

A study of emerging trends in digital preservation literature: An analysis of journal articles presented in course syllabi

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Introduction

Digital preservation, the formal endeavor to ensure that digital information of continuing value remains accessible and usable (Digital Preservation Coalition, 2008), has rapidly evolved as an important and distinctive subfield within Library and Information Science (LIS) as well as Archival Science, with urgency for preserving authentic digital information (Library of Congress, 2002). Over the past decades, a number of national and international efforts have been initiated to preserve digitally represented information, combining various considerations for digital preservation such as policies, strategies, and actions to ensure access to digital content with necessary technologies (American Library Association, 2008). As the field is evolving, many authors from various sectors have contributed to digital preservation literature, including the cultural heritage community, librarians, archivists, museum curators, and researchers in liberal arts and social science, as well as from science and engineering (Gladney, 2007).

With the growth of digital preservation as a field, there is a need to educate future digital preservation professionals to meet the demand of the field. While there are different ways to achieve the goal of education, degree programs are certainly one most prominent educational methods to produce future professionals. For this reason, scholars have examined existing curricula relevant to digital preservation, including course content, topics, and assignments, to offer insights regarding what content have been taught through which methods (Yoon et al., in press).

In educational research, syllabi examination has been utilized to address a variety of curriculum-related questions. Stanny et al. (2015) conducted a comprehensive content analysis of performed a content analysis of undergraduate syllabi to examine learning outcomes, assessments, rubric design, topics, course readings. The researchers evaluated the syllabi for High Impact Pedagogical Practices (HIPPs) identified by the National Survey of Student Engagement (NSSE) and criteria from the AAC&U (Association of American Colleges and Universities). Bers et al. (2000) conducted a three-part study that analyzed the content of course syllabi, surveyed students on which items they deemed most important in a syllabus, and conducted faculty workshops to analyze the important components of syllabi. This research noted disciplinary differences in syllabi content expectations, and that some disciplines are more prescriptive while others are not. Lastly, Goodwin et al. (2018) analyzed undergraduate course syllabi to inform curricula reform. While part of this study focused on items such as departmental and university policies, the study also examined course reading material to determine potential content and knowledge gaps that existed in the content of the courses.

Additionally, examining syllabi and course readings have provided insights for several subdisciplines in LIS and are useful techniques for investigating major themes in LIS education. Pomerantz et al. (2006) examined digital library education through examining the core readings and themes from these readings assigned in digital libraries courses in LIS. Irwin (2002) examined masters-level LIS core courses by comparing mandatory (core) course descriptions at ALA-accredited schools to recommendations from the International Federation of Library Association (IFLA) and by examined the course titles and course descriptions to determine the major themes in LIS core courses. Nicholson

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(2005) examined course syllabi and course readings of the U.S. News and Work Report top ten LIS schools to determine how the topic of ‘search’ was integrated into the curriculum, the subtopics that were covered by course readings, and the core readings used in ‘search’ education across LIS curriculum.

Previous studies have utilized citation analysis, topic modeling, and visualization to understand themes within scientific disciplines and examine historical trends in various fields and subfields, both within and outside of LIS. Additionally, syllabi studies, including the examination of assigned course readings, have provided insight into trends in subdisciplines in LIS, such as business information and search.

Problem Statement

While the previous studies have significantly contributed to LIS education efforts, as well as how topic modeling and visualization techniques can be used to understand domains, understanding how the existing body of knowledge is represented and taught in digital preservation courses is equally important. Previous studies have suggested that all digital preservation courses heavily utilized various types of literature. Specifically, most digital preservation courses utilize journal articles and conference proceedings for course readings; few courses use textbooks, and even when textbooks are used, digital preservation courses heavily rely on journal articles and conference proceedings to support students’ learning (Yoon et al., in press). Course assigned literature are an integral part of any class and usually reflects what is considered the most seminal literature in the field to deliver the subject knowledge to students. Therefore, the literature examined in this research is assumed to represent the main topics and concepts taught in digital preservation courses. Students’ interaction with literature is a critical part of student learning as it will shape their views on the existing knowledge as well as new opportunities in the field.

This study is one of the first efforts to explore the trends of digital preservation literature used in curricula through a bibliometric examination of journal articles and conference proceedings assigned in digital preservation courses. The reason for focusing on research articles and conference proceedings is due to the inclusion of abstracts and keywords, both of which provide rich information for text analysis. By investigating the major themes and seminal topics in the literature assigned in digital preservation courses, our study contributes to the broader understanding of digital preservation education by exploring what is considered core literature in the field digital preservation education and provides a snapshot of the trends in digital preservation research. This study aims to understand the trends in topics and concepts taught in digital preservation courses through a textual analysis of the assigned journal articles and conference proceedings.

For the purpose of our analysis, we reviewed the literature utilized in the digital preservation courses within North America ALA-accredited Masters in Library and Information Science (MLIS) program. As large-scale textual analysis can be cumbersome, we adopted topic modeling and visual analysis to examine our data. Topic modeling was employed on the abstracts of the literature to gain an understanding of the major themes in this corpus of literature. Visual analysis of the citation data was also

utilized to complement the topic models and further examine the literature assigned in digital preservation courses.

Literature Review

The field of digital preservation continues to evolve and change since its inception in the 1970s (Conway, 2014) long before digital information existed in abundance as it does today. The involvement of the archival community helped drive digital preservation forward, beginning in the late 1980s (Conway, 2011). The initiation of digital preservation education could be indicated from the Northeast Document Conservation Center (NEDCC) conference in 1995 (Tibbo, 2015). In the 2000s, academic libraries and other institutions began to provide support for digital preservation efforts through institutional repositories, as well as the development of institutional repository systems such as DSpace and EPrints (Lynch, 2003). The European Union support of the Electronic Resource and Preservation and Action Network (ERPANET), led by the Humanities Advanced Technology and Information Institute (HATII) increased the support for the preservation of both cultural and scientific artifacts (Ross, 2004). The establishment of the Digital Curation Centre in 2004 created a network and resources for digital preservation and curation researchers and educators (Digital Curation Centre, 2020). Further developments occurred in the field of digital preservation as the digital curation field emerged, focusing on the lifecycle model of curation and broadening the scope of digital preservation (Gracy and Kahn, 2012). As the field continued to grow, additional developments occurred by examining the needs of disciplines and research data associated with particular user communities (Akers and Doty, 2013). With these developments in data preservation, also came the development of new infrastructures (Wilson et al., 2010), metadata (Caplan and Guenther, 2005), ontologies (Gelernter and Lesk, 2011), preservation techniques (Woods and Brown, 2008), and new materials to consider for preservation, such as video games (Hudgins, 2011).

Citation analysis, topic modeling, and visualization are techniques rarely used in archives and preservation. However, topic models are often used to understand pertinent themes in scientific fields. Hall et al. (2008) examined historical trends in the field of Computational Linguistics using unsupervised topic modeling of the ACL Anthology, a hosting service of papers on the study of computational linguistics. Fabrizio et al. (2012) examined aquaculture trends through a topic model and semantic analysis of bibliographic and abstract information from aquaculture articles retrieved from Scopus. More closely related to this research, Timakum et al. (2018) used topic modeling and visualization of full-text journal articles to understand the knowledge structures of library science.

Furthermore, visualizing bibliographic networks has been used to assist in understanding trends in scientific fields, related literature, and co-citation trends. Börner et al. (2003) provided a history and extensive discussion of various visualization techniques used for scientometrics, bibliometrics, and citation analysis used to understand scientific fields and trends. De Moya-Anegón and colleagues (2007) generated scientograms of major scientific domains to understand the relationships between worldwide scientific output. More closely related to this study, Jacobson et al. (2013) conducted a citation analysis of

articles from archival studies journals from 1980 to 2010 to identify works related to collective memory.

Syllabus studies and course content studies have been conducted as a way to examine a variety of subject areas of LIS. Lowe (1989) conducted a historical review of the changes in syllabi and readings in business information education from the early 1900s to the late 1980s. Lowe's analysis discusses the importance of content, including course readings in syllabi, to ensure that students are prepared for their roles as business librarians. Chan (1987) conducted a survey to identify the instructional materials used in teaching cataloging and classification course. This study aimed to identify the readings materials and how satisfied instructors were with those reading materials. An important point that instructors stated was the importance of keeping content up to date because of changes in technology. White (2005) examined course syllabi for courses regarding business information to examine general topics, business-specific topics, assignments and projects, textbooks and assigned readings to determine the context taught in business information courses in LIS. Hrycaj (2006) analyzed the subject content and assessments of introductory library skills courses to understand the dominant subject matter of these courses and determine what topics and course materials should be included in these courses. Maybee et al. (2015) examined course syllabi using a grounded theory approach to examine how faculty addressed information and data literacy in nutritional sciences and political science courses. Lastly, Worthington (2017) conducted a quantitative content analysis of syllabi from MLIS programs to examine the education of children's librarians.

Additionally, syllabi and curricular studies have been conducted as a way to examine digital preservation and related subdisciplines in LIS. Costello (2010) analyzed the course catalogs of the 26 iSchools to determine which iSchools offered digital preservation classes. Gracy and Croft (2011) surveyed LIS educators to examine the types of preservation courses being offered, the content of these courses, future plans for the curricula, and the topics covered in current courses. Yang (2015) compared topical similarities between digital curation and data curation curricula by identifying topics and comparing topics in course descriptions. Hank et al. (2015) conducted an intensive review of Master's level syllabi to understanding convergence and divergence of reading assignments between digital library and digital curation curriculum. More closely related to this study, Harris-Pierce and Liu (2012) conducted an analysis of course digital curation syllabi from LIS schools in North America focusing on the objective, requirements, topics, and assignments identified in the course. Trace and Ovalle (2012) conducted a study to examine archival courses offered by ALA-accredited MLIS programs during the 2009-2010 academic year. Lastly, Yoon et al. conducted an analysis of digital preservation course syllabi from ALA-accredited schools and examined course content, assigned readings, topics, and assignments. This research included an analysis of the most frequently assigned readings in digital preservation courses (Yoon et al., in press).

Research Methods

This study collected data from Digital Preservation syllabi from the sixty ALA-accredited MLIS program in the United States and Canada between 2017 and 2018 to determine core themes of digital preservation through topic modeling and visual analysis.

Figure 1 provides an overview of the study's research procedures, which consisted of the following steps:

1. ALA-accredited MLIS programs were determined through an examination of the ALA website.
2. Syllabi, in relation to “digital preservation,” were gathered from each accredited ALA-MLIS program.
3. Reading lists from each extracted from each syllabus.
4. Journal articles and conference papers, including keywords and abstracts, were imported into Zotero, and the metadata was cleaned to ensure the accuracy of each item.
5. The Zotero collection was exported to create a .ris and .csv for analysis.
6. Topic modeling analysis was conducted using the Stanford Topic Modeling Toolbox (TMT).
7. Visualization analysis was conducted using VOSviewer.
8. An analysis of digital preservation core themes was conducted by the researchers.

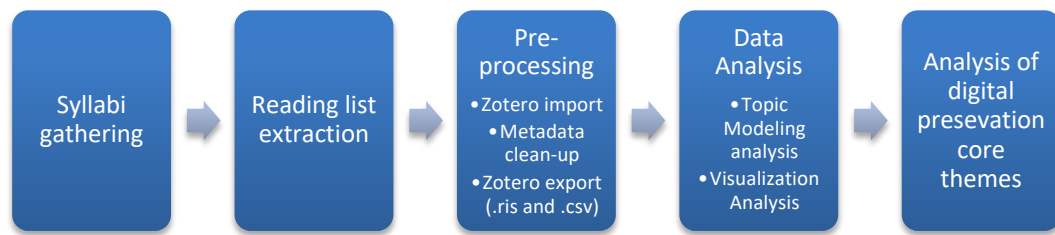


Figure 1. Figure 1 provides this study's research procedures.

Data Collection

To collect a subset of digital preservation literature, we first identified and collected Digital Preservation syllabi from the sixty ALA-accredited MLIS programs in the United States and Canada between 2017 and 2018. These syllabi were identified through an examination of the websites and course listings of each ALA-accredited program. Once the syllabi were gathered, the reading list was extracted from the syllabi. The reading list was further refined to include only journal articles and conference papers due to the practicality of analysis as these types of publications to include keywords and abstracts. For the purposes of topic modeling and visualizations, any duplicate publications were removed from the corpus. However, analyzing the most frequent reading materials is

useful information for the digital preservation education field and can be found in Yoon et al. (in press).

In total, there were 36 courses with syllabi. Some institutions had more than one digital preservation-related course. Appendix 1 provides a list of the institutions and course names of the syllabi examined. Of the 36 course syllabi examined, 27 had reading lists included in the syllabus.

These journal articles and conference papers were then imported into Zotero, and the metadata was cleaned and updated to ensure the accuracy of each item. Abstracts and keywords were identified and added for each item using Scopus, Web of Science, or the journal website. Once these items were updated, the data was exported using Zotero export to create a .ris file and a .csv file for analysis. The final collection of literature includes 427 pieces of literature.

Data Analysis

Two methods were used to analyze the data. First, we employed topic modeling using the Stanford Topic Modeling Toolbox (TMT) (The Stanford Natural Language Processing Group, n.d.). Secondly, we analyzed the data using visual analysis with VOSviewer (Centre for Science and Technology Studies, Leiden University, The Netherlands, 2018). We choose these tools because they both work well with .csv and .ris files, which were directly exported from Zotero, the bibliographic management system we used. Additionally, the TMT provides several topic model methods options, and the VOSviewer provides the ability to visualization by year; these options were helpful to the aims of our study. These two methods of analysis complement each other to provide a more complete understanding of the readings assigned in the Digital Preservation courses and will be described in more detail below.

Topic Modeling of Abstracts

As it is challenging to determine themes from large-scale textual data, topic modeling was employed to analyze the abstracts from the literature. Topic modeling has “proved useful for analyzing and summarizing large-scale textual data” (Song and Ding, 2014). The specific algorithm used was the Latent Dirichlet Allocation (LDA), which produces proportions of topics within documents and is a “generative probabilistic model for collections of discrete data such as text corpora” (Blei et al., 2003).

We employed the TMT developed by the Stanford Natural Language Processing Group to create each topic model. The software provides a simple Java interface and works well with .txt and .csv files. Additionally, the software provides a series of tokenizers to prepare the data for analysis and then provides parameters for training the LDA models. Furthermore, the software provides the option to explore several topic model methods, including a Collapsed Variation Bayes Approximation and a Collapsed Gibbs Sampler, both were tested, and the Collapsed Variation Bayes Approximation was ultimately used to create the topic models.

The software provides the ability to calculate a perplexity calculation. The perplexity calculation determines the most optimal number of topics for the dataset, meaning how many topics should be produced for optimal analysis. Therefore, we calculated the

perplexity prior to creating the topic models. In the case of this dataset, the most optimal number of topics was 5.

The concept behind LDA is that “one document contains multiple topics, and each topic requires specific words to describe it” (Song and Ding, 2014: 235). Therefore, in topic modeling, the observed variables are words in the documents, and the hidden variables are topics. The output of the topic models included the top twenty terms per each topic and the probability of each term and topic. All proportions of the terms and topics were converted into percentages for ease of reading.

Once the software generated the five topics and the top twenty terms per topic, and probabilities, we analyzed each topic and the terms within the topic to determine the thematic meaning of each topic, as recommended by the literature (Song and Ding, 2014). LDA uses soft clustering, so each term can appear in more than one topic, and it is recommended to incorporate human judgment to increase thematic meanings of topics (Song and Ding, 2014). For the topic modeling analysis, we interpreted the meaning of the topics or themes through considering the prevalent terms in each topic, the term probability, and the themes seen in each topic. Through this analysis, the thematic meaning of each topic was determined.

Visual Analysis of Citation Data

Another method proven useful to analyze large-scale textual data is visualization. As we wanted to examine the themes, the year distribution of themes, and the co-authorship found in the literature, we produced several visualizations using the VOSviewer software. Bibliometric data contains a vast amount of information, including title, author, keywords, and abstracts. This data can be used to better understand the bibliometric network, and “visualization has turned out to be a powerful approach to analyze a large variety of bibliometric networks” (Jan van Eck and Waltman, 2014). As described in the literature, bibliometric networks consist of nodes and edges where the nodes are, for example, keywords, research, and publications, and the edges indicate the relations between pairs of nodes (Jan van Eck and Waltman, 2014). A variety of analyses can be conducted, including co-authorship, co-citations, and title, abstract, and keyword analysis.

The VOSviewer software, created at Leiden University, is a free software tool for constructing and visualizing bibliometric networks (Centre for Science and Technology Studies, Leiden University, The Netherlands, 2018). The software provides the ability to import .ris and .csv files to conduct a number of visualization techniques, including co-authorship, title, abstract, and keyword analysis, which was the analysis conducted for this research. The researchers produced several visualizations, including abstract and title, keyword, and co-authorship visualization. Additionally, the VOSviewer allows for these visualizations to be examined by the publication year, which provided further insight into the digital preservation literature.

Findings

Of the 36 course syllabi examined, 27 had reading lists included in the syllabus. From those 27 reading lists, a total of 427 journal articles and conference papers were gathered. The date of publication ranged from 1953 to 2017, with 2011 having the most publications (Figure 2).

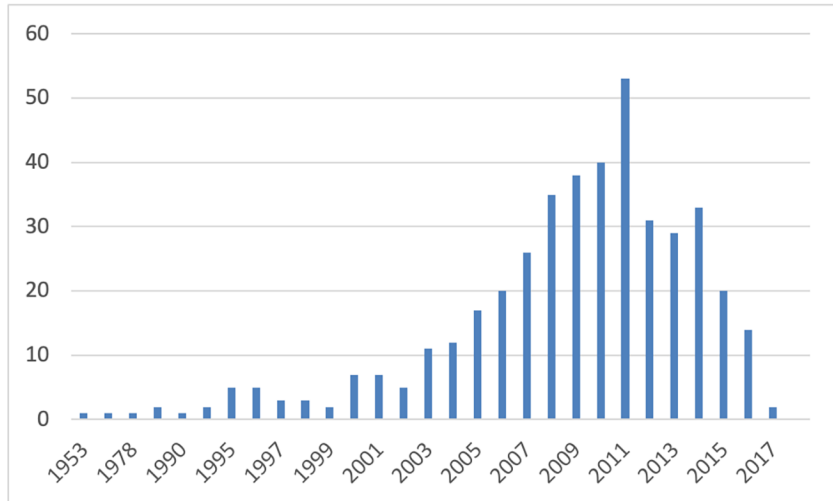


Figure 2. Figure 2 provides the number of publications per year in the dataset.

The majority of the readings were published in American Archivists and the International Journal of Digital Curation. Table 1 shows the Top 10 journals and the count and percentage of the total corpus each comprised.

Table 1. Table 1 provides the top 10 journals in the literature.

Journal Name	# Publications	% Publications
American Archivist	52	12.21%
International Journal of Digital Curation	46	10.80%
D-Lib Magazine	40	9.39%
Archivaria	35	8.22%
Archival Science	19	4.46%
Library Trends	10	2.35%
Library Hi Tech	7	1.64%
Preservation, Digital Technology & Culture	6	1.41%
Ariadne: A Web & Print Magazine of Internet Issues for Librarians & Information Specialists	6	1.41%
Journal of the Association for Information Science & Technology	6	1.41%

Topic Modeling: Major Themes by Topics

Five topic models were produced using the LDA topic modeling Stanford Topic Modeling Toolkit.

Figure 3 shows the major themes of each topic. The topics are fairly equally distributed, with each falling between 22 and 18 percent of the total corpus. The theme “Library Contribution to Digital Preservation” is the most salient of the topics, followed by “Technical Requirements for Digital Preservation,” “Digital Archives,” “Access and Use,” and “Research Data Management Across Disciplines.” Each of these topics represents the major themes in the abstracts of the corpus of literature from the digital preservation courses.

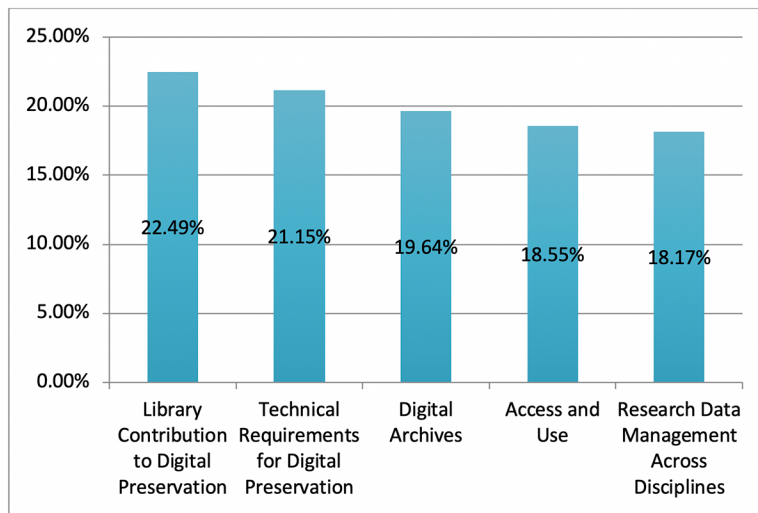


Figure 3. Figure 3 depicts the probability in percentages of each topic model in the dataset.

The TMT toolbox provides more detailed information regarding each topic by producing the top twenty terms for each topic and the probability of each term (Table 2). Again, probabilities were changed to a percentage for ease of reading. The researchers analyzed each topic and the associated top twenty terms to determine the topic themes as described in the research methods.

Table 2. Table 2 provides the top twenty terms in each topic and percentages of each term and topic.

Topic 1: Library Contribution to Digital Preservation (22.49%)	Topic 2: Technical Requirements for Digital Preservation (21.15%)	Topic 3: Digital Archives (19.64%)	Topic 4: Access and Use (18.55%)	Topic 5: Research Data Management Across Disciplines (18.17%)
Digital (19.85%)	Preservation, Preserve, Preserving	Archives/ Archival (23.42%)	Web (11.14%)	Data (34.17%)

	(26.22%)			
Library(ies) (14.15%)	Digital (21.72%)	Records (18.09%)	Information (10.95%)	Science/Scientists/Scientific (12.16%)
Preservation (8.57%)	Authenticity (4.50%)	Metadata (7.74%)	Access (8.45%)	Research (9.47%)
Project(s) (7.80%)	System(s) (4.36%)	Electronic (4.74%)	Collections (5.75%)	Repository(ies) (8.00%)
Curation (6.73%)	Article (4.08%)	Article (4.59%)	Use (5.71%)	Management (3.78%)
Institution(s)/ Institutional (4.45%)	Objects (3.67%)	Digital (3.98%)	Archives (5.66%)	Sharing (3.23%)
Research (4.35%)	Requirements (3.62%)	Systems (3.43%)	Online (5.58%)	Social (3.19%)
Article (3.96%)	Content (3.43%)	Practice (3.34%)	Content (4.88%)	Open (2.44%)
Information (3.77%)	Issues (3.30%)	Implementation (3.17%)	Users (4.78%)	Practices (2.34%)
National (2.88%)	Storage (2.67%)	Theory (2.92%)	Format (4.11%)	Trust (2.28%)
Management (2.80%)	Physical (2.56%)	Evidence (2.66%)	File (3.95%)	Humanities (2.26%)
Digitization (2.80%)	Information (2.54%)	Personal (2.66%)	Copyright (3.77%)	Services (2.25%)
Collections (2.76%)	Used (2.32%)	Tools (2.59%)	Article (3.50%)	Curation (2.20%)
University (2.52%)	Public (2.24%)	Archivists (2.61%)	Archivists (3.45%)	Datasets (2.15%)
Development (2.47%)	Computer (2.17%)	Practices (2.55%)	Collection (3.12%)	Users (2.14%)
Challenges (2.41%)	Questions (2.17%)	Process (2.44%)	Approach (3.11%)	Researchers (2.05%)
Resources (2.10%)	Years (2.15%)	Research (2.42%)	Tools (3.10%)	Faculty (1.92%)
Discusses (2.09%)	Long-term (2.13%)	Concept (2.40%)	Provide (3.01%)	Context (1.34%)
Program (1.78%)	Technical (2.09%)	PREMIS (2.26%)	People (3.00%)	Analysis (1.32%)
Material (1.76%)	Media (2.06%)	Forensics (2.05%)	Material (2.99%)	Design (1.31%)

The top twenty terms of each topic provide distinctive themes important to digital preservation. The first topic, “Library Contribution to Digital Preservation,” is referring to how libraries support digital preservation and curation. The terms, including projects, management, digitization, collections, development, and resources, indicate the types of activities that libraries and institutions perform to contribute to digital preservation efforts. The topic’s focus indicates how organizations, including libraries and other institutions, contribute to digital preservation through the many activities they perform.

Topic two, “Technical Requirements for Digital Preservation,” shows the importance of understanding the technical issues involved with digital preservation, including authenticity, systems, storage, long-term requirements, and media. This topic focuses on the various technical requirements needed for digital preservation, as without systems and storage, digital preservation could not be achieved. This theme indicates how the

literature assigned in digital preservation coursework ensures that students understand the technical concerns within digital preservation.

Topic three, “Digital Archives,” shifts the focus to digital archives and the importance of archival theory, records, and practice in digital preservation. As discussed in the literature review, the archival field has been an important contributor to digital preservation. This topic demonstrates the importance of the archival field within the digital preservation field by showing how the digital preservation curriculum ensures that students have a thorough understanding of digital archives.

Topic four focuses on “Access and Use,” showing the importance of understanding access, user groups, and designated communities of digital collections. This topic focuses on access, including web access and other online portals, as well as the potential complications of access and use, including copyright and format. This topic stresses the importance of understanding the user community, as well as any limitations to access of collections for the user community.

Topic five, “Research Data Management Across Disciplines,” shows the importance of research data management for all disciplines. This topic includes terms such as science, social, and humanities, showing how all disciplines are impacted by research data management and how much of these data are managed by repositories. The importance of research data management across all disciplines has been impacted by the data sharing policies of major grant funders, as well as data sharing policies of journals. Digital preservation supports and provides the necessary tools for the long-term preservation of research data and to adhere to grant and journal requirements. Additionally, this topic includes terms such as sharing, open, and trust, indicating how open and shared data are growing more significant amongst all disciplines, and how trust is important in sharing and reuse of research data.

Together these five topics show the main themes included in the literature that are assigned in digital preservation courses. These themes indicate what topics are deemed as most important to educators when it comes to digital preservation curriculum, as well as the themes that most educators focus on throughout digital preservation courses. MLIS students taking digital preservation courses are spending significant portions of their time exploring these topics through the course readings.

Visualization: Major Themes through Visualization

Visualizations were created to gain a deeper understanding of the themes in digital preservation literature. As with topic modeling, visualizations can also assist in finding themes in textual-based documents. Figure 4 provides a clustering of terms from the abstracts and titles of the literature and provides five themes predominant occurring within the literature.

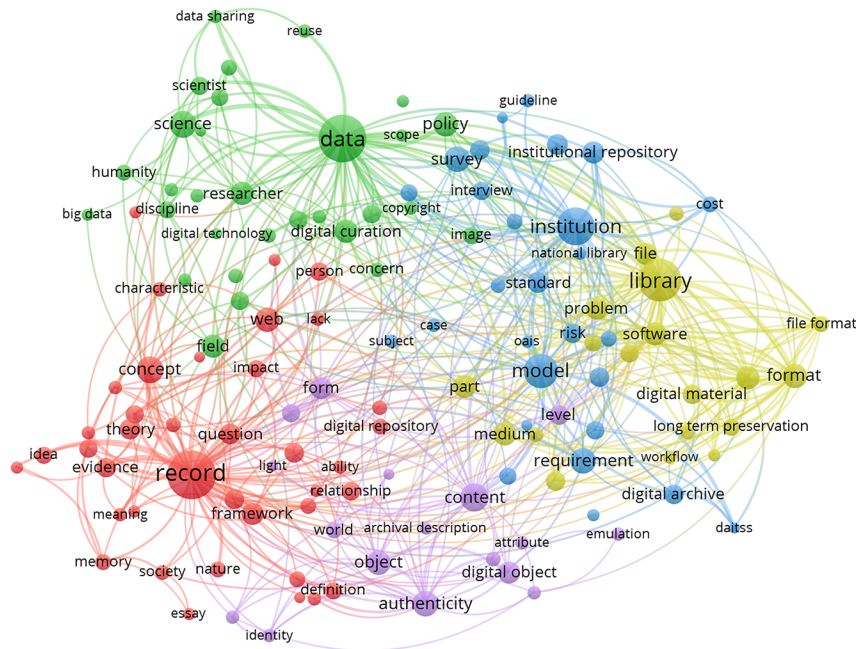


Figure 4. Figure 4 depicts the abstracts and titles terms.

The themes include:

1. The red cluster is records-focused
2. The green cluster is data-focused
3. The blue cluster is institutional-focused
4. The yellow cluster is library-focused
5. The purple cluster is digital object-focused

When examining the records-focused cluster (red), several items stand out. First, its relation to the purple cluster show there are connections and overlaps in terms such as authenticity and object. In the archival field, authenticity refers to “the quality of being genuine, and is closely associated with the creator of a record, however, does not automatically imply that the content of the record is reliable” (Society of American Archivists, 2020) and is a core concept in studying archival materials. This connection shows digital preservation literature used in the classroom included theories and practices from archival science literature.

The data-focused cluster (green) focuses on research data through terms such as researchers, scientists, science, humanities, and discipline, showing the importance of research data across all disciplines. Additionally, this cluster connects strongly with both the records-focused cluster (red) and the institution-focused cluster (blue), indicating the relationship between these two themes. In many cases, it is the universities or institutions that support data management. Many universities provide the infrastructure for data deposition through institutional repositories and the support and services for research data management by providing guidance on data management plans, education on best practices for research data management, and guidance on data repositories that exist outside of the institution.

The institution-focused cluster (blue) focuses on items related to institutional repositories such as guidelines, standards, copyright, and digital archives. This cluster is strongly related to the library-related cluster (yellow), as institutional repositories are often associated with libraries. While libraries and institutional repositories are two distinct organizations, there has historically been a relationship between the two entities. As described by Cragin et al. (2010), scientists turn to their university libraries and institutional repositories to assist with their data problems. In a study by Westell (2006), the author described the relationship between institutional repositories and academic institutions, as well as how they provide support and guidance for items such as copyright and access. To be clear, academic institutions can have both internally managed and externally managed through commercial vendors' institutional repositories.

The library-focused cluster (yellow) focuses specifically on actions that the library participates in to ensure preservation, such as file, format, medium, indicating that the library takes part in the creation of long-term preservation strategies. This cluster is most strongly connected with the institution-focused and (digital) object-focused cluster. As described previously, there has been a historical relationship between academic libraries and institutional repositories. This relationship demonstrates how libraries assist with the specific technical requirements for long-term preservation through educational resources and by providing the technical infrastructure needed.

The digital object-focused cluster (purple) is the least strong in regards to determining a precise understanding of the theme associated with this cluster. However, it focuses on digital objects and the associated archival topics and conceptual approaches for preservation, such as authenticity, attributes, and archival description. This cluster has the strongest relationship with the red cluster, or record focused cluster. As the purple cluster is focused on archival-related requirements associated with digital objects, it would make sense that this group had the strongest relationship with the records cluster, given the history of archival theory approaches in archives and records management (Brown, 2014).

Trends by Year

Analysis of the abstracts and titles by year provides additional insights into digital preservation literature. Figure 4 provides the visual analysis of the abstracts and titles, which is the same as Figure 5, however, in the case of Figure 5, the terms are color-coded by the year that they most often appear.

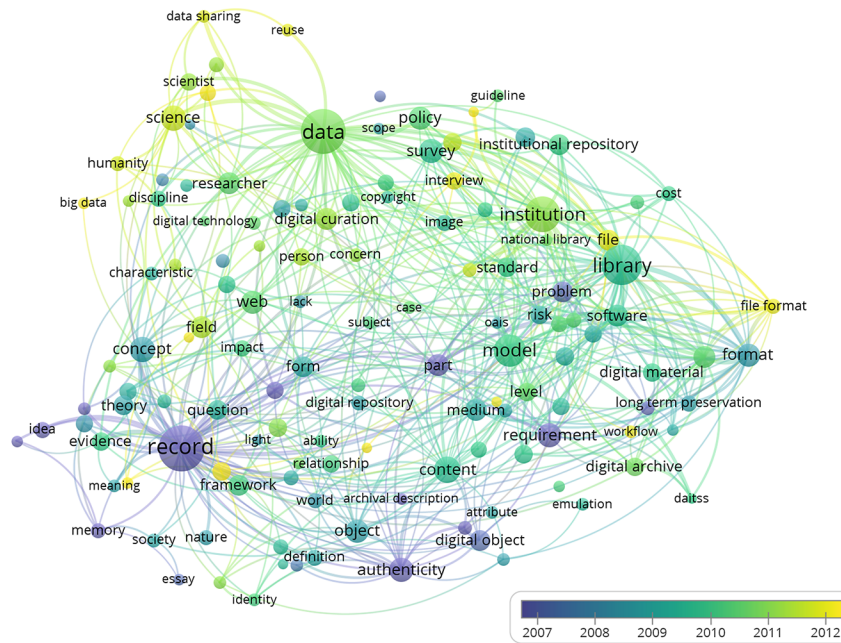


Figure 5. Figure 5 depicts the abstracts and titles terms, as well as the year they are most prevalent.

Figure 5 provides a way to examine the prevalent themes in the literature based on the year the associated publication was published and can be used to examine the changes over time in the themes of digital preservation literature. As can be seen, record, authenticity, and digital object were particularly important in the early literature (2007-2008), format, library, and institutional repository (2009-2010), digital curation, data, and scientist (2010-2011), and big data, humanities, data sharing and reuse (2012-present).

These results are supported by an additional analysis of the keywords associated with the digital preservation publications by year. As shown in Figure 6, the keywords followed a similar; however, not always precisely the same pattern as the abstract and title analysis.

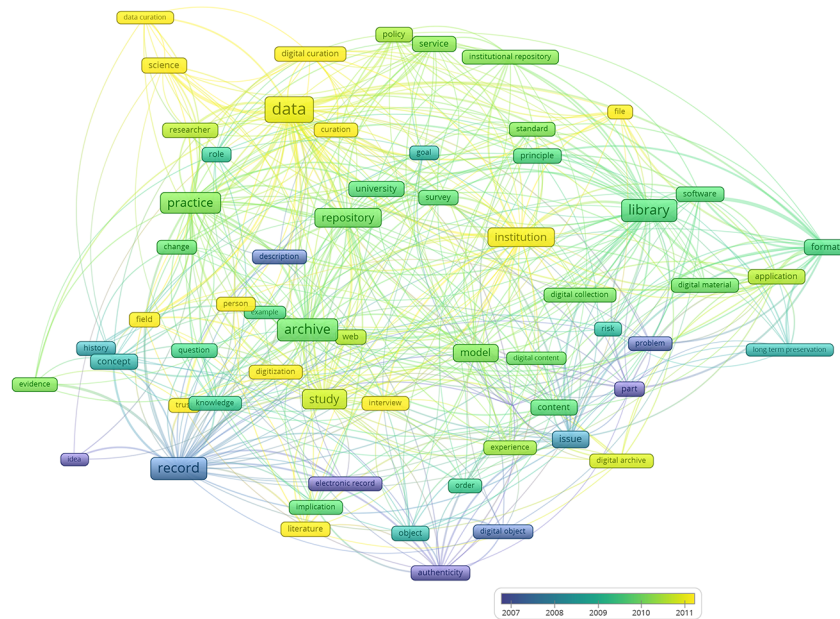


Figure 6. Figure 6 depicts keyword visual analysis, and the year they are most prevalent.

In Figure 6, the keywords most prevalent in the early literature included electronic record, authenticity, followed by record, digital object, description, followed by library, archive, and then long-term preservation, digital collection, institutional repository, and format, and finally ended with data, curation, and science. This follows a similar pattern as the abstracts and titles, with some variation, however, shows the same general trends that have occurred in digital preservation literature.

Trends in Co-Authorship

The last visual analysis that was conducted was an analysis of the co-authorship of the publications. Figure 7 shows the co-authorship within the corpus of literature; six co-authorship clusters were found. These six clusters include the lead authors of Andreas Rauber (Vienna University of Technology), Christoph Becker (University of Toronto), Seamus Ross (University of Toronto/University of Glasgow), Margaret Hedstrom (University of Michigan), Christopher Lee (University of North Carolina-Chapel Hill), and Geoffrey Brown (Indiana University-Bloomington).

The visualization provides six clusters and shows any links that occurred between the clusters. For example, in the green cluster, Rauber co-authored more often than the others in this cluster. He has links to both the blue cluster and the yellow cluster. Similarly, Becker in the blue cluster has co-authored with Hofman in the yellow cluster and Kulovits in the green cluster. This was not surprising given that the majority (57%) of the publications in the corpus were single-authored publications.

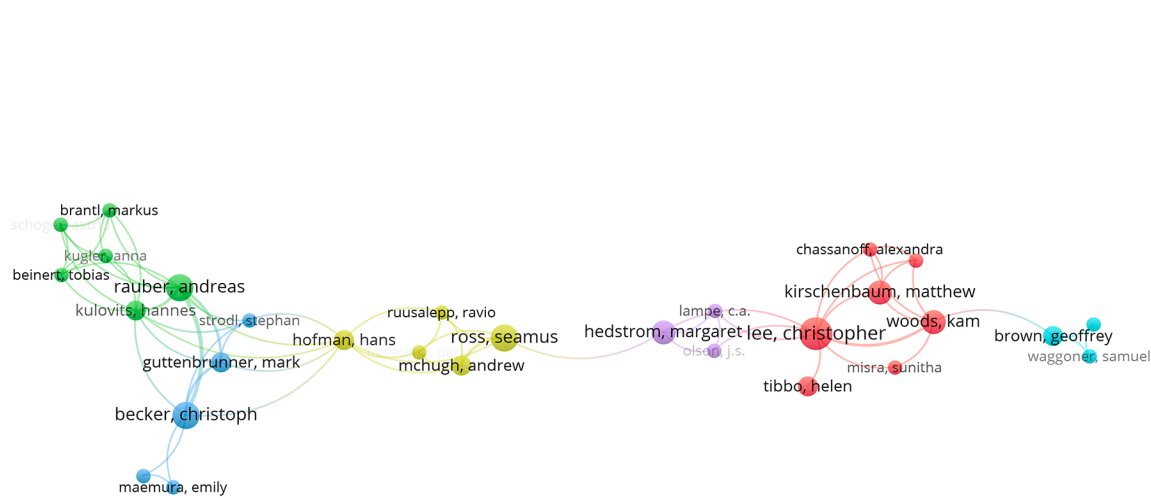


Figure 7. Figure 7 depicts a co-authorship visualization of the literature.

Several of these clusters came from authors from the same university. For example, Lee, Tibbo, Woods, and Chassenoff are all from the University of North Carolina-Chapel Hill, and Hedstrom and Lampe are both from the University of Michigan. There was some collaboration between the University of Glasgow and the National Archive of the Netherlands and the Vienna University of Technology and Bavarian State Library.

Discussion

The results provide a deeper understanding of what is considered core digital preservation literature in a higher educational context. The themes embedded in the literature are subsequently being taught in digital preservation courses and provide an understanding of the current scope and focus of digital preservation education.

From the topic models, these major themes include libraries' contribution to digital preservation, technical requirements for digital preservation, digital archives, access and use, and research data management. From the visual analysis, these themes include libraries, institutions, digital objects, records, and data.

The topic modeling and visualization analysis support and complement each other. While the topic maps provide very concrete and clear delineations of topics in the literature, the visualization broadly supports these delineations and provides a secondary analysis of the changes in themes over time and the connections between the themes. These findings are supported by the disciplinary activity of both libraries and archives in the development of digital preservation, as well as the more recent inclusion of research data management as part of digital preservation, and lastly the importance of understanding technical requirements, as well as access and use needs in digital preservation. These findings reflect the breadth and depth of topics digital preservation educators include in digital preservation courses.

Both topic modeling and visualization produced similar groupings of the major themes, and in this way, both techniques supported and corroborated the findings. Table 3 provides the findings corroboration between each method, the major themes, and the strength of the corroborative relationship. We examined the terms the topic models (Table 2) and the terms from the visualization clusters (Figure 4) to determine similarities and semblances between the topics and visualization clusters. When we observed considerable overlap between terms, we considered these strong relationships, while

weak relationships were considered clusters that had fewer overlapping terms or themes. For example, topic 5, Research Data Management Across Disciplines, and the Green cluster share many terms such as data, science, scientists, sharing, and humanities, indicating a strong relationship. These are the major themes found in the digital preservation literature and are subsequently the focus of digital preservation education.

Table 3. Findings Corroboration

Topic Models	Abstract and Title Visualization	Relationship Strength
Library Contribution to Digital Preservation	Library-focused cluster (Yellow) Institution-focused cluster (Blue)	Strong relationship
Technical Requirements for Digital Preservation	Digital object-focused cluster (Purple)	Weak Relationship
Digital Archives	Digital object-focused cluster (Purple) Record-focused cluster (Red)	Strong Relationship
Access and Use	Record-focused cluster (Red)	Weak Relationship
Research Data Management Across Disciplines	Data-focused cluster (Green)	Strong Relationship

While there was overlap with the visualization clusters, there were two Topic Models that did not appear as distinctly in the visualization analysis. These are the Technical Requirements for Digital Preservation and Access and Use and are noted with “weak relationship” in Table 3.

Similar corroboration for year distribution of terms was found both in the visualization of abstracts and titles (Figure 5) and visual of keywords (Figure 6). From these figures, we see a general change over time in digital preservation education through the use of literature from records to libraries to institutional repositories to data curation, and lastly to big data. This change over time supports the general change we see in the literature and the field moving from records and archives focused to data curation and preservation focused. It also demonstrates the major themes and topics the field is currently focusing on, including the more recent and emerging topic of big data. The change in digital preservation education focus could be indicative of the general changes in the digital preservation field.

The co-authorship analysis (Figure 7) indicated six co-authorship groups that existed within the corpus of literature that we analyzed. It is important to reiterate that the majority of the literature in our corpus were single-authored, which likely accounts for the relatively small number of co-authorship clusters. Additionally, the corpus only

included journal articles and conference proceedings, not technical reports or white papers. One possible consideration for the relatively small number of co-authorship clusters is that the nature of research articles are often theoretically or conceptual-based research that may tend to lead toward single-authorship or just a few co-authors. Hank et al. (2015) had similar findings, in that, the majority of the journal articles found in the digital curation syllabi they analyzed were single-authored. Additionally, Hank et al. (2015) found that four authors accounted for nearly 10% of the assigned journal articles.

One noticeable feature of the findings is that the six co-authorship groups indicated some of the major research groups that have also been supported through major grant projects. For example, the red cluster that includes Lee, Tibbo, Chassanoff, Woods, and Kirschenbaum were all researchers who worked on the DigCCurr¹ and BitCurator² projects together. Another example is the purple cluster indicating that Hedstrom, Lampe, and Olson worked together on the CAMiLEON Project³. Additionally, these findings indicate how these major research groups interact. For example, the teal and red cluster are connected by Woods and Brown, who both worked together at Indiana University. Another interaction occurs with Lee from the red group, connecting with the purple group through his work with the CAMiLEON Project.

While these co-authorships and connection may seem relatively minimal, it is important to remember that technical reports and white papers were not included in this analysis. And from previous literature, it is known that technical reports and white papers are heavily used as course content in digital preservation courses (Yoon et al., in press).

These findings are important to the field in several ways. They provide reflective feedback to digital preservation educators by demonstrating what concepts are being taught to MLIS students and can be used to determine what gaps there are in the current digital preservation courses.

These gaps include the need for more inclusion of newer technologies and techniques such as cloud computing and new storage techniques for digital materials and special topics such as web archiving, digital forensics, and 3D preservation. As technology and data change, it is important to ensure that these topics are included in digital preservation education. While some newer topics such as big data seem to be represented in the literature used in the classroom, other important topics such as digital forensics and 3D preservation were not represented in either analysis. The topics such as web archiving, digital forensics, and 3D preservation were also not found in previous studies of syllabi and curriculum (Hank et al., 2015; Harris-Pierce and Liu, 2012). However, in Harris-Pierce and Lui (2012), the third most prevalent topic included hardware and software platforms and technologies, which could potentially include cloud computing and storage techniques.

Additionally, there is a need for specific topics to be included, such as ethics, governance, and policy. While policy was represented in the data-related cluster in the visual analysis, it was not a top term for any of the topic models. Ethics was not represented in any of the

¹ <https://ils.unc.edu/digccurr/>

² <https://bitcurator.net/>

³ http://chnm.gmu.edu/digitalhistory/links/cached/preserving/8_3a_si.htm

findings, which is a major concern as it is important for students to understand any ethical considerations for working with digital objects. Furthermore, governance was not represented in any of the findings as well. Similar findings were found in previous research from Yoon et al. (in press) and Garnar (2016), in that these studies also indicated that there was a general lack or shortage of ethics topics in courses. In the data curation curriculum review conducted by Harris-Pierce and Lui (2012), ethics, governance, and policy were not found as major topics in the curriculum.

Lastly, digital preservation techniques were not strongly represented in the literature used in the classroom, such as emulation, migration, fixity, and persistent identifiers, which indicate the need to emphasize technical and practical aspects of digital preservation within the classroom. This may be because these techniques are being taught through other means, such as websites, technical reports, and textbooks that are not represented in this corpus that was analyzed for this study. However, as discussed in the problem statement, textbooks are not often utilized in digital preservation courses. In a study by Yoon et al. (2016), emulation and migration were indicated as topics that appeared in syllabi, however, fixity and persistent identifiers were not. The DigCurV Curricular Framework (2013) includes digital forensics, 3D preservation, policy formulation, software, cloud storage, emulation, migration, fixity, and persistent identifiers as core competencies reinforcing that these concepts should be taught in digital preservation courses.

Limitations and Conclusions

This study provides a way to understand the emerging trends in digital preservation education through an analysis of literature assigned in digital preservation courses at ALA-accredited MLIS programs with the assumption that this literature is representative of the main topics and concepts taught in these courses.

There are several limitations to this study. One limitation of this study is that the corpus of literature for this study included only journal articles and conference proceedings and, therefore, did not include technical reports and white papers important to the digital preservation field. This decision was made because technical reports and white papers do not often contain abstracts and keywords. We recognize this is a limitation due to the importance of technical reports and white papers in the Digital Preservation community. In a study of digital preservation course syllabi, it was noted that technical reports and white papers were the second-highest most assigned reading. However, journal articles were the highest most assigned reading, conference proceedings were commonly assigned, and textbooks were not common (Yoon et al., in press). Another limitation is that the majority of the publications in the corpus were single-authored; therefore, it is difficult to assess co-authorship. Furthermore, collaborative efforts could be occurring in reports and white papers and, therefore, not represented in this research. Even with this limitation, co-authorship analysis provides some insights in terms of intellectual leaders of the field.

Despite these limitations, this study provides a way to understand the current trends in digital preservation education, as well as an understanding of the most recent changes in

the field, and can be a useful tool for curriculum development and research within digital preservation. From this research, several future studies can be considered.

A qualitative analysis of the textual data from this research could provide additional information. While topic modeling and visualization are both excellent methods to understand large-scale textual data, both methods can lack nuance in that they only consider the most prevalent terms in the corpus. For this paper, we chose the TMT Toolkit and the VOSViewer software because they work well with .ris and .csv files, which can be directly exported from bibliographic management systems such as Zotero. However, this same bibliographic data can be qualitatively analyzed, which could provide additional insights into trends in digital preservation education.

An additional future study would be to consider that digital preservation is taught outside of LIS in other disciplines, such as engineering and computer science. These fields take on a more technical approach to digital preservation (Li et al., 2010) or a software development approach (Drees et al., 2018). This research is often excluded from LIS syllabi and therefore is likely not represented in the findings. Examining the syllabi from these other disciplines is a future opportunity that could complement this study and potentially provide a meaningful comparison of the various approaches to teaching digital preservation.

This study provides an examination of digital preservation educational trends by examining the assigned literature in courses from ALA-accredited MLIS programs. This study provides an understanding of the current topical trends, collaborative contributions, and potential gaps in the literature. This study can be used as a guide by digital preservation educators to understand current trends and to consider including literature that is not currently well-covered in digital preservation courses.

Data Accessibility

The data for this research is available through IUPUI DataWorks at <http://hdl.handle.net/11243/26> (Murillo and Yoon, 2020).

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Appendix 1: Institutions and Course Syllabi Examined

Institution	Course Name/Syllabi Examined
University of Arizona	Introduction to Digital Preservation and Curation
University of Arizona	Preserving Digital Collections
British Columbia, University of	The Preservation of Digital Records
University of California, Los Angeles	Digital Preservation
Catholic University of America	Digital Curation
Emporia State University	Issues in Preservation, Access, and Digitization
Indiana University	Digital Curation
Indiana University-Purdue University Indianapolis (IUPUI)	Digital Preservation
Kent State University	Introduction to Digital Preservation
Kent State University	Digital Curation
McGill University	Digital Curation
University of Maryland	Policy Issues in Digital Curation
University of Maryland	Digital Preservation
University of Maryland	Curation in Cultural Institutions
University of Maryland	Implementing the Curation and Management of Digital Assets
University of Maryland	Introduction to Archives and Digital Curation
University of Maryland	Principles of Digital Curation
University of Maryland	Solving Problems in Digital Curation - Capstone Course

University of Maryland	Field Study in Archives and Digital Curation
University of Michigan	Digital Preservation
University of Montreal	Digital Archives Management
University of North Carolina-Chapel Hill	Digital Forensics for Curation of Digital Collections
University of North Carolina-Chapel Hill	Digital Preservation and Access
University of Oklahoma	Preservation of Information Materials
City University of New York, Queens College	Digital Preservation
San Jose State University	Seminar in Archives and Records Management Topic: Digital Curation
San Jose State University	Seminar in Archives and Records Management Topic: Tools, Services, and Methodologies for Digital Curation
San Jose State University	Enterprise Content Management and Digital Preservation
San Jose State University	Seminar in Archives and Records Management Topic: Digitization and Digital Preservation
San Jose State University	Seminar in Archives and Records Management Topic: Characteristics and Curation of New Digital Media
Simmons College	Archiving and Preserving Digital Media
Syracuse University	Creating, Managing, and Preserving Digital Assets
University of Tennessee	Digital Curation
University of Texas-Austin	Digital Archiving and Preservation
University of Toronto	Digital Preservation and Curation
University of Wisconsin-Madison	Digital Curation