Competency-based Curriculum: An Effective Approach to Digital Curation Education

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The University of North Texas conducted a project involving rigorous curriculum development and instructional design to address the goal of building capacity in the Library and Information Sciences curriculum. To prepare information professionals with the competencies needed for digital curation and data management practice, the project developed curriculum using a competency-based approach. The purpose of this paper is to discuss the design and implementation of the digital curation curriculum at the University of North Texas. The paper advances theoretical perspectives of competency-based curriculum as steps taken toward innovative curriculum development efforts. Additionally, it contributes to the practice of digital curation education. The set of competencies defined in the paper can serve as a common language among stakeholders to prepare future digital curation professionals. This paper concludes that a competency-based approach is effective, sustainable, and can be customized to address the skill gaps in the rapidly evolving information professions.

Keywords: curriculum development, competency, competency-based education, competency-based curriculum, digital curation, data management

Introduction

Novel trends within higher education over the last decade have seen the emergence of innovative learning initiatives that involve the application of new and emerging technology tools, delivery platforms, and/or new business models and pedagogy. One such initiative is competency-based education (CBE), which has become one of the biggest "buzzwords" in academia today. This is evidenced by recent publications on this topic, for example, EDUCAUSE Learning Initiative White Paper, "*7 Things You Should Know About Competency-Based Education,*" (2014). Likewise, the *New Media Consortium Horizon Report 2015* listed CBE as an alternative to traditional place-based education and as a way to bring greater personalization to higher education curricula (Johnson, Becker, Estrada, & Freeman, 2015). CBE was also discussed in the *2015 Association of College & Research Libraries Environmental Scan* as one of the emerging issues that will define the future of academic and research libraries (Association of College & Research Libraries, 2015).

Although the concept and boundaries of CBE are frequently blurred, there is a general agreement that CBE is characterized by the development of clearly defined competencies, a mapping of the curriculum to achieve those competencies, and an assessment process matched to the competencies. (Jones, Voorhees, & Paulson, 2002). Such competencies are often linked to workforce needs, as defined by employers and the profession—i.e., specific knowledge, skills, and abilities (KSAs) valued by working practitioners in the field. A curriculum consists of a specified, organized body of learning activities designed to equip students with the KSAs and integrative experiences that lead to the

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acquisition of competencies needed for a degree (Jones, 2001).

While this approach to preparing professionals goes back to the 1970s, an emphasis on program goals and objectives was widely adopted in the early 21st century (Frank *et al.*, 2010). In the United States, the competency-based teacher education movement served as the starting point for the next movement. The approach also influenced the design and delivery of vocational education in the United Kingdom and particularly in Australia, where national reforms in the late 1980s and early 1990s required that all accredited vocational education programs be competency-based (Hodges & Harris, 2012). Later, the National Postsecondary Education Cooperative convened a group of experts in CBE and published a report that explored CBE models in postsecondary institutions. According to that report (National Center for Education Statistics, 2002), implementing competency-based initiatives is important for two major reasons:

> One main reason is that specific articulations of competencies inform and guide the basis of subsequent assessments at the course, program, and institutional levels. Secondly, specific competencies help faculty and students across campus, as well as other stakeholders such as employers and policymakers, to have a common understanding about the specific skills and knowledge those undergraduates should master as a result of their learning experiences (p. vii).

In recent years, the approach has attracted renewed interest among educators in higher education (Fain, 2013; Parry, 2013). In March 2013, the U.S. Department of Education issued guidance for higher education institutions that offer competency-based programs. The department announced that colleges could begin providing student federal aid based on students' mastery of "competencies;" that is, what students know and can do. This focus on the demonstration of competency has been exemplified in several initiatives, including Mozilla's Open Badges and edX's Verified Certificates of Achievement. Furthermore, the shift from credit hours completed to competency demonstrated has been executed in a number of institutions in the USA, such as Indiana University-Purdue University Indianapolis (IUPUI), Michigan State University, and University of Wisconsin. These institutions are currently offering competency-based professional degrees and certificates in nursing, public health, and business and technical communications.

The approach, which focuses on the competency necessary to be proficient for employment or practice in a profession may also have application in the Library and Information Science (LIS) field. In the context of preparing information professionals, the concept of competencies has been discussed and utilized. Many professional associations have put effort into developing competency statements that set their expectations for the desired KSAs professionals should possess. One example from the American Library Association (ALA) is its Core Competences of Librarianship, which includes areas such as organization of recorded knowledge and information; reference and user services; technological skills and knowledge; and administration and management (ALA, 2009). Additionally, a competency-based approach in LIS education has been discussed and examined in a range of domains. These include identifying competencies through the analysis of job advertisements (e.g., Fisher, 2001; Sutton & Davis, 2011; Winston & Dunkley, 2002), addressing competencies for specific positions or in certain areas (e.g., Nwakanma, 2011; Hazeri, Sarrafzadeh, & Martin, 2007), and exploring to what extent LIS curricula are meeting professionals competencies (e.g., Kules & McDaniel, 2010; Lester & Van Fleet, 2008; Scripps-Hoekstra, Carroll, & Fotis, 2014). Although much discussion has taken place

on the topic of competency in workforce development and education, the concept of competency in LIS has centered on what is expected of a professional in the workplace rather than on the learning process. As such, one area of concern that provides scope for additional investigation is how to systematically link competencies to student learning outcomes or assessment of student learning.

The University of North Texas Department of Library and Information Sciences recently developed and implemented a digital curation curriculum based on a competency-based approach. This paper will address the background behind the creation of the curriculum, and then discuss its development and implementation according to the following three phases:

1. Identifying competencies;
2. Linking competencies to courses; and
3. Assessing competencies in curriculum.

Although these phases are discussed here as discrete steps, the three phases took place in a continuous cycle as program segments were developed.

Background

With the advent of the digital era, libraries, archives, and museums have increased their responsibility and work in creating, collecting, preserving, managing, and providing access to their digital information resources. Research and practice in digital preservation and archiving has shown "it is impossible to keep things the same forever" (Cloonan, 2001, p. 235). With this in mind the focus of the profession has shifted to questions concerning the value and long-term sustainability of information. These questions have gained interest and support in the LIS field given the explosion in the amount and complexity of digital data being generated. As such, the strategic emphasis on long-term management has moved from passive preservation to active curation. To ensure the access, use, and reuse of digital materials throughout their lifecycle, digital curation has emerged as a new area of interest to address such questions.

Institutional digital library and digitization initiatives in research libraries have brought to light the exponential growth of research data. This in turn has led to the development of an institutional view of stewardship and preservation. Researchers now generate, integrate, manage, and share large data sets to ensure that they are retrievable for future research or reuse. Many U.S. government agencies increasingly recognize that the scientific, biomedical, and engineering research communities are undergoing a profound transformation in regard to accessing and reuse of large-scale and diverse research data sets. As such, these agencies have written policies that encourage data sharing and mandate data management plans. In light of this movement, the importance of curating research data has been highlighted and has brought not only new opportunities to libraries but also some with corresponding challenges. In particular, the lack of cross-disciplinary expertise has often been regarded as one of the impediments to implementing research data management and curation. Therefore, the need to educate a workforce with skills and capacity in digital curation and data management has been widely recognized (e.g., National Science Board, 2011; Ogburn, 2010; Soehner, Steeves, & Ward, 2010).

In this context, the LIS field started to discuss the need for formal training in digital curation and data management in the mid-2000s. The outcome of the discussion was several Institute of Museum and Library Services (IMLS)-funded projects that developed new curriculum and programs for digital curation, including the University of North Carolina's digital curation curriculum project, the University of Illinois's data curation specialization program, the University of Michigan's preservation of information specialization, and the University of Arizona's digital

information management certificate program. Each program is unique and has different foci and strategies to educate and prepare professionals who are capable of engaging in curation activities in digital and data-driven environments.

Another example is the University of North Texas's graduate academic certificate in digital curation and data management. The curricular structure of this program is based on a competency-based approach. The certificate program is a deliverable of a project funded by the IMLS and conducted from September 2011 to August 2015[1] to address the goal of building capacity in LIS curriculum. The target audience for this program is graduate students pursuing careers in digital curation and data management, post-master's information professionals who need retraining for digital curation responsibilities, and discipline-specific graduate students (e.g., graduate students in engineering, science, and the humanities) who may be responsible for managing data for their scientific and scholarly projects.

Competency-based Curriculum for Digital Curation

We designed a theoretical framework that guides the development and implementation of the competency-based curriculum. This theoretical framework was drawn from a number of guides and case studies on competency-based program planning and curriculum development (e.g., Calhoun, Rowney, Eng, & Hoffman, 2005; Center for Health Policy, Columbia University School of Nursing & Association of Teachers of Preventive Medicine, 2004; Chyung, Stepich, & Cox, 2006; Jones, Voorhees, & Paulson, 2002; Howard, Gladding, Kiguli, Andrews, & John, 2011). The framework delineates the steps involved in developing and implementing a competency-based curriculum. It describes each step, shows how the steps are related to the overall educational structure, and illustrates the iterative nature of curriculum development.

As presented in Figure 1, we first reviewed the competency standards that have been developed from various organizations/institutions as well as existing digital curation curriculum developed by other LIS schools. Along with our digital curation job analysis, we synthesized the skills, competencies, and goals identified in this review into a set of statements that would describe the competencies the students attain upon completion of the program. Those statements were grouped together by category then performance statements that elaborate what is involved to develop the skills students need to exhibit a particular sub-competency were developed. The next step was to use those competencies to design our digital curation curriculum. The performance statements were aligned to each course's learning outcomes. For each learning outcome instructional units and instructional methods to address the learning outcomes were created. The last step was to perform a program evaluation to assess the effectiveness of the curriculum in helping students achieve the established competencies.

Identifying Competencies

Competencies are neither curricula nor learning objectives. Competencies do not address the details of how the KSAs are to be packaged, the best methods for learning, or the criteria for attainment. What they do provide is a framework based on performance outcomes around which a curriculum is developed and delivered and against which performance can be measured. Thus, competency-based curriculum is organized around competencies required for practice. It is also grounded in the empirically validated principle that students, when given appropriate instruction, can all master the prescribed performance outcomes.

[1]The project was originally planned to run from September 2011 to August 2014 but was extended another year.

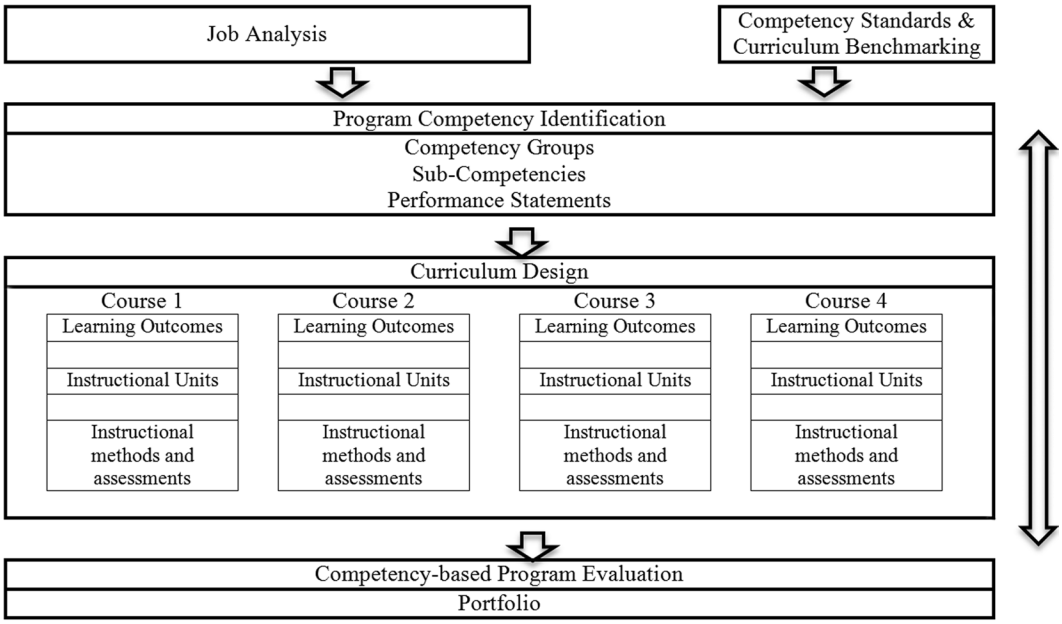

Figure 1. Theoretical framework for competency-based curriculum.

Defining professional competencies is the cornerstone upon which a competency-based curriculum is built. Therefore, the first stage in our curriculum development involved identification of the various components of professional competencies necessary to be proficient for employment or practice in digital curation and data management. We reviewed current literature on digital curation workforce development and education with particular focus on existing skills and standards for related competencies, such as the Matrix of Digital Curation Knowledge and Competencies developed by University of North Carolina's DigCCur Project (Lee, 2009). We also reviewed digital curation curriculum developed by other LIS schools by examining the websites of ALA-accredited library and information science schools in North America. In addition to descriptions of the programs available on each school's website, course titles and descriptions in online course catalogs were collected to identify goals and objectives of their programs and curricular characteristics.

An analysis of digital curation job descriptions was then conducted to identify the job duties, performance expectations, and qualifications required by the broad range of professionals working in the field of digital curation. A total of 173 digital curation-related job advertisements posted on various job career sites were collected and analyzed to determine the patterns of specific job characteristics and requirements. Detailed methodological procedures and results are reported in Kim, Warga, and Moen (2013). It is important to note that we used job advertisements as an indicator of the current competency demand and of the evolving skill set needed for digital curation because an understanding of how practitioners integrate KSAs, values, and other characteristics to successfully perform specific tasks or functions is essential in competency-based curriculum (Jones, 2001).

As a result, we developed four program competencies as follows:

1. *Content Curation Competency*: This competency is required to understand and carry out a range of activities as defined in the digital curation lifecycle model, including the creation, acquisi-

tion, management, representation, access, organization, transformation, and preservation of digital content.

2. *Curation Technologies Competency*: This competency is required to identify, use, and develop tools and applications to support digital curation activities. The context of this competency is information technology infrastructure, including the tools and applications deployed to support digital curation.
3. *Curation Models and Modeling Competency*: This competency is required for high-level, abstract thinking and critical analysis of complex systems, workflows, and conceptual models related to digital curation. This is also required for planning, coordinating, implementing, and assessing programs, projects, and services related to digital curation.
4. *Curation Services Competency*: This competency is required to identify, understand, and build services to respond to a community's and/or institution's digital curation needs.

It should be noted that we decided on an open, collaborative, and iterative process to develop these competency groups. This process required multiple cycles of sharing drafts of competencies, incorporating feedback, and holding group discussions before we reached a consensus. For instance, as part of this process, we shared our initial draft of competencies with working professionals who were staff of the digital project unit of the UNT libraries and requested their revisions and additions.

We then sequentially separated all required sub-competencies for each competency group and connected each sub-competency to performance statements. Performance statements need to be clearly identified as the core of competency-based curriculum development to ensure that learners will be able to demonstrate their learned capabilities after they have acquired a necessary combination of KSAs (Chyung, Stepich, & Cox, 2006). For instance, if the students are to be competent in *content curation*, then they will have to be competent to *ingest data and digital objects to an archive,* and they will need the ability to *extract and create metadata records for data in a digital repository system*. Table 1 illustrates the sub-competencies and performance statements that can fulfill the Content Curation Competency.[2] The full list of competencies is included in Appendix I.

Linking Competency to Curriculum

The next step was to articulate how students would attain and acquire the competency. Particularly, we wanted to address the following questions: (1) What content is needed to support the development of the competency in the curriculum? (2) What instructional strategies and methods are most effective in developing the competency? These questions are addressed below in two sections: Course Development and Instructional Design.

Course Development

The following four 3-credit hour courses were developed:

- INFO 5841 Digital Curation Fundamentals

This course introduces fundamental vocabulary, concepts, practices, procedures, and processes for the entire curation lifecycle, from creation through appraisal, ingest, and storage, to access and reuse. Topics include history and background; concepts and principles; community standards and practices; challenges and issues; and some basic techniques for curating

[2]It should be noted that the set of competencies presented in this paper is not the same as the first version of competencies reported in Kim, Warga, and Moen (2013). The first version was revised to ensure component distinctiveness and exclude some general professional competencies, such as communication and professional development.

Table 1. Competency Group, Sub-competencies, and Performance Statements.

Competency Group	Sub-competency	Performance Statements	Learning Domain Levels
1. Content Curation Competency	1.1. Create data in standard data formats and file types	1.1.1. Identify the standards for data content and structure	Foundation
		1.1.2. Determine significant properties of data and digital objects	Foundation Application
	1.2. Appraise and select for long-term archiving	1.2.1. Develop and apply appraisal and selection policy	Execution
		1.2.2. Understand and evaluate the local/community practice and legal requirements	Foundation Application
	1.3. Ingest data and digital objects to an archive	1.3.1. Prepare data for ingest (e.g., file normalization, checksums)	Foundation Application
		1.3.2. Extract and create metadata records for data in a digital repository system	Foundation Application Execution
	1.4. Implement preservation methods	1.4.1. Describe the best practice for long-term storage	Foundation
		1.4.2. Select appropriate formats and methods/strategies for long-term storage	Application Execution
	1.5. Support access and use	1.5.1. Apply access controls and authentication procedures	Application
		1.5.2. Incorporate user requirements into preservation systems and services	Application Execution

and managing digital data. The course is designed with the following learning modules: Module 1—Concepts and background; Module 2—Conceptual models; Module 3—Creating/formatting data; Module 4—Documenting/describing data; Module 5—Storing/archiving data; Module 6—Sharing/accessing/reusing data; and Module 7—Data management plans. Each learning module includes a topic overview, supporting resources, and assignments to guide the student's comprehension of the topic presented.

- INFO 5842 Digital Curation Tools and Applications

This course covers the technical infrastructure, including systems and services necessary for digital curation. In particular, it focuses on techniques, tools, and applications for curating digital data. Topics covered include creating and executing an action plan for archiving digital data, deciding what to store, consolidating multiple file versions, and creating metadata. The course also explores institutional/

disciplinary repositories and underlying platforms. Like INFO 5841, the course is designed with seven learning modules as follows: Module 1—Introduction of UNIX/Linux; Module 2—Significant properties of digital objects; Module 3—Technical metadata; Module 4—Format and file information; Module 5—Microservices; Module 6—Repository platforms; and Module 7—Digital curation team. Each learning module includes a topic overview, supporting resources, and hands-on exercises to give students practical experience and real-world simulations.

- INFO 5843 Preservation Planning and Implementation for Digital Curation

This course provides students an opportunity to develop a plan for preservation throughout the curation lifecycle of digital materials. Students will apply digital curation concepts and models learned in INFO 5841 to conceptualize preservation planning processes and use various tools and applications learned in INFO 5842 to implement the plan on digital data. The course is project based; students work on a semester-long project in which students develop a plan for curating digital materials, design a draft workflow for curation, develop a test plan, revise it, and implement it by curating the materials in a digital repository system. Along with the project, the course includes weekly discussions and presentations with an emphasis on student involvement.

- INFO 5844 Advanced Topics in Digital Curation

This course is designed as a capstone experience, which means its purpose is to both tie together the materials covered in previous courses in the digital curation program at UNT and to integrate/expand students' knowledge of concepts and techniques of digital curation. The course consists of two components. The first is a seminar designed to explore advanced and emerging topics in the area of digital curation. Topics include preservation of three-dimensional, computer-aided design, or other complex objects; trustworthy digital repository audit and certification; forensic computing; and copyright and other intellectual property issues related to digital curation. In particular, we invited practitioners who have experience working on a digital curation–related capacity to present in class. The second is a research community project exploring a specific research community's curation practices and needs.

The assumption behind the sequence of these four courses is that the competencies are not taught as a whole in a single course, but performance statements are presented throughout the curriculum. Further, such performance statements are reflected in the three learning domain levels, *foundation, application*, and *execution*, which were adopted by Bloom's taxonomy of learning domains (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). At the foundation level, students explore fundamental knowledge and basic skills. At the application level, students work through and apply a conceptual knowledge base and skills to practical tasks. At the execution level, students assess a given situation to determine what problems, issues, and opportunities exist and integrate learning from different areas into a plan for solving a problem. Table 1 mapped performance statements against learning domain levels.

For instance, to be competent to *extract and create metadata records for data in a digital repository system*, students learned different metadata types and functions, the efficacy of a descriptive standard for a particular community, and the importance of technical, structural, and rights metadata in INFO 5841. Students also had the opportunity to create descriptive metadata for selected resources in a repository system; this supports the foundation level. Then they delved into the details of technical metadata in INFO 5842, which introduced common types of technical metada-

ta embedded in digital objects, explained how different elements of technical metadata are used in digital curation, and used the ExifTool to extract metadata; this also supports the foundation level. In INFO 5843, students needed to make a decision about entering required and optional metadata at both the collection and object level. Metadata records were provided in the form of XML files/comma-separated or tab-delimited spreadsheets. This supports the application/execution level.

Another example can be found in the *prepare data for ingest* competency. In INFO 5841, students were introduced to file fixity, why it is important, when to generate it, and some common algorithms for calculating checksums; this supports the foundation level. Then in INFO 5842, students were introduced to tools used to create checksums. They were then required to create a checksum for an actual data set using command-line utilities on UNIX. This supports the foundation/application level. In INFO 5843, during which students developed and implemented a digital curation plan, students addressed how their proposed submission agreement, a contract between the curation repository and the depositor, can entail data validation by incorporating when and how a checksum file needs to be created and validated. This also supports the application level.

Instructional Design

Lasnier (cited in Demers, Woodburn, & Savard, 2006) argues that instructional strategies and methods that lead to competency development are action based, are as closely related to the real task as possible, and take place in as authentic a setting as possible. The following examples describe the instructional strategies and methods used for our courses.

Indirect instruction was adopted in many of the courses. In particular, case scenario, which depicts real-life situations in which problems need to be solved, was used as an instructional method. A local example of a concept, topic, and/or issue being covered in class was often provided to the students for discussion and analysis. For instance, in INFO 5841, students were assigned a hands-on exercise in which they developed a file structure and proposed a file-naming convention. For the exercise, students were provided a scenario based on a real research project carried out at UNT. This included the purpose and context of the project as well as generated data files. They had to respond to the needs of the project by providing instruction regarding how they would manage data in the project. Another example is INFO 5842's digital curation team project. For this project, a hypothetical situation in which an academic library is planning research data services for its community was given to the students. Students were instructed to work in a group to allocate the various roles for the project and develop a plan detailing data curation and management services by consulting curation services groups in other academic libraries.

Experiential learning, which focuses on "learning by doing," was another popular strategy. INFO 5842, which focuses on tools and applications to support digital curation, required the students to work at the command line of Linux servers of specific applications, such as DSpace, Fedora, and Archivematica. These were loaded on local servers for students to use. Assuming that students need to understand Linux/UNIX commands and operations in a more holistic way, a mini-course called "Introduction to UNIX/Linux" was developed and implemented as a prerequisite for completing exercises in INFO 5842. The digital curation plan project in INFO 5843 is another example. Students needed to put their understanding of various stages of the curation process, including appraisal, acquisition, ingest, and dissemination, into practice. In particular, students were asked to use actual data sets, such as data produced by the Mapping Text project (http://mappingtexts.org) funded by Na-

tional Endowment for the Humanities and materials produced during the course of the IMLS Connecting to Collections Initiative (http://www.imls.gov/collections), as digital objects to be curated for the plan.

Lastly, interactive instruction that often involved grouping and discussions was used extensively in our courses. In INFO 5844, which included a research community project, students were instructed to interview one or more researchers in a specific research community (e.g., astronomy, biology, computational linguistics, history) to identify major funding sources, data management/sharing requirements, common data file formats and data structures, and so forth. This interactive discussion with a researcher in a particular field helped students learn the practices and challenges to curation of data faced in these fields.

Assessing Competency

To deliver a competency-based curriculum, it is imperative that students know, can apply, and can execute knowledge, skills, and abilities desired by the industry. To bridge the gap between industry and academia, a structured process of connecting KSAs to assessment is critical. When assessing competency two important questions to be addressed are (1) Have students acquired the program competencies by the end of the program? (2) If so, was the acquisition of the competencies a result of the program?

A variety of assessment methods are needed for assessing the program-level competencies. Portfolios appear to have the potential to integrate these methods and are effective assessments of both formative and summative performance. Portfolios are often used as an instrument that allows students to see each part of the process in its wider context, encouraging self-assessment. Further, it has been asserted that portfolios can serve as a good assessment method for competency by making students responsible for providing evidence of the outcomes of their learning and its processes, how they have developed, and where further learning is needed (McMullan *et al.*, 2003).

With the worth of portfolio assessment in mind, we decided to adopt these as a method to assess students' competency. This tool was embedded as a final project in INFO 5844, the last course students take for the program. Students were required to provide specific illustrations in the form of artifacts from their coursework to indicate the acquisition and mastery of the program competencies. The portfolio includes the following components:

1. *Evidence of competencies*: At least two artifacts were required from students to demonstrate mastery for each competency. The two artifacts were carefully selected in order to cover any specific competency statements associated with each competency group. One artifact could be used to demonstrate more than one competency. The artifacts could be in the form of written documents, links and/or screenshots of any technologically supported creations, audio or video recordings, and so on.
2. *Supportive writing for competencies*: Along with the artifacts, the student had to provide a short reflective statement that described their competency and how the selected artifacts demonstrated achievement of each competency. The student could also address what has been successful/unsuccessful and what has acted as a trigger to reexamine practice.
3. *Self-evaluation*: At the end of each reflective statement of competency, students were asked to rate themselves on their achievement of each competency using the following rating system: 1 = failed to achieve competency, 2 = marginal achievement of competency, 3 = adequate achievement of competency, 4 = above-average achievement of competency, and 5 = exemplary achievement of competency.

A review of ten students' portfolios indicated that students assessed their achievement of competency fairly highly across all competencies. The Content Curation Competency was achieved throughout all courses. Many students mentioned that the first two courses, INFO 5841 and INFO 5842, provided ample opportunities for curation, such as file normalization and migration, and metadata extraction and creation. The hands-on use of tools and techniques gave practical insights into curation content. Those two courses also provided a lot of worthwhile exposure to both theoretical and technical frameworks. Students were able to implement such frameworks in the next course, INFO 5843, by depositing and ingesting actual data sets into a digital repository system. One student commented: "The curation project we conducted in course 3 [INFO 5843] involved putting concepts and theory into 'motion' as well as choosing and using tasks, tools, and technologies. It was the beginning of practical curation work."

Many students enjoyed this transition from theoretical models to actual curation practice, as indicated in one student's statement: "Courses followed a very natural and steady progression through the concepts and technologies of digital curation culminating in the advanced course [INFO 5844], in which we had the opportunity to observe how actual curation work can be commenced by interacting with professionals who share their experience in projects and initiatives." During this course of transition, students were able to use, refine, and expand the knowledge and skills acquired from previous courses. This helped students conceptualize what components and services are needed and how they fit into the process when they were exposed to the full digital lifecycle by designing and implementing a workflow. This transition certainly helped students solidify the Curation Models and Modeling Competency.

The Curation Services Competency was also acquired throughout the program. Students acknowledged that the rich knowledge of concepts and tools from all courses provided the basis for designing a digital curation program or service for the institution. Many students mentioned that in INFO 5841, the review of various scholarly disciplines' practices and their ideologies concerning the creation, use, and sharing of data served as a good foundation to understand the needs of the user community. They also added that the research community project in INFO 5844 provided the opportunity to look at different aspects of the designated communities and what services might be expected or needed.

It is worthwhile to mention that the achievement of the Curation Technology Competency was rated lower than other competencies. The main reason for this is that most students have no experience with Linux/UNIX and had difficulty incorporating their understanding of Linux into actual curation works. Some students felt that it was challenging to grasp the technical aspects and operational phases of a digital repository platform, such as DSpace and Fedora. One student reported: "While we did have a number of opportunities to work with digital repositories, such as DSpace and Fedora, I did not feel like we received enough depth of experience to understand those platforms sufficiently."

Looking Forward: Challenges Remaining

The field of LIS is experiencing drastic and fundamental changes as a result of changing technologies and expanding job roles. Today's library and information professionals need to be multi-skilled and knowledgeable in various areas to adapt to the changing demands of the work environment and to effectively contribute to their profession. In 2013, the Association of College & Research Libraries' Research Planning and Review Committee foresaw that library employers would fill positions from broader talent pools of individuals holding a variety of credentials that meet

the job specifications, with more concern for meeting the requirements of the positions than with holding a master's degree in LIS (Association of College & Research Libraries, 2013). It is worth noting that the master's-level qualification is not the norm for professional entry to the LIS profession in many countries; undergraduate training and diploma/apprenticeship models are common elsewhere and competency underpins many of these programs.

It is important for LIS educators to be aware that changes in employer demand and the emerging skill sets of other professions demand that new knowledge sets be incorporated into an already stringent and comprehensive academic curriculum. To support such demand, the incorporation of competency-based curriculum is emerging as a necessity. Although educators are faced with the task of structuring their curricula to ascertain the knowledge, skills, and abilities each student possesses, a model for identifying the competencies and implementing them into curriculum has not been found in LIS. In a sense, we anticipate that steps taken toward curriculum development can be used as a process model to design a competency-based curriculum for other subject areas in LIS.

Furthermore, competencies identified and implemented in our digital curation curriculum can serve as an excellent basis for designing an educational and professional framework for digital curation. Competencies can be used as a common language among stakeholders to prepare future digital curation professionals, and they can be used to support recruitment, performance management, and career planning (Corrall, 2013). They also can offer a means to identify, plan, and evaluate training to meet the requirements of professionals engaged in digital curation. Particularly, our program competencies encompass the wide range of knowledge, skills, and abilities required for success in the digital curation workforce. Although one person would not be expected to perform all functions covered in the four competency groups in the actual work environment, having a broad understanding of all the functions and skills needed is still required to be a high-level contributor to the curation responsibilities of an institution. Additionally, competencies presented in this paper can fit into requirements of the "I-shaped model," which encompasses a broad understanding of techniques across curation, a deep specialization in curation, and a general level of knowledge at least one application domain (Stanton, Palmer, Blake, & Allard, 2012).

Nevertheless, some challenges remain. One of the biggest challenges the competency-based curriculum posed is the development of a robust assessment to measure competency. Although portfolios have been proven as an effective tool for collecting and managing multiple types of assessment evidence from multiple contexts and sources within the curriculum, the evaluation should be complemented by a curriculum-embedded assessment model in which students are assessed during the various learning pathways—i.e., early, middle, and end points. For this, competency statements, which align with performance standards and assessment plans, should undergo periodic reviews by faculty and external stakeholders. Another challenge is that competencies are dynamic and evolving. The needed knowledge, skills, and abilities that make up competencies change continuously as jobs and the workforce evolve and new work practices are discovered. Furthermore, the field of digital curation is continuously changing in intriguing ways. Bunn's (2014) point is well taken: Teaching emerging practices in digital curation is like trying to hit a moving target. Although there has been significant effort to identify and compile various practices and the spectrum of skill sets that comprise digital curation, ongoing assessment is necessary to ensure that competencies reflected in the curriculum are up to date and relevant to job market needs. This is, in fact, true for most other areas in the LIS field!

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Appendix I. Competency Group, Sub-competencies, and Performance Statements for Digital Curation Curriculum

Competency Group	Sub-competency	Performance Statements
1. Content Curation Competency	1.1. Create data in standard data formats and file types	1.1.1. Identify the standards for data content and structure
		1.1.2. Determine significant properties of data and digital objects
	1.2. Appraise and select for long-term archiving	1.2.1. Develop and apply appraisal and selection policy
		1.2.2. Understand and evaluate the local/community practice and legal requirements
	1.3. Ingest data and digital objects to an archive	1.3.1. Prepare data for ingest (e.g., file normalization, checksums)
		1.3.2. Extract and create metadata records for data in a digital repository system
	1.4. Implement preservation methods	1.4.1. Describe the best practice for long-term storage
		1.4.2. Select appropriate formats and methods/strategies for long-term storage
	1.5. Support access and use	1.5.1. Apply access controls and authentication procedures
		1.5.2. Incorporate user requirements into preservation systems and services

(continued)

Appendix I (continued). Competency Group, Sub-competencies, and Performance Statements for Digital Curation Curriculum

Competency Group	Sub-competency	Performance Statements
2. Curation Technologies Competency	2.1. Work in a variety of computing environment	2.1.1. Utilize networking and various operating system services
	2.2. Implement and maintain digital curation repository system	2.2.1. Employ command line tools and programs
		2.2.2. Install and configure a digital repository platform
	2.3. Utilize software, applications for digital curation	2.3.1. Select and apply tools and applications for depositing and ingesting digital objects into a digital repository
		2.3.2. Select and apply tools and services for the technical foundation of a trusted digital repository
3. Curation Models and Modeling Competency	3.1. Use the conceptual model for curation	3.1.1. Analyze and present a conceptual framework for use in planning, development, and implementation of curation activities
		3.1.2. Apply the framework to build a repository system and service
	3.2. Administer curation lifecycle actions	3.2.1. Apply a broad range of principles, practices and procedures in overseeing digital curation management and resources
		3.2.2. Design and implement workflows and procedures to manage the digital curation program
4. Curation Services Competency	4.1. Assess the curation need of users	4.1.1. Understand data created by the users and its workflow
		4.1.2. Differentiate various scholarly disciplines practices and their ideology concerning the creation, use, and sharing of data
		4.1.3. Identify and build services to respond to individual user's data management need
	4.2. Understand policies and requirements for institutions	4.2.1. Appraise and develop relevant institutional policies and plans
		4.1.2. Apply tools and services that address a digital repository's organizational and financial needs
	4.3. Provide user service	4.3.1. Provide administration and user support for the repository service
		4.3.2. Offer a variety of supporting reference and instruction services to users