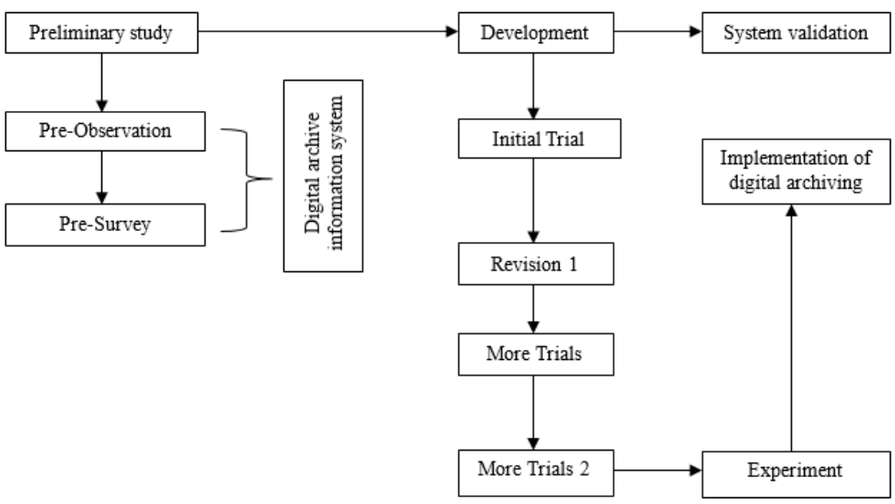

Figure 1. Research flowchart.

The preliminary study aimed to map the existing condition of archival management at the UNNES Archives Unit, identify obstacles encountered in practice, and examine the needs of users and lecturers teaching archival courses regarding digital learning media. The findings from this stage served as the basis for designing a contextual learning media model that was aligned with the needs of the institution and its partner schools.

This research adopted a mixed methods approach by integrating qualitative and quantitative analyses to obtain a comprehensive understanding of the system development process and its implementation.

1. Qualitative Analysis

At the initial stage, qualitative data were collected through in-depth interviews and focus group discussions (FGDs) involving teachers and lecturers. These data were analyzed using content analysis techniques to identify themes, patterns, and key needs related to archival management and the design of appropriate learning media. The results of this analysis formed the basis for developing a digital system blueprint that was responsive to user needs and aligned with the principles of archival learning. In addition, the qualitative analysis facilitated the identification of distinctive institutional values of Semarang State University (UNNES), such as conservation and educational innovation, which were subsequently integrated into the learning media design.

2. Quantitative Analysis

Following the development and implementation of the archival learning media prototype, quantitative data were collected through a user survey involving teachers and lecturers in Office Administration Education. The survey instrument was designed to assess effectiveness, efficiency, ease of use, and improvements in users' understanding of digital archiving concepts. The quantitative data were analyzed using descriptive statistics to describe levels of user satisfaction, performance improvement, and perceptions of the system's benefits. Subsequently, a t-test or analysis of variance (ANOVA) was conducted to examine the significance of improvements in learning outcomes or work efficiency before and after the use of the digital system. The results of the quantitative analysis were used to reinforce the qualitative findings and to form the basis for the final assessment of the feasibility of the developed learning media.

This research adapted the development stages proposed by Borg and Gall (1989), which consist of ten steps. However, within the context of this study, these stages were adjusted to better suit the process of developing digital-based archival learning media at Semarang State University (UNNES). Each stage was implemented systematically and iteratively, guided by the principles of validity, practicality, and effectiveness of the resulting product. The research stages are described in detail below.

1. Potential and Problems

The first stage involved identifying potential and problems arising in archival management and archival learning activities at Semarang State University (UNNES). Observations were conducted of both the learning process and archival management practices at the Archives Unit, and were complemented by interviews with lecturers, archivists, and teachers of Office Administration Education. The findings indicated a need for digital learning media capable of integrating archival theory with information system–based archival management practices. In addition, the availability of partner institutions highlighted the need for external support from organizations willing to facilitate electronic archiving training.

2. Initial Data Collection

At this stage, literature and field studies were conducted to strengthen the understanding of concepts, models, and standards related to digital archive development. Data were obtained through documentation review, scientific literature analysis, and interviews with relevant stakeholders. This stage provided the theoretical and empirical foundation for designing a contextual learning media model that was aligned with user needs.

3. Preliminary Product Design

Based on the results of the needs analysis, an initial prototype of a digital information system–based archival learning media was developed. The prototype comprised user interface design, system workflows, and integrated learning content, including archival management simulations, digital modules, and interactive videos. This initial design was developed using user-centered design principles to ensure alignment with the characteristics and needs of users within the UNNES academic environment and its partner institutions.

4. Design Validation by Experts (Expert Judgment)

The initial prototype was subsequently validated by experts in archiving, learning media, and information technology. The validation process aimed to evaluate content appropriateness, visual presentation, ease of use, and alignment of the media with learning objectives. Feedback and recommendations provided by the experts served as the basis for refining the design prior to the trial stage.

5. Product Revision – Phase 1

Based on the results of expert validation, revisions were made to the learning media design. These revisions included refining the user interface, incorporating additional interactive features, and reorganizing the content structure to enhance clarity and effectiveness in supporting the learning process.

6. Small-Group Trial

This phase was conducted with a small group of users, including lecturers teaching archival courses, teachers of Office Administration Education, and several representatives from partner institutions. The trial aimed to evaluate ease of use, visual appeal, and the extent to which the learning media supported instructional activities and simulated digital archival management practices. Feedback obtained from this limited trial served as the basis for further revisions.

7. Product Revision – Phase 2

Subsequent revisions were implemented based on the outcomes of the small-group trial, particularly with respect to technical and pedagogical aspects. These revisions included improving system navigation, refining language and terminology, and increasing the level of content interactivity. This phase resulted in a more stable version of the product that was ready for large-scale testing.

8. Field Testing

The field-testing phase involved a broader group of users, encompassing several study programs relevant to archival and office administration disciplines. Data were collected through observations, questionnaires, and interviews. The findings from this phase were used to evaluate the effectiveness of the learning media in enhancing users' understanding and skills related to digital archiving concepts and practices.

9. Product Revision – Final Phase

Based on the results of the field testing, final refinements were made to the learning media in both technical and content-related aspects. The finalized product was expected to meet three principal criteria: validity in terms of academic merit, practicality in terms of ease of use, and effectiveness in terms of its positive impact on learning outcomes and the efficiency of archival management.

10. Dissemination and Implementation

The final stage focused on the dissemination and implementation of the digital archival learning media at Semarang State University (UNNES) and its partner institutions. Dissemination was conducted through lecturer training programs, teacher workshops, and scientific publications. The implementation of this learning media was intended to strengthen UNNES's role as an institution actively involved in knowledge dissemination, learning innovation, and technology-based archival management.

This methodological approach was designed not only to produce an innovative digital archival learning media product but also to reinforce UNNES's position as a center for knowledge dissemination and a reference institution in modern archival management. By integrating system development methods with empirical evaluation, this research aimed to make a tangible contribution to digital transformation in higher education and to strengthen the integration of theory, practice, and technology in archival learning.

3. Research Result

3.1. Factual Model of E-Archives Learning

As outlined in the methodological stage, the development of E-Archives Learning aligns with established scientific principles of archival management. This alignment provides a clear foundation for system development and ensures conformity with recognized archival procedures. In this study, such alignment is realized by positioning Electronic Archives as a digital file storage platform in which documents are managed electronically using computers or laptops. Physical documents are initially digitized through scanning and are then stored for further processing within the Electronic Archives system.

During the storage process, documents follow the applicable archival storage system. Accordingly, virtual representations of drawers, folders, and files are required. As stated by Sugiarto and Wahyono (2005), an electronic archival system consists of three core components: virtual cabinets, virtual folders, and archive sheets in file form. Consistent with this concept, files stored in Electronic Archives are systematically organized into virtual cabinets (Drawers), virtual folders, and virtual files.

The subsequent stage in the development of Electronic Archives involves the creation of folders as the basic storage structure. The platform incorporates an additional menu referred to as a Guide, which functions as a virtual connector between folders within the designated drawer. To enhance user comprehension, the Electronic Archives interface is designed to present a sequential structure consisting of drawer folders, guides, folders, and files. At this stage, the basic operational mechanism of Electronic Archives demonstrates conformity with records management principles, thereby fulfilling the initial product design phase in the form of a functional prototype.

This initial prototype takes the form of a folder-based archival platform. The model is illustrated by creating a main folder entitled "Electronic-based folder" within the computer system. Within this folder, six subfolders are established: Alphabetical, Subject Matter, Date (Chronological), Decimal, Terminal Digit, and Region. These folder labels correspond to the archival storage system principles that underpin the operational logic of each menu within the Electronic Archives platform. The prototype is presented in Figure 2.

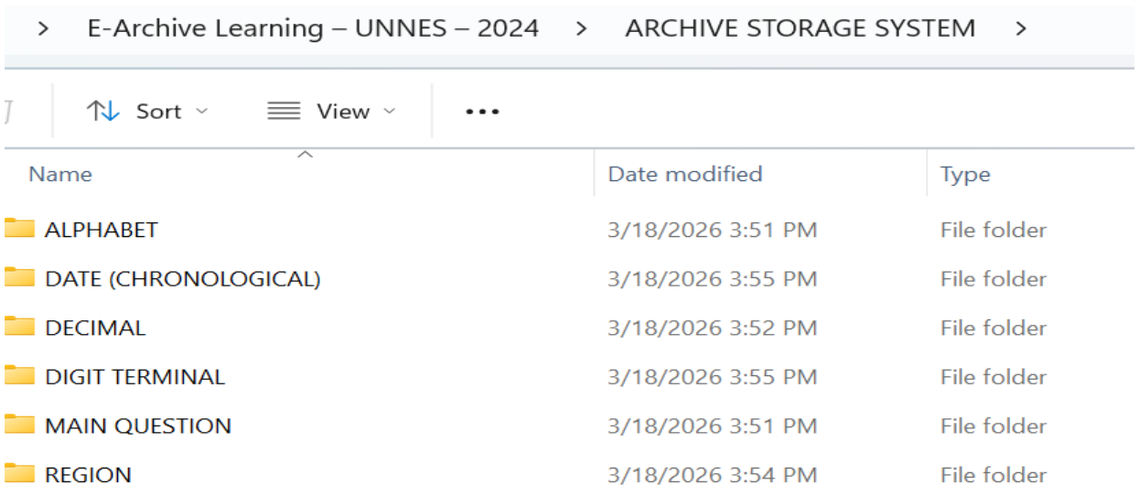

Figure 2. Folder Based E-Archive Storage System Folder.

3.2. Developing a Hypothetical Model of E-Archives Learning

The subsequent stage of the research focuses on developing a hypothetical model of the archival learning platform based on recommendations provided by archival experts during the evaluation of the initial prototype. The evaluation indicates that further development is required to achieve a more organized and structured system to enhance usability and facilitate user interaction with the platform.

In response to this feedback, the initial application menu is redesigned to create a more intuitive main interface that supports efficient user navigation. The redesigned interface incorporates several essential functional elements that reflect the core processes of digital archival management as follows:

1. New Archive Menu

This feature enables users to create new archival documents directly within the system. This feature represents a key component of the initial menu, as it is designed to simplify the process of creating, managing, and storing digital archives from the outset of archival activities.

2. Archive Management Menu

This feature functions as the control center for managing all digital archives within the system. This menu provides comprehensive functionalities, including archive searching and indexing, categorization and classification, archive loan management, as well as reporting and analytical features. The menu is developed with an intuitive interface, allowing users to manage complex archival data efficiently without requiring advanced technical expertise. As such, this feature constitutes the core of the digital archival learning platform, ensuring that archival management practices are implemented effectively and in accordance with established digital archiving standards.

Overall, the initial menu display is designed using consistent color schemes and visual elements to create a professional and comfortable user experience. Interface components are strategically arranged to support ease of access and smooth navigation, thereby enhancing the overall usability of the learning platform.

Table 3. Shapiro-Wilk normality test.

Variable	Shapiro-Wilk	Sig. (p)
Pre-Test	0.927	0.354
Post-Test	0.853	0.040

Source: Processed data (2025).

3.3. Testing the Feasibility and Effectiveness of the Hypothetical Model of E-Archives Learning Pre-Test and Post-Test Results

As presented in Table 3, the Shapiro–Wilk normality test results show that the pre-test scores are normally distributed, with a significance value of p = 0.354, which exceeds the 0.05 threshold. In contrast, the post-test scores indicate a slight deviation from the normality assumption, as reflected by a p-value of 0.040, which is below 0.05. Despite this deviation, the use of a paired-sample t-test remains justifiable, particularly considering the relatively small sample size (n = 12) and the robustness of the test to minor violations of normality.

Table 4. Paired sample t-test.

Test	t	Sig. (p)
Paired Sample t-Test	-4.818	0.001

Source: Processed data (2025).

The results displayed in Table 4 reveal a statistically significant difference between participants' pre-test and post-test scores with a t-value of −4.818 and a significance level of p = 0.001, which is well below the 0.05criterion. This outcome indicates that the training or intervention delivered through the digital archival learning media leads to a meaningful improvement in participants' abilities.

Table 5. Cohen's d effectiveness tests.

Effect Size	Value
Cohen's d	1.391

Source: Processed data (2025).

As shown in Table 5, the calculated Cohen's *d* value of 1.391 reflects a very large effect size, indicating a strong influence of the intervention on learning outcomes. This effect is also evident in the increase in the mean score from 86 on the pre-test to 94 on the post-test. Collectively, these findings demonstrate that the developed learning media are effective in enhancing participants' understanding and practical skills related to digital archiving.

A pre-test and post-test design was employed to measure changes in participants' understanding and competencies following the use of the developed archival learning media. The pre-test was administered prior to participation in the digital media trial to assess baseline knowledge of archival concepts and practices, while the post-test was conducted after the completion of all learning sessions to evaluate the effectiveness of the learning media. A quantitative comparison of pre-test and post-test results was carried out to determine the extent of improvement in participants' understanding and to assess the contribution of the media to knowledge transfer and the strengthening of archival competencies. The comparison of pre-test and post-test scores is presented in Table 6.

Table 6. Pre-test and post-test results comparison.

No.	Participants	*Pre-Test*	*Post-Test*
1	Participant 01	88	100
2	Participant 02	86	100
3	Participant 03	86	96
4	Participant 04	87	92
5	Participant 05	85	84
6	Participant 06	84	100
7	Participant 07	88	92
8	Participant 08	86	100
9	Participant 09	86	84
10	Participant 10	87	96
11	Participant 11	85	92
12	Participant 12	84	92
Average		**86**	**94**

Source: Processed data (2025).

As shown in Table 6, the average participant score increases from 86 in the pre-test to 94 in the post-test following the use of the developed archival learning media. Most participants demonstrate score improvements, indicating that the learning media positively influence their understanding of digital archival concepts and practices. The relatively consistent pattern of improvement across participants suggests that the learning media effectively support the learning process. Although two participants experience a slight decline in their scores, the overall trend

confirms a positive learning effect. These findings further support earlier results, which indicate that digital-based learning media enhance learning outcomes and participant engagement by presenting archival material in a more interactive and applicable format.

Further examination of Table 6 indicates that participant scores range from a minimum of 84 to a maximum of 100. The classification of these scores into interval categories is presented in Table 7.

Table 7. Category of score interval.

No.	Score Interval	Category	Numbers	Percentage
1	84-89	Fair	14	58%
2	90-95	Good	3	13%
3	96-100	Very Good	7	29%
Total			24	100%

Source: Processed data (2025).

Based on Table 7, 58% of the 24 trial participants fall within the fair category, 13% are classified in the good category, and 29% are categorized as very good. These results indicate that most participants achieve an adequate level of mastery of the material after using the developed archival learning media. Although a considerable proportion of participants remain within the fair category, the presence of participants in the good and very good categories reflects a meaningful improvement in understanding. Overall, these findings indicate that the developed digital learning media is effective in strengthening archival competencies, while also suggesting the need for further refinement to encourage more evenly distributed achievement across higher performance categories.

The empirical findings of this study are consistent with previous research on digital archives and learning outcomes. Owens and Padilla (2021) emphasize that digital sources reshape the construction of historical evidence and necessitate new approaches to verification. This perspective is relevant in interpreting the observed increase in the average score from 86 to 94, which reflects participants' enhanced understanding of the value and authenticity of digital evidence following a systematically designed learning intervention. Similarly, Borgman et al. (2019) conceptualize digital archives as knowledge infrastructure, suggesting that improvements in learning outcomes illustrate how appropriate infrastructure and governance can strengthen knowledge utilization within archival contexts. In addition, Jaillant and Aske (2024) highlight that user readiness for computational methods remains uneven, supporting the interpretation that, despite substantial average improvements, continued effort to strengthen technological literacy is required to sustain the long-term effectiveness of digital learning media.

The pre-test and post-test assessments included a set of questions designed to measure specific indicators of archival management competence. These indicators were used to compare theoretical principles of archival management with their practical application in the electronic archival system developed in this study. Detailed results for each indicator are presented in Table 8.

Table 8. Indicator of E-Archives learning version 2.0's success.

No.	Indicator	*Pre-Test*	*Post- Test*
1	Basic electronic archiving concepts	88	100
2	Digital archives maintenance	86	98
3	Digital archives disposition	86	94
4	Archives digitization process	87	88
5	Digital archives security	85	92
6	Electronic archives risk management	84	96
Average		**86**	**95**

Source: Processed data (2025).

As shown in Table 8, all competency indicators demonstrate improvement from the pre-test to the post-test. The average score increases from 86 to 95, indicating a broad enhancement in participants' understanding across multiple dimensions of digital archival management. The most substantial improvement is observed in the basic electronic archiving concepts indicator, which increases from 88 to 100. This result suggests that the developed learning media are particularly effective in strengthening participants' conceptual understanding of electronic archival practices.

In contrast, the archive digitization process indicator exhibits the smallest increase, rising slightly from 87 to 88. This finding suggests that the practical and technical aspects of archival digitization require further refinement to provide a more optimal and consistent learning experience. Despite this limited improvement, the overall results demonstrate that version 2.0 of the archival learning media effectively enhances user competencies in digital archival management, particularly in conceptual understanding, archive maintenance, and security aspects. These outcomes indicate that the developed learning media has strong potential as an effective instructional tool in academic settings.

The findings of this study are broadly aligned with prior research on digital archival systems and learning design. Blanke (2024) noted that the design and representation of digital archives, particularly the way foundational concepts are presented, play a critical role in shaping inclusiveness and user understanding. This view is consistent with the substantial improvement observed in indicators related to basic archival concepts. Moreover, Abney, Boczar, and Jordan (2024) showed that context-aware metadata management can improve both accessibility and user trust in digital collections, which corresponds with the observed gains in archive security and risk management aspects in version 2.0 of the learning media. In addition, Post and Chassanoff (2021) underscored the importance of clearly documented workflow and curation practices, lending support to the finding that procedural and pedagogical refinements in the development of E-Archives Learning make a meaningful contribution to improved learning achievement outcomes.

3.4. Descriptive Statistical Analysis Results

Based on the respondents' response scale ranging from 1 to 5, perception index scores were calculated on a scale from 10 to 100. Using the Three-Box Method, this range was divided into three categories with equal intervals,

resulting in an interval width of 30 for interpreting respondents' perception indices. The classification criteria are presented in Table 9.

Table 9. Indices and criteria.

Index	Criterion
10.00 – 40.00	Low
40.01 – 70.00	Medium
70.01 – 100	High

Source: Processed data (2025).

Referring to the assessment criteria shown in Table 9, the next step involved calculating the respondents' perception index for each variable examined in this study. This index offers a more comprehensive picture of respondents' levels of understanding, attitudes, and acceptance of the developed archival learning media. Through this measurement, the effectiveness of individual media components can be identified, including visual presentation, ease of use, and the relevance of the material to archival learning needs at Semarang State University. Consequently, the perception index serves as an objective and quantifiable basis for evaluating the performance of the learning media, while also providing guidance for potential improvements in subsequent development stages. The detailed results of the perception index calculation are presented in Table 10.

Table 10. Description of variables of digital archiving understanding.

Indicator	Percentage of respondents' response frequency					Index (%)	Respondent's Perception
	1	2	3	4	5		
Understanding of digital-based archiving concepts	9.7	0.0	0.0	41.9	48.4	83.9%	Teachers understand digital-based archiving concepts.
Understanding the use of technology for archives management	9.7	0.0	0.0	41.9	48.4	83.9%	Teachers understand the benefits of technology-based digital archiving.
Knowledge of archiving software	0.0	9.7	0.0	80.6	9.7	78.1%	Teachers know how to digitize physical archives.
Average						**81.97%**	

Source: Processed data (2025).

As shown in Table 10, which presents the variable of digital archiving understanding, respondents exhibit a high level of comprehension across the assessed indicators, with an average perception index score of 81.97%. The indicators related to understanding the concept of digital-based archiving and the application of technology in archival management achieve the highest index values, each reaching 83.9%. These results suggest that most respondents demonstrate strong mastery of both conceptual foundations and practical technological applications in digital archiving. Overall, the findings indicate that the developed learning media effectively enhance conceptual understanding and support technological adaptability in the context of contemporary archival management.

The indicator related to knowledge of archiving software records a comparatively lower perception index score of 78.1%. This finding suggests that respondents' technical understanding, particularly in operating digital archive management applications or systems, still requires further strengthening. While respondents show familiarity with the digitization of physical archives, the development of more advanced technical skills remains necessary to enable more optimal and efficient system utilization.

By contrast, indicators associated with understanding the concept of digital archiving and the application of technology in archival management attain higher index scores, each reaching 83.9%. These results indicate that respondents possess a solid conceptual grasp of digital archiving principles and are aware of the advantages of technology-based archival systems in supporting work efficiency. Overall, respondents' understanding of digital archiving falls within the high category, as reflected by an average perception index of 81.97%. Despite this favorable outcome, the findings underscore the continued need for strengthening technical competencies through sustained training to ensure the effective and sustainable implementation of digital archiving systems in a professional context.

These results are consistent with Jaillant (2022) findings, which identify user competency as a key barrier to effective digital archive management, alongside challenges related to metadata and copyright. Although respondents demonstrate a high level of conceptual understanding, as indicated by the 83.9% index score, technical constraints may still limit optimal system use. Owens and Padilla (2021) further emphasize that a clear understanding of the characteristics of digital sources is essential for maintaining the validity and accountability of scientific evidence. This perspective supports the increased understanding index observed in this study, indicating that participants comprehend not only digital archiving terminology but also the function of digital archives as valid and reliable records. In addition, Borgman et al. (2019) stress the role of knowledge architecture, including infrastructure and policy support, in facilitating mastery of digital archival concepts. The average understanding index of 81.97% obtained in this study aligns with this view, suggesting that higher levels of understanding emerge when learning is supported by appropriate systems and institutional frameworks.

The variable representing the availability of technological facilities and infrastructure describes the extent to which supporting resources such as hardware, software, internet connectivity, and data storage systems are available and function effectively in supporting the implementation and development of digital archiving. This variable constitutes a crucial determinant of both learning media implementation and archival information system performance, as the adequacy of technological facilities directly affects the efficiency, accessibility, and long-term sustainability of digital-based archival management at UNNES. A summary of the measurement results for this variable is presented in the following table.

Table 11. Description of the availability of technological facilities and infrastructure variable.

Indicator	Percentage of respondents' response frequency					Index (%)	Respondents' perception
	1	2	3	4	5		
Availability of technological devices	0.0	9.7	12.9	58.1	19.4	77.4%	Teachers understand how to create digital archive metadata.
Accessibility of technological devices for employees	9.7	0.0	16.1	45.2	29.0	76.8%	Teachers understand security risks in digital archives management.
Average						**77.10%**	

Source: Processed data (2025).

Based on Table 11, the availability of technological facilities and infrastructure among respondents is classified as good, with an average perception index score of 77.10%. The indicator related to the availability of technological devices achieves the highest index score at 77.4%, indicating that most teachers have access to adequate devices and possess a basic understanding of digital archive metadata creation as part of the digitization process.

Meanwhile, the indicator concerning the accessibility of technological devices for employees records an index score of 76.8%. This result suggests that access to technological facilities is relatively evenly distributed among respondents, although certain constraints remain, both in terms of infrastructure sufficiency and users' technical ability to utilize available resources optimally. Overall, these findings indicate that existing technological facilities and infrastructure provide adequate support for the implementation of digital archiving systems. Nevertheless, continued efforts to enhance user capacity and upgrade infrastructure remain necessary to ensure sustained and optimal system performance.

These findings are in line with Odhiambo (2018) study, which underscores that institutional readiness – covering policy support, technical infrastructure, and staff awareness – is frequently insufficient. This observation corresponds with the perception index score of 77.10% obtained in this study, suggesting that technological facilities are generally available but still require further strengthening. Borgman et al. (2019) similarly argue that technical infrastructure can function effectively only when supported by clear governance mechanisms and institutional policies, which may explain why the infrastructure index score in this study is lower than the score for user competency. Furthermore, Post et al. (2019) demonstrate that the availability of technological devices alone is not sufficient unless accompanied by documented workflows, software integration, and structured human processes that enable optimal utilization of technological resources.

The variable describing user capability in digital archiving technology reflects the level of competence, knowledge, and skills possessed by teachers in applying information technology to support digital archival management processes. This variable includes the ability to operate archival software, understand document digitization procedures, apply data security principles, and manage archival information systems efficiently. Assessing user capability is essential, as it represents a key determinant of the successful implementation of both digital learning media and archival information systems. Higher levels of user competence increase the likelihood of establishing a modern and integrated archival process that aligns with technology-based archival management standards at Semarang State University. A detailed overview of this variable is presented in the following table.

Table 12. Description of user capability in digital archiving technology variable.

Indicator	Percentage of respondents' response frequency					Index (%)	Respondents' Perception
	1	2	3	4	5		
Basic capability in using digital devices	9.7	0.0	0.0	35.5	54.8	85.2%	Teachers are able to upload documents to digital storage.
Capability to utilize archiving software	9.7	0.0	0.0	38.7	51.6	84.5%	Teachers are able to download digital archives easily.
Experience with previous technology training	2.8	2.8	1.4	47.2	27.8	78.9%	Teachers are able to transfer archives from physical media to digital formats.
Average						**82.87%**	

Source: Processed data (2025).

Based on Table 12, which presents data on user capability in digital archiving technology, the average perception index score reaches 82.87%, indicating that teachers' technological capability falls within the high category. The indicator related to basic digital device usage achieves the highest index score at 85.2%, demonstrating that most respondents are able to operate digital devices independently, including uploading documents to digital storage systems.

The indicator measuring capability in utilizing archiving software attains an index score of 84.5%, indicating that respondents are generally familiar with the use of archival applications for downloading, managing, and organizing digital archives efficiently. By contrast, the indicator related to experience with technology-based training records a lower index score of 78.9%. This finding suggests that although fundamental technical skills are already well established, continuous capacity development through regular training remains necessary to prepare users for ongoing technological change in the archival field. Overall, these results indicate that users demonstrate solid proficiency in digital archiving technology; however, sustained competency enhancement is required to ensure that digital archival systems are implemented in an effective, adaptive, and sustainable manner.

These findings are supported by Post and Chassanoff (2021), who emphasize the importance of practical and professional competencies for archivists involved in the transfer and management of digital records. This perspective is consistent with the average user competency index score of 82.87% obtained in this study, suggesting that respondents possess strong foundational capabilities and are well-positioned for further skill development. Similarly, Madrid (2013) argues that digital curation competencies encompass cognitive, technical, and social dimensions, a view that aligns with the present findings showing strong basic skills and software proficiency alongside more varied training experience. Owens and Padilla (2021) further note that an understanding of the characteristics of digital

sources underpins effective technical practices in archival management, which helps explain why user competencies in this study are reflected in practical activities such as uploading, downloading, and migrating digital archival files.

The variable describing the effectiveness of digital technology use in archiving reflects the extent to which technological applications improve the quality, efficiency, and speed of archival management processes in the workplace. This variable includes the system's capacity to support archive searching, accelerate document storage and retrieval, and enhance data security and reliability. In addition, technological effectiveness is assessed in terms of ease of access, system integration capability, and its impact on productivity and service accuracy in archival operations. As such, this variable serves as a key indicator for evaluating the success of digital archival system development and implementation, as technological effectiveness constitutes a primary benchmark for assessing the contribution of digital innovation to operational efficiency and the strengthening of modern archival governance at Semarang State University. The results for this variable are presented in the following table.

Table 13. Description of effectiveness of digital technology use in archival activities variable.

Indicator	Percentage of respondents' response frequency					Index (%)	Respondents' Perception
	1	2	3	4	5		
Efficiency in archives management after the implementation of digital technology	0.0	9.7	0.0	38.7	51.6	86.5%	Teachers are able to utilize digital technology to improve work efficiency.
Impact on speed and accuracy	0.0	9.7	0.0	25.8	64.5	89.0%	Teachers are able to apply digital archiving practices to facilitate data retrieval.
Average						**87.75%**	

Source: Processed data (2025).

Based on the analysis presented in Table 13, the effectiveness of digital technology use in archival activities is classified as very good, with an average perception index score of 87.75%. This result indicates that the application of digital technology has a strong positive influence on archival management performance. The first indicator, archival management efficiency following the implementation of digital technology, records an index score of 86.5%, reflecting that most document managers are able to use digital tools to improve work efficiency and reduce the time and effort required for archival processes.

The second indicator, which assesses the impact of digital technology on the speed and accuracy of archival management, records a higher index score of 89.0%. This result suggests that the implementation of digital systems enables document managers to retrieve archival data more rapidly while also enhancing accuracy in archival operations. Taken together, these findings confirm that digital technology plays a central role in establishing archival systems that are more effective, efficient, and reliable, thereby contributing to improvements in administrative service quality and archival governance in the workplace.

In addition, the variable describing the need for digital archiving training captures archivists' perceived need, awareness, and readiness to engage in training related to the application of digital technology in archival practices. This variable reflects the extent to which training is regarded as a key mechanism for strengthening human resource capacity, allowing archivists to manage records in a modern and efficient manner in response to the demands of digital transformation. A detailed summary of this variable is presented in the following table.

Table 14. Description of the need for digital archiving training variable.

Indicator	Percentage of respondents' response frequency					Index (%)	Respondents' Perception
	1	2	3	4	5		
Need for training on digital-based archiving	0.0	9.7	0.0	54.8	35.5	83.2%	Teachers perceive that participating in digital technology training improves the quality of archival services.
Need for training on digital archiving devices and applications	0.0	5.1	0.0	35.6	15.3	45.82%	School principals support the implementation of digital archiving by assigning office administration teachers to participate in digital archiving training.
Willingness to participate in training.	0.0	9.7	0.0	64.5	25.8	81.3%	Archivists support institutional policies for digital archiving capacity development training.
Average						70.11%	

Source: Processed data (2025).

Based on the results presented in Table 14, the variable representing the need for digital archiving training shows that most respondents consider training in digital-based archival management to be important, with an average perception index score of 70.11%. The indicator measuring perceived training needs achieves the highest index score at 83.2%, indicating that archivists recognize competency development through training as essential for supporting the quality and sustainability of archival services.

The indicator measuring willingness to participate in training attains a high index score of 81.3%, reflecting strong institutional support, particularly from school principals, for encouraging office administration teachers to engage in digital capacity development programs. By contrast, the indicator related to training needs for digital archival devices and applications records a comparatively low index score of 45.82%. This finding suggests that respondents have limited understanding or practical experience with the technical use of archival software and digital applications. Taken together, these results indicate a clear and urgent need for structured digital archiving training to enhance user competencies and to strengthen human resource readiness for digital transformation in the archival sector.

These results are consistent with Odhiambo (2018) observation that institutional readiness is often constrained by limited training opportunities and insufficient policy support. This view aligns with the overall training needs index score of 70.11% obtained in this study, particularly for technical device and application competencies, which register the lowest score at 45.82%. In addition, Jaillant (2022) emphasizes that barriers related to access and user competence represent major challenges in digital transformation initiatives, reinforcing the importance of structured and continuous training programs. Supporting this argument, Azmir, Alwi, and Ramli (2022) highlight that ongoing training encompassing both technical and conceptual dimensions is essential for building staff capacity to effectively utilize digital archiving systems.

4. Discussion

Based on the sequence of research stages conducted, the findings indicate that the average pre-test score increased from 86 to 94 following the implementation of the digital archiving learning media. This improvement suggests a meaningful enhancement in participants' understanding and practical skills. Such results align with Matusiak (2022) study on user interaction with digital archives developed through the Omeka platform, which demonstrated that positive user experiences contribute to greater access to and more effective use of digital archival systems. This correspondence reinforces the conclusion that the learning media intervention in the present study supported the development of user competence, particularly when technological change was accompanied by appropriate learning support that enabled users to adapt to the new system.

In addition, E-Archives Learning version 2.0 achieved a very high success index of 95%, especially for indicators related to basic electronic archiving concepts and electronic archiving risk management. Shekgola and Ngoepe (2026), in a study on digital archive curation using free and open-source software, found that open systems combined with inclusive design approaches enhanced user engagement and higher awareness of security and risk considerations in digital archival practices. These findings support the interpretation that the effectiveness of learning media is influenced not only by content quality but also by users' conceptual understanding, awareness of archival risks, and application of digital security principles. Accordingly, beyond providing an intuitive application interface, a strong grounding in archival science emerges as a key factor in ensuring the effectiveness of digital archiving learning media.

Consistent with these outcomes, the variable measuring understanding of digital archiving recorded an average index score of 81.97%, indicating a generally high level of comprehension among users regarding archival concepts and the role of technology. However, Jaillant (2022) notes that even when conceptual understanding is sufficient, technical challenges such as metadata management, copyright constraints, and limited user skills often restrict the optimal use of digital archives. In this respect, the results of the present study align with Jaillant (2022) conclusions, showing that strong conceptual understanding must be accompanied by enhanced technical and practical competencies in order to support more effective and sustainable use of digital archiving systems.

Moreover, the availability of technological facilities and infrastructure records an average index score of 77.10%, suggesting that existing conditions are adequate but not yet optimal. Odhiambo (2018) emphasizes that institutional readiness, including technical infrastructure and policy support, plays a significant role in determining the effectiveness of digital archive implementation. Accordingly, although users of the E-Archives Learning version 2.0 demonstrate sufficient capability, limitations in facilities and infrastructure still have the potential to become constraints on maximum system utilization. This finding is consistent with the present study, which indicates that while facilities are available at an acceptable level, further enhancement is required to achieve optimal performance.

Finally, the user capability variable, with an index score of 82.87%, along with the training needs variable, which records an index score of 70.11%, suggests that archivists possess solid foundational competencies but continue to require additional training. This need is particularly evident in the use of digital archiving applications, which obtain a relatively low index score of 45.82%. Oyelude and Alonge (2023) study on teaching digital preservation and curation in library and information science programs underscores the importance of curriculum development and technical training in preparing competent digital archiving professionals. Therefore, the findings of this study indicate that, alongside the availability of effective learning systems and media, sustained investment in human resource development remains essential to ensure the long-term sustainability of digital archiving implementation.

5. Conclusion

Based on the research findings and data analysis, it can be concluded that the implementation of the E-Archives Learning system version 2.0 positively influenced teachers' understanding and ability to manage digital archives. The pre-test and post-test results indicate an increase in the average score from 86 to 94, reflecting a substantial improvement in the mastery of digital archiving concepts and practices. This conclusion is reinforced by the score categorization results, which show that 58% of respondents were classified in the fair category, 13% in the good category, and 29% in the very good category. These distributions indicate a clear tendency toward improved competency following the training intervention and the application of the digital system.

Furthermore, the success indicators of E-Archives Learning version 2.0 achieve an average index score of 95%, with the most notable improvements observed in the basic concepts of electronic archiving, which increase from 88 to 100, and in electronic archiving risk management, which rises from 84 to 96. These outcomes demonstrate that E-Archives Learning version 2.0 effectively strengthens both the conceptual and technical aspects of digital archive management.

Regarding the level of understanding of digital archiving, the variable records an average index score of 81.97%, indicating a highly positive perception among respondents toward the concepts and use of digital-based archival technology. Meanwhile, the availability of technological facilities and infrastructure attains an average index score of 77.10%, suggesting that although facilities are generally sufficient, further optimization of device accessibility within the work environment remains necessary to support optimal system implementation.

For the user capability in digital archival technology variable, the average index score of 82.87% indicates that archivists demonstrate solid basic skills in operating digital devices and using archival software. In line with this result, the variable assessing the effectiveness of digital technology use in archival activities records an average index

score of 87.75%, showing that the application of digital technology has made a meaningful contribution to improving efficiency, speed, and accuracy in the archive management process.

The training needs in digital archival technology variable attain an average index score of 70.11%, indicating that most respondents continue to require capacity development through regular and well-structured training programs. This requirement is particularly apparent in the technical use of digital archiving devices and applications, which shows a relatively low index score of 45.82%. These findings confirm that training support and the strengthening of human resource competencies remain essential to maintaining an effective and adaptive digital archiving system amid ongoing technological change.

Overall, the findings demonstrate that the implementation of E-Archives Learning version 2.0 has contributed significantly to improving archivists' competencies, work efficiency, and operational performance. However, continuous mentoring and systematic capacity-building efforts are still necessary to ensure sustained digital transformation in the archiving sector and its effective integration within organizational practices.

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