



# DIGITAL LIBRARIES

## Curriculum Development

### **NSF Final Report (through 2009):**

### **Collaborative Research: Curriculum Development: Digital Libraries**

Funded by NSF through Virginia Tech (VT) grant IIS-0535057 and University of North Carolina at Chapel Hill (UNC-CH) grant IIS-0535060

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PI (UNC-CH): Barbara M. Wildemuth  
Co-PI (UNC-CH): Jeffrey P. Pomerantz

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#### **1. *Project Participants***

##### **1.1 People working directly on the project**

- Project Team at VT:
  - PI: Edward A. Fox
  - GRA: Seungwon Yang
  - REU: John Ewers
- Project Team at UNC-CH:
  - PI: Barbara M. Wildemuth
  - Co-PI: Jeffrey P. Pomerantz
  - GRA: Sanghee Oh

##### **1.2 Other organizations involved as partners**

- The JCDL 2007 workshop was co-organized with colleagues from Indiana University (Mostafa) and the University of Illinois (McDonough, Mischo). The JCDL 2008 education workshop in which we participated was organized by Joyce Ray (IMLS) and Helen Tibbo (UNC-CH). PI Fox is the chair for an education workshop to be run at JCDL 2010.
- The ECDL 2007 workshop was co-organized with a European colleague from the University Carlos III of Madrid (Méndez); however, conference organizers cancelled it due to logistical reasons.

### 1.3 Other collaborators or contacts

- Volunteers involved in module development or review (including Advisory Board members and others contributing to the Advisory Board meetings)
  - Suzie Allard, University of Tennessee, Knoxville
  - Bob Allen, Drexel University
  - Nick Belkin, Rutgers University
  - Rob Capra, University of North Carolina, Chapel Hill
  - Hugh Cayless, University of North Carolina, Chapel Hill
  - Sally Jo Cunningham, University of Waikato, New Zealand
  - Allison Druin, University of Maryland
  - Helene Francke, University College of Boras, Sweden
  - Vicki Gregory, University of South Florida
  - Jane Greenberg, University of North Carolina, Chapel Hill
  - Stephanie Haas, Univ of North Carolina, Chapel Hill
  - Trudi Bellardo Hahn, University of Maryland
  - Brad Hemminger, Univ of North Carolina, Chapel Hill
  - Ingrid Hsieh-Yee, Catholic University of America
  - Joe Janes, University of Washington
  - Jim Jansen, Penn State University
  - Judy Jeng, New Jersey City University
  - Pratik Karia, Virginia Tech
  - Diane Kelly, University of North Carolina, Chapel Hill
  - Mick (Michael) Khoo, Drexel University
  - Stacy Kowalczyk, Indiana University
  - Cal Lee, University of North Carolina, Chapel Hill
  - Michael Lesk, Rutgers University
  - Elizabeth Liddy, Syracuse University
  - Lili Luo, San Jose State University
  - Michael Lynch, Middlebury College
  - Steven MacCall, University of Alabama
  - Gary Marchionini, University of North Carolina, Chapel Hill
  - Jerry McDonough, University of Illinois, Urbana-Champaign
  - Lorraine Normore, University of Tennessee, Knoxville
  - Claudia Perry, Rutgers University
  - Tefko Saracevic, Rutgers University
  - Candy Schwartz, Simmons College
  - Natasha Smith, University of North Carolina, Chapel Hill
  - Nguyen Hoang Son, Hue University, Vietnam
  - Shigeo Sugimoto, University of Tsukuba, Japan
  - Pertti Vakkari, University of Tampere, Finland
  - Ruth Vondracek, Oregon State University
  - Tom Wilson, University of Sheffield, England (retired)
  - Meredith Weiss, University of North Carolina, Chapel Hill
  - Ian Witten, University of Waikato, New Zealand

- Hong (Iris) Xie, University of Wisconsin, Madison
- Eun-young Yoo, North Carolina Central University
- Additional colleagues with whom we have consulted:
  - Helen Tibbo, University of North Carolina, Chapel Hill
  - Carol Perryman, University of North Carolina, Chapel Hill
  - Orion Pozo, North Carolina State University
  - Larry Taylor, University of North Carolina, Chapel Hill
  - Ian Witten, University of Waikato, New Zealand
  - Marcos André Gonçalves, Universidade Federal de Minas Gerais, Brazil
- Advisory Board members
  - See listing at <http://curric.dlib.vt.edu/advisory/advisory.html>.

## **2. Activities and Findings**

### **2.1 Major research and education activities**

A request for a one year no cost extension was submitted on 11/25/2008 and approved on 12/23/2008, giving a project end date of 12/31/2009.

#### **Project team meetings held**

The project team met together on many occasions over the course of the project:

- December 11, 2006, at Virginia Tech;
- June 21, 2007, in Vancouver, BC (during JCDL);
- July 9, 2007, at UNC-CH;
- January 4, 2008, at UNC, with particular focus on the possibilities of extending this work into Second Life (guests: Perryman, Pozo, Taylor);
- May 27, 2008, at UNC, including lengthy discussions of sustainability and broadening participation in the initiative; and
- February 11, 2009, at UNC during the iSchools Conference held in Chapel Hill.

In addition, we augmented face-to-face meetings with phone- and video-conferences (including some meetings via Adobe ConnectPro), held on:

- April 2, July 29, August 12, August 29, September 6, September 19, October 3, October 10, October 24, and November 21, 2008;
- January 26, February 16, March 16, March 30, April 13, April 27, July 17, September 2, September 30, October 14, and October 28, 2009.

These project meetings were essential for closely coordinating our other activities. They were supplemented throughout the year by frequent email discussions, and many local face-to-face meetings at each project site.

#### **Advisory Board meetings/activities**

The full list of Advisory Board members is available at <http://curric.dlib.vt.edu/advisory/advisory.html>. We convened the Advisory Board a number of times during the course of the project. Rather than scheduling separate

meetings in Chapel Hill or Blacksburg, the Advisory Board meetings were generally held during/at a conference at which many of the Board members were in attendance. By scheduling many of the meetings during conferences, we also were able to include additional scholars and practitioners involved in digital library education and practice.

The Advisory Board meetings were held:

- May 1, 2006, at Virginia Tech; attended by a number of the members from Virginia Tech;
- June 14, 2006, during the Joint Conference on Digital Libraries, in Chapel Hill; 11 members and invitees attended;
- November 6, 2006, during the annual meeting of the American Society for Information Science & Technology, in Austin; 15 members and invitees attended;
- June 21, 2007, during the Joint Conference on Digital Libraries, in Vancouver; 18 members and invitees attended;
- October 27, 2007, during the annual meeting of the American Society for Information Science & Technology, in Milwaukee; 10 members and invitees attended;
- June 18, 2008, during the Joint Conference on Digital Libraries, in Pittsburgh; 14 members and invitees attended; and
- October 28, 2008, during the annual meeting of the American Society for Information Science & Technology, in Columbus; 13 members and invitees attended.

The discussion at the 2007 meetings focused on the first modules that had been developed, and the expert review of those modules; the meetings were used to test the expert review template/guidelines. The discussion at all of the 2008 meetings focused on ways to form a sustainable community of DL scholars and practitioners. In 2009 meetings there was discussion of module generation, review, and sustainability.

### **Development of the curriculum framework**

Our original proposal included a draft framework, organizing the components of a curriculum for digital library education that would be suitable both for computer science programs and for library and information science programs. It included 18 modules: 9 covering core topics and 9 covering related topics. We proposed to develop 12 modules.

Two approaches were used to validate this preliminary framework and develop it further. The first was a theoretical approach, using the 5S framework (streams, structures, spaces, scenarios, and societies) to ensure that the framework would include all the necessary components of a DL. The second was an empirical approach. We analyzed current literature related to digital libraries (relevant conference papers and articles published in D-Lib Magazine). Each paper was classified, using the preliminary curriculum framework; the results are summarized in section 2.2 (Major Findings). Based on this early theoretical and empirical work, the framework was modified to include 10 core topics and 36 related topics. As we were continuing to refine the framework, this version

was presented at the 9<sup>th</sup> International Symposium on Electronic Theses and Dissertations (ETD 2006), by Edward A. Fox.

To further develop the framework (and the modules it specified), an analysis of current syllabi was undertaken. We considered the DL course syllabi from ALA-accredited programs in Library and Information Science (LIS). This analysis identified several concepts not included in the preliminary curriculum framework. Examples of those include 'project management', 'DL evaluation', and 'cost/economic issues.' Therefore, we extended the 9 DL educational modules to 10 modules ensuring coverage of those concepts.

In 2007, we undertook two additional analyses supporting refinement of the framework. First was an analysis of the syllabi of computer science courses on digital libraries. This analysis, in its procedures, paralleled the earlier analysis of DL courses in information and library science. The findings are reported in section 2.2, and were presented in a short paper at the 2007 Joint Conference on Digital Libraries. Second was an informal survey of ILS faculty members who teach DL courses to identify the types of assignments given to students and the DL application used in these assignments.

By the end of the project's second year, the curriculum framework was reasonably stable. Even so, we continued to identify a few new modules to add to the framework, including modules on Images (2-b1), Web publishing (3-e/7-e), Crawling (3-f/7-f), Information visualization/summarization (6-e), and Image retrieval (7-a1).

### **Module development**

Each of the topics in the curriculum framework is a candidate for development as a curriculum module. The syllabus analyses provided a strong starting point for the development of specific curriculum modules – the next step of our work. In order to develop a workable template for module development, two draft modules ('Multimedia, Hypertext and Information Access' and 'Information needs, Relevance, Evaluation/Effectiveness') were developed and discussed by the project team and some members of the project advisory board in June, 2006. Based on this discussion, we developed a template that was used for the development of all the modules.

The first four modules were prepared for discussion with our Advisory Board at the meeting of the American Society for Information Science & Technology (ASIS&T) in November 2006. Work on developing additional modules within the curriculum framework progressed more rapidly during 2007 and 2008, and continued through 2009. The template used for each module is available at <http://curric.dlib.vt.edu/DLcurric/moduleTemplate.html>. Details of progress in this work are provided in section 2.2.

## **Module review**

Ten modules were reviewed by external experts during 2008. The reviews involved 32 experts outside the project team. Their comments were recorded/shared on the project's wiki, established for this purpose. Because of the wiki, the reviewers' comments were available to each other, and the evaluation process could be more interactive. The results from these reviews were incorporated in the modules. Our experiences with this evaluation process were developed into a poster for presentation at the 2009 ASIS&T meeting.

## **Module field testing**

Once modules have been reviewed by experts, they are ready for field testing. The field testing procedures include the implementation of the module in a course related to digital libraries, interviewing the instructor about the modifications made to the module as it was implemented and about the usefulness of the module, and surveying the students about the effectiveness of the module for supporting their learning.

Starting in early December 2008, we invited many others to join in the field testing. In particular, we sent emails with subject "Invitation to participate in DL curriculum module field test" to the jesse listserv, for LIS educators, and the ASIS&T SIG DL list.

During three semesters, Spring 2008 through Spring 2009, 44 field tests of individual modules were conducted. One or more modules was implemented at each of 15 universities in four different countries. The preliminary findings are summarized in the next section.

## **2.2 Major findings**

### **Analysis of DL literature**

In order to validate our preliminary curriculum framework, we undertook an analysis of the DL literature, in order to understand which topics were discussed most frequently. We analyzed current literature related to digital libraries (189 ACM DL conference papers, 1996-2000; 354 JCDL papers, 2001-2005; and 521 articles published in *D-Lib Magazine*, July 1995-February 2006). Each of these papers was classified, using the preliminary framework. The results indicated that the most common topics at DL conferences over the past ten years have been 'services' and 'architecture.' For *D-Lib Magazine* articles, 'legal issues' as well as 'services' and 'architecture' were the frequent topics. Based on this analysis, those aspects of our module framework have been expanded, to include 10 core topics and 36 related topics. The results were reported at the 2006 JCDL meeting.

### **Analysis of ILS syllabi from digital libraries courses**

In order to further validate our curriculum framework and to begin the development of specific modules within it, we undertook an analysis of syllabi for digital libraries courses. Our first analysis focused on those used in information and library science

courses. The analysis of course syllabi found that 29 (of the 55 ALA-accredited) library and information science programs offered 40 different courses related to digital libraries. From those courses, 20 syllabi were collected.

The analysis focused primarily on the course reading lists. From these lists, 1,697 titles were classified into the 9 DL core topics included in our preliminary curriculum framework. From this data, we could identify the most frequently assigned books, journal articles, and journals, and the most frequently assigned authors. Readings in the areas of 'project management' and 'architecture' were more frequently assigned than readings in other areas. During this analysis, we also found words and concepts in the reading lists that could not be properly classified into the 9 core topics already specified in the curriculum framework. Examples of those include 'project management', 'DL evaluation', and 'cost/economic issues.' Therefore, we extended the 9 DL core areas to 10, and added a specific module on project management. The results from this preliminary study were published in *D-Lib Magazine* in November, 2006.

### **Analysis of CS syllabi from digital libraries courses**

In an effort to identify the "state of the art" in digital library education in computer science (CS) programs, we analyzed CS courses on digital libraries and digital library-related topics in 2007. The websites of almost 300 CS graduate programs were examined to identify courses on digital libraries. Fifteen courses mentioning digital libraries in the course title or short course description were identified; of these, five focused on digital libraries. The readings assigned in those five courses were analyzed, and the results were compared to the findings from the previous analysis of readings assigned in DL courses offered by ILS schools. Arms' book on digital libraries<sup>1</sup> was the only book assigned in these courses; *D-Lib Magazine* and *Computers in Libraries* were the two journals that were most frequently assigned. The results indicated that there is little consistency in the assigned readings across the five courses (similar to the findings from the analysis of ILS courses) and that the two disciplines, CS and ILS, have different perspectives on some core DL topics, e.g., services. The results of this analysis were presented at the 2007 Joint Conference on Digital Libraries, as a short paper. They also resulted in modifications to our curriculum framework.

### **Analysis of project-based digital libraries courses in ILS programs**

The 2006 analysis of DL course syllabi in ILS schools found that many of these courses were project-based: the major course assignment was for the students to build a prototype DL. In an effort to gather more detail about these projects, an informal survey was conducted of ILS faculty members who teach these DL courses. This survey found that the DL application, Greenstone, was almost universally used in project-based DL courses in ILS programs. The results of this analysis appeared in the *International Journal on Digital Libraries*, May 2009. As a result of this finding, we have begun to consult with the team at the University of Waikato, New Zealand, that develops Greenstone.

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<sup>1</sup> Arms, W. Y. (2000). *Digital Libraries*. Cambridge, MA: The MIT Press.

## Module development

The status of each of the 23 modules developed during the project is described in the following table.

### Status of module development

ID	Title and scope	Lead developer	Status
1-b	History of digital libraries and library automation	Pomerantz	Expert review completed Feb 08; field tested in 4 classes
2-c/ 8-d	File formats, migration, transformation	Leidig, Alon, Chigani, Gopalakrishnan, Park	Drafted and reviewed by project team, Nov 08
3-b	Digitization	Oh	Expert review completed Dec 07; field tested in 7 classes
3-e/ 7-e	Web publishing	Karia	Drafted and reviewed by project team, May 08
3-f/ 7-f	Crawling	Fox, Khandeparker	Drafted, Oct 09
4-b	Metadata	Pomerantz, Greenberg	Expert review completed Jul 08; field tested in 7 classes
5-a	Architecture overviews/models	Fox	Expert review completed Aug 08; field tested in 1 class
5-b	Applications software	Yang	Expert review completed Feb 08; field tested in 5 classes
5-d	Protocols	Singh, Chen, Santhanam, Zhu	Drafted and reviewed by project team, Dec 08
6-a	Information needs/relevance	Wildemuth	Expert review completed Dec 07; field tested in 2 classes
6-b	Search strategy, information seeking behavior, user modeling	Oh	Expert review completed Dec 07; field tested in 2 classes
6-d	Interaction design and usability assessment	Oh	Expert review completed Aug 08; field tested in 3 classes
7-a	Search engines, IR, indexing methods	Karia	Drafted and reviewed by project team, Jun 08
7-a1	Image retrieval	Kuppuswami, Fox	Drafted and reviewed by project team, Dec 09
7-b	Reference services	Pomerantz	Expert review completed Jan 08
7-c	Recommender systems	Fox, Palani	Drafted and reviewed by project team, Oct 09
7-d	Routing, community filtering	Fox, Ganesan	Drafted and reviewed by project team, Oct 09
7-g	Personalization	Robinson, Rosson, Pochu, Guo	Drafted and reviewed by project team, Dec 08
8-a	Preservation	Lee, Pomerantz	Field tested in 1 class
8-b	Web archiving	Lee, Kan'an, Jiao	Drafted and reviewed by project team, Dec 08; field tested in 1 class
9-b	Case studies	Wildemuth	Template ready for further development of case studies, Oct 08

<b>ID</b>	<b>Title and scope</b>	<b>Lead developer</b>	<b>Status</b>
9-c	Digital library evaluation, user studies	Wildemuth	Expert review completed Jan 08; field tested in 4 classes
9-e	Intellectual property	Weiss, Wildemuth	Drafted and reviewed by project team, Aug 07; field tested in 4 classes

### **Module review**

The 2007 JCDL meeting provided us with the opportunity to move forward with our evaluation of draft modules. First, Dr. Wildemuth was able to present our evaluation plans during the pre-conference workshop on DL education (supported by Dr. Fox's earlier talk there about the core of the field, and Dr. Pomerantz's talk on IT and DLs), and we received feedback on our evaluation plans from the workshop participants. Second, we were able to pilot test our formative evaluation procedures with our Advisory Board members and other invited scholars and practitioners during our meeting with them.

Our formative evaluation procedures were based on expert reviews of each module. At that June 2007 Advisory Board meeting, the participants worked in pairs to evaluate each of the draft modules, using the evaluation protocol we developed. The participants in the pilot test made several suggestions for improving the process, which were subsequently implemented. Later that summer, we established a wiki to manage the input from evaluators. Specific experts were invited to evaluate each module. The module was viewable from the wiki; a discussion page for each module was used to coordinate the evaluators' comments on it. These comments were available for viewing by the evaluators and continue to be available. A description of the expert review process supported by a wiki was the focus of a poster at the 2009 ASIS&T annual meeting.

As shown in the table above, ten modules have been reviewed by experts. In each evaluation, three or more experts used the project wiki to provide comments related to five areas:

- Objectives: Are the objectives appropriate for the topic?
- Body of knowledge: Does the module address all areas of the topic that need to be addressed?
- Readings: Are the readings the best and most appropriate for the topic?
- Learning activities: Are the activities appropriate for the topic?
- Logistics: Is it feasible to teach the module as it is currently constructed?

The reviewers' comments then were used to improve the module prior to its evaluation in the field.

### **Module field testing**

During Spring, Summer, and Fall 2008 and Spring 2009, 12 modules were field tested in 33 classes (see the table above for a list of the modules field tested). The participating instructors were:

- Nora Bird, Univ. of North Carolina, Greensboro,
- Ron Brown, Univ. of South Carolina,
- Jiangping Chen, Univ. of North Texas,
- Youngok Choi, Catholic Univ. of America,
- Ed Fox, Virginia Tech,
- Vicki Gregory, Univ. of South Florida,
- Nancy John, Dominican Univ.,
- Cal Lee, Univ. of North Carolina, Chapel Hill,
- Jerome McDonough, Univ. of Illinois,
- Jeff Pomerantz, Univ. of North Carolina, Chapel Hill,
- Cristina Ribeiro, Faculdade de Engenharia- Universidade do Porto (Portugal),
- Candy Schwartz, Simmons College,
- Nafiz Zaman Shuva, Univ. of Dhaka (Bangladesh),
- R.S.R. Varalakshmi, Andhra Univ., Visakhapatnam (India),
- Hong (Iris) Xie, Univ. of Wisconsin, Milwaukee, and
- Eun-Young Yoo, North Carolina Central Univ.

Student survey results from the spring 2008 field tests were reported at the workshop, “Education for Digital Stewardship: Librarians, Archivists, or Digital Curators?”, held at the Joint Conference on Digital Libraries, Pittsburgh, PA, June 20, 2008. Those results, plus the results from the summer field test, are presented here.

Nine of the modules were field tested in more than one class. To provide an overview of the data that can be derived from the multiple field tests, the student survey results are summarized here. In each case, the average rating on each survey item was calculated for each class; these means were then aggregated across classes. Each column also indicates the number of classes and the number of individual students providing ratings of each module.

**Student survey results: Mean ratings, aggregated across classes**  
**Includes modules for which multiple field tests were conducted**

	1-b, History of DL	3-b, Digiti- zation	4-b, Meta- data	5-b, App soft- ware	6-a, Info needs	6-b, Search strat., info seek.	6-d, Inter- action design	9-c, DL eval., user studies	9-e, Intellec- tual property
Number of classes in which field test was conducted	4	7	7	5	2	2	3	4	4
Total number of students providing ratings	63	60	75	30	18	12	21	25	35
Clearly outlined objectives and outcomes were provided. <sup>2</sup>	4.2	4.1	3.8	3	3.6	4.1	3.8	4.2	3.7
The module was well-organized. <sup>4</sup>	4.2	4.1	3.9	3.2	3.1	4	3.6	4.1	3.6
The amount of work required for this module was appropriate. <sup>4</sup>	3.9	3.7	3.8	3.2	3.4	4.1	3.5	4	3.2

	1-b, History of DL	3-b, Digiti- zation	4-b, Meta- data	5-b, App soft- ware	6-a, Info needs	6-b, Search strat., info seek.	6-d, Inter- action design	9-c, DL eval., user studies	9-e, Intellec- tual property
The assigned readings helped me better understand the subject matter. <sup>4</sup>	4	4.1	3.8	3	3.3	4.2	3.5	3.9	3.3
Given the module's objectives, the learning activities and/or assignments were appropriate. <sup>4</sup>	2	4	3.2	2.7	3.4	3	2.7	3.4	2.3
The learning activities and/or assignments required thinking and understanding. <sup>1</sup>	2.2	4.1	3.3	2.5	3.4	3	2.8	3.5	2.4
The learning activities and/or assignments were stimulating. <sup>3</sup>	1.9	3.8	3.1	2.6	3.3	2.6	2.9	3.3	2.2
Assignments for this module helped me understand what will be expected of me as a professional. <sup>3</sup>	1.9	3.8	2.7	2.8	3.9	2.5	2.2	3.2	2.4
I learned useful professional skills from this module. <sup>1</sup>	3.5	3.8	3.6	3.1	3.6	3.6	3.4	4	3.4
I know significantly more about this subject than before I took this module. <sup>4</sup>	4.1	3.8	3.7	3.1	4	3.9	3.5	3.9	3.3
Class lectures added to my understanding of the subject. <sup>1</sup>	3.5	3.7	3.8	3	3.2	3.9	3.5	3.6	3.5
I gained a good understanding of the basic concepts related to this subject. <sup>2</sup>	4.1	4	3.9	3	3.1	4	3.9	3.9	3.5
I learned to interrelate important issues related to this subject. <sup>2</sup>	3.9	3.8	3.8	2.2	2.1	3.8	3.8	3.8	2.6
This module stimulated me to think critically about the subject matter. <sup>4</sup>	3.9	3.6	3.7	2.2	2	3.6	3.7	3.8	2.7
I feel that this learning module served my needs well. <sup>2</sup>	3.9	3.7	3.7	2.2	2	3.8	3.3	4	2.8
I was very satisfied with this learning module. <sup>2</sup>	3.9	3.6	3.6	2	2	3.9	3.3	3.8	2.6
Overall, considering its content, design, and structure, this module was effective. <sup>4</sup>	4.1	3.8	3.8	2.3	2	4	3.4	4.1	2.9

1 = Strongly disagree, 5 = Strongly agree  
 Sources of items: <sup>1</sup> From Snare (2000) <sup>3</sup> From Flashlight <sup>2</sup> From McGorry (2003) <sup>4</sup> From Neal (2004)

These data are augmented by interviews with many of the instructors, as well as examination of class materials and student work/assignments. A brief report is being prepared for each field test, summarizing the results from that implementation. These reports will be made available on the project website. In addition, they will be aggregated and summarized in a planned journal publication.

### **2.3 Opportunities for training/development provided by the project**

The project team consists of two full professors (one at each institution), one assistant professor (at UNC), two graduate research assistants (one at each institution), and, during fall 2008, an REU undergraduate research assistant (at VT). Each of the team members has increased their research skills and experience through this project, as well as gained insights into curriculum development in the area of digital libraries.

During 2006, the research assistants were involved in two areas of the project. First, they were directly involved in the collection and analysis of data concerning publications about digital libraries (from the ACM DL and JCDL conferences, or published in D-Lib Magazine). They now more fully appreciate the need to gather data systematically and verify its accuracy before drawing conclusions. In addition, they gained significant experience in reasoning from the raw data to our conclusions about which modules would be most appropriate for inclusion in a digital library curriculum. Second, they were involved in the development of content for the curriculum modules. This experience allowed them to participate in one aspect of teaching, i.e., course development. For each module, Mr. Yang or Ms. Oh thoroughly investigated the topic (including reviewing existing syllabi that included the topic) and made judgments about specific areas that should be covered in the module and how those areas should be covered.

During 2007, the research assistants were primarily involved in three areas: supporting the analysis of the CS courses on digital libraries; developing a digital library of the readings assigned in the ILS and CS courses on digital libraries, including classification of each item based on our curriculum framework; and developing draft modules. The analysis of the CS courses involved the collection and analysis of data concerning CS programs and their offerings, and more detailed analysis of several specific courses. As last year's analysis of ILS courses and this year's analysis of CS courses were being undertaken, the GRAs also designed and implemented a digital library of the publications assigned in the courses. They classified each reading, based on its fit within our curriculum framework, and made the full text of the reading available in the digital library. While not available for public use (due to intellectual property protection), this DL provided strong support for our further development of additional modules in the curriculum. Each of the GRAs also drafted one of the curriculum modules: 5-b, Applications, and 6-b, Search strategy, information seeking behavior, user modeling.

During 2008 and 2009, the research assistants have been primarily involved in three areas: developing draft modules; managing the expert review process; and managing the field testing. Seungwon Yang, at Virginia Tech, was responsible for developing the module on Applications software and provided the initial draft of the module on Architecture overviews. In addition, Seungwon has been responsible for the project website and wiki (used in the expert reviews). These responsibilities have increased his knowledge of the technical aspects of digital library management, as well as allowed him to explore the ways that advanced technologies might be used to support this project and

digital libraries. Sanghee Oh, at UNC, developed the modules on Digitization and Interaction design and usability assessment; in addition, she worked on a module on Text resources. She also was responsible for managing the expert reviews and the field testing. These responsibilities have increased her knowledge of the operational aspects of digital libraries and her understanding of user behaviors, as well as increasing her social science research skills.

At Virginia Tech, in Fall 2008, 16 students took CS6604, Digital Libraries, and one other student visited/audited the class. This advanced graduate class was taken mostly by Ph.D. students. They provided considerable help related to this project, and also learned a great deal. The class had 4 teams, each presenting 2 of the modules, across 2 class sessions. Thus, 8 weeks of the class dealt with students presenting 8 modules (3-b, 4-b, 5-a, 5-b, 6-a, 6-b, 6-d, and 9-c), that followed after the instructor presenting module 1-b. The team presenting each module learned that module in-depth, while the rest of the class also learned, by doing all the required reading and at least one of the exercises, as well as participating in the 2 class sessions about that module. Later in the class student teams both developed and presented 4 new modules: 2-c/8-d (File formats, transformation, migration), 5-d (Protocols), 7-g (Personalization), and 8-b (Web archiving). They learned an important skill, rarely covered for graduate students, of how to develop an educational module, and benefited from detailed feedback as they spent a full class session presenting that module (and from comments by another team assigned to give them a peer review critique).

## **2.4 Outreach activities**

### **Tutorials**

Fox presented a number of tutorials using the modules developed for the project:

- ECDL 2006, Sept. 17, 2006, Alicante, Spain, half-day
- ECDL 2007, Sept. 16, 2007, Budapest, Hungary, full-day
- ICADL 2007, Dec. 10, 2007, Hanoi, Vietnam, half-day
- JCDL 2008, June 19, 2008, Pittsburgh, half-day
- JCDL 2009, June 15, 2009, Austin, TX, full-day

### **Workshops**

- Castelli, D., & Fox, E.A., co-organizers (2007). First Workshop on Digital Library Fundamentals. Workshop 2 at Joint Conference on Digital Libraries, Vancouver, BC, June 23, 2007
- Mostafa, J., McDonough, J., Mischo, W., Fox, E.A., Wildemuth, B.M., & Pomerantz, J., co-organizers (2007). Developing a Digital Libraries Education Program. Workshop 1 at Joint Conference on Digital Libraries, Vancouver, BC, June 18, 2007
- Fox, E.A., & Wildemuth, B.M., participants. (2008). Education for Digital Stewardship: Librarians, Archivists, or Digital Curators? Joint Conference on Digital Libraries, Pittsburgh, PA, June 16-20, 2008.

## Invited presentations and panels

- Fox, E.A. (2006). Digital libraries for education: Lessons learned and promising opportunities. Invited workshop keynote, LODL 2006, Learning Object Repositories as Digital Libraries: Current Challenges, 2006 European Conference on Digital Libraries, September 22, 2006, Alicante Spain (by videoconference).
- Abbas, J., Kim, K.-S., & Wildemuth, B. M. (Organizers). (2006). Education for digital librarianship: Employers' needs and how they can be addressed. Panel presented at the American Society for Information Science and Technology, Austin, TX, November 5-9, 2006.
- Fox, E.A. (2007). Digital libraries: From proposals to projects to systems to theory to curricula. Keynote presentation, DELOS Conference on Digital Libraries, Pisa, Italy, February 13-14, 2007.
- Pomerantz, J., & Wildemuth, B.M. (2007). Digital curation issues within the context of a curriculum for digital librarianship. DigCCurr 2007: An International Symposium on Digital Curation, Chapel Hill, NC, April 19, 2007.
- Wildemuth, B.M. (2007). An interdisciplinary proposal for a curriculum in digital librarianship. Panel presentation, Digital Libraries: Continuing the Vision of Dr. James E. Shepard, North Carolina Central University, Durham, NC, April 27, 2007.
- Wildemuth, B.M. (2007). Bringing digital libraries into view on an individual's information horizon. Keynote presentation, Libraries in the Digital Age, Dubrovnik and Mljet, Croatia, May 28-June 2, 2007.
- Fox, E.A. (2007). 5S Perspective. Invited presentation, 1st Workshop on Digital Library Foundations, ACM/IEEE Joint Conference on Digital Libraries, Vancouver, June 18-23, 2007.  
<http://fox.cs.vt.edu/talks/2007/20070623JCDLdlfWkshpFox-5S.ppt>
- Fox, E.A. (2007). Quality modeling. Invited presentation, 1st Workshop on Digital Library Foundations, ACM/IEEE Joint Conference on Digital Libraries, Vancouver, June 18-23, 2007.  
<http://fox.cs.vt.edu/talks/2007/20070623JCDLdlfWkshpFox-Quality.ppt>
- Fox, E.A. (2007). Core DL curriculum. Panel presentation for the workshop, Developing a Digital Libraries Education Program, Joint Conference on Digital Libraries, Vancouver, BC, June 18-23, 2007.  
<http://fox.cs.vt.edu/talks/2007/20070617JCDLeducWkshpFox-Core.ppt>
- Pomerantz, J. (2007). Digital library education in computer science programs. Panel presentation for the workshop, Developing a Digital Libraries Education Program, Joint Conference on Digital Libraries, Vancouver, BC, June 18-23, 2007.
- Wildemuth, B.M. (2007). Evaluating specific modules in a digital library curriculum. Panel presentation for the workshop, Developing a Digital Libraries Education Program, Joint Conference on Digital Libraries, Vancouver, BC, June 18-23, 2007.

- Fox, E.A. (2007). Enhancing computing education through LIKES, NSDL, and NDLTD. Invited presentation, Google Education Summit 2007 (part of Google Faculty Summit), Mountain View, CA, July 27, 2007.
- Wildemuth, B.M. (2007). Bringing your library into view. Presented at Jinonice Monday's, Institute of Information Studies and Librarianship, Charles University, October 1, 2007.  
<http://curric.dlib.vt.edu/DLcurric/JinoniceInfoMondays.Prague2007.pdf>.
- Pomerantz, J.P. (2008). Designing, developing, and evaluating an interdisciplinary digital library curriculum. Invited keynote presentation, Libraries in the Digital Age, Dubrovnik, Croatia, June 4, 2008.  
[http://curric.dlib.vt.edu/DLcurric/Pomerantz\\_LIDA2008.ppt](http://curric.dlib.vt.edu/DLcurric/Pomerantz_LIDA2008.ppt).
- Wildemuth, B.M., Pomerantz, J., Oh, S., Yang, S., & Fox, E.A. (2008). Preliminary results from field testing of DL curriculum modules. Paper presented at the workshop, "Education for Digital Stewardship: Librarians, Archivists, or Digital Curators?", Joint Conference on Digital Libraries, Pittsburgh, PA, June 16-20, 2008.  
[http://curric.dlib.vt.edu/DLcurric/JCDL2008\\_workshop\\_eval\\_slides.pdf](http://curric.dlib.vt.edu/DLcurric/JCDL2008_workshop_eval_slides.pdf).
- Molly Bragg, Edward A. Fox, Margaret Hedstrom, Christopher A. Lee. (2009). Moving web archiving into the classroom. Panel presented at DigCCurr2009: Digital Curation Practice, Promise and Prospects, April 1-3, 2009, Chapel Hill, NC. (<http://www.ils.unc.edu/digccurr2009/>)
- Pomerantz, J., Oh, S., Wildemuth, B.M., Hank, C., Tibbo, H., Yang, S., & Fox, E.A. (2009). Comparing curricula for digital library and digital curation education. Paper presented at DigCCurr 2009: Digital Curation Practice, Promise and Prospects, April 2, 2009, Chapel Hill, NC. Presentation slides: <http://ils.unc.edu/~jpom/presentations.html>.

### **3. Publications and Products**

#### **3.1 Publications**

- Fox, E. A., Yang, S., Wildemuth, B. M., Pomerantz, J. P. (2006). Digital library curriculum development: Enhancing education and comprehension of NDLTD. Paper presented at the Ninth International Symposium on Electronic Theses and Dissertations.
- Pomerantz, J., Wildemuth, B. M., Fox, E., & Yang, S. (2006). Curriculum development for digital libraries. Proceedings of the Joint Conference on Digital Libraries (Chapel Hill, NC, June 15, 2006), 175-184.
- Phillips, M., Fox, E.A., & das Neves, F. (2006). Finding computer science syllabi on the World Wide Web. Virginia Tech Dept. of Computer Science Technical Report TR-06-25. <http://eprints.cs.vt.edu/archive/00000930/>
- Pomerantz, J., Wildemuth, B. M., Oh, S., Yang, S., & Fox, E. A. (2006). Briefing: Digital libraries curriculum development. *D-Lib Magazine* 12(7/8). <http://www.dlib.org/dlib/july06/07inbrief.html#POMERANTZ>.

- Fox, E.A. (2006). A 5S perspective on digital libraries for e-learning: With case studies from archaeology, computing, and dissertations. Invited keynote, DeLFI 2006 (Die 4. e-Learning Fachtagung Informatik), Darmstadt, GE, September 14, 2006.
- Fox, E.A. (2006). Improving graduate education with digital libraries. Invited keynote, Inauguration of the DFG Graduiertenkollegs 1223, "Quality improvement in e-Learning by feedback processes" (Eröffnung des DFG-Graduiertenkollegs 1223 Qualitätsverbesserung im E-Learning durch rückgekoppelte Prozesse), Darmstadt, GE, September 14, 2006.
- Shen, R., Vemuri, N.S., Fan, W., & Fox, E.A. (2006). What is a successful digital library? *Proceedings of ECDL 2006* (Alicante, Spain, September 17-21, 2006), Research and Advanced Technology for Digital Libraries. *Lecture Notes in Computer Science*, 4172, 208-219. [http://dx.doi.org/10.1007/11863878\\_18](http://dx.doi.org/10.1007/11863878_18).
- Moreira, B.L., Gonçalves, M.A., Laender, A.H.F., & Fox, E.A. (2006). 5SQual - A quality assessment tool for digital libraries. *Proceedings of WDL 2006* (Florianopolis, SC, Brasil, October 20, 2006). 10 pages.
- Yang, S., Fox, E.A., Wildemuth, B.M., Pomerantz, J., & Oh, S. (2006). Interdisciplinary curriculum development for digital library education. In *Proceedings of ICADL 2006* (Kyoto, Japan, November 2006), *Lecture Notes in Computer Science*, 4312, 61-70. [http://dx.doi.org/10.1007/11931584\\_9](http://dx.doi.org/10.1007/11931584_9).
- Yang, S., Oh, S., Pomerantz, J.P., Wildemuth, B.M., & Fox, E.A. (2007). Improving education and understanding of NDLTD. Paper presented at ETD 2007: The 10<sup>th</sup> International Symposium on Electronic Theses and Dissertations, Uppsala, Sweden, June 13-16, 2007.
- Murthy, U., Gorton, D., Torres, R., Gonçalves, M., Fox, E., & Delcambre, L. (2007). Extending the 5S digital library (DL) framework: from a minimal DL towards a DL reference model. 1st Workshop on Digital Library Foundations, ACM/IEEE Joint Conference on Digital Libraries, Vancouver, June 18-23, 2007.
- Agosti, M., Ferro, N., Gonçalves, M.A., & Moreira, B.L. (2007). Towards a reference quality model for digital libraries. 1st Workshop on Digital Library Foundations, ACM/IEEE Joint Conference on Digital Libraries, Vancouver, June 18-23, 2007.
- Pomerantz, J., Oh, S., Wildemuth, B.M., Yang, S., & Fox, E.A. (2007). Digital library education in computer science programs (short paper). *Proceedings of the 2007 Joint Conference on Digital Libraries* (Vancouver, June 20-23, 2007), 177-178. <http://doi.acm.org/10.1145/1255175.1255208>.
- Ma, Y., Fox, E.A., & Gonçalves, M.A. (2007). PIM through a 5S perspective (poster). *Proceedings of the 2007 Joint Conference on Digital Libraries* (Vancouver, June 18-23, 2007), 491. <http://doi.acm.org/10.1145/1255175.1255290>.
- Moreira, B.L., Gonçalves, M.A., Laender, A.H.F., & Fox, E.A. (2007). 5SQual: A quality assessment tool for digital libraries (demonstration). *Proceedings of the 2007 Joint Conference on Digital Libraries* (Vancouver, June 18-23, 2007), 513. <http://doi.acm.org/10.1145/1255175.1255313>.

- Gonçalves, M.A., Moreira, B.L., Fox, E.A., & Watson, L.T. (2007). What is a good digital library? - A quality model for digital libraries. *Information Processing & Management*, 43(5): 1416-1437.  
<http://dx.doi.org/10.1016/j.ipm.2006.11.010>.
- Yang, S., Wildemuth, B.M., Kim, S., Murthy, U., Pomerantz, J.P., Oh, S., & Fox, E.A. (2007). Further developments of a digital library curriculum: Evaluation approaches and new tools. *Asian Digital Libraries: Looking Back 10 Years and Forging New Frontiers, Lecture Notes in Computer Science*, 4822, 434-443.  
[http://dx.doi.org/10.1007/978-3-540-77094-7\\_55](http://dx.doi.org/10.1007/978-3-540-77094-7_55).
- Yang, S., Levy, J., Miller, K., Pomerantz, J.P., Oh, S., Wildemuth, B.M., Fox, E.A. (2008). Two approaches to enhance the education for ETDs: Developing educational modules and migrating the *ETD Guide* into a community wiki. Paper presented at ETD 2008: The 11th International Symposium on Electronic Theses and Dissertations, Aberdeen Scotland, June 4-7, 2008.  
<http://curric.dlib.vt.edu/DLcurric/ETD08-dlcurric-2008-05-19-final.pdf>.
- Pomerantz, J., Wildemuth, B.M., Oh, S., Yang, S., & Fox, E.A. (2008). Evaluation of a curriculum for digital libraries. Poster presented at the Joint Conference on Digital Libraries, Pittsburgh, June 16-20, 2008.  
<http://curric.dlib.vt.edu/DLcurric/JCDLposter.2008-06-05.pdf>. Recipient of 3<sup>rd</sup> place prize in the JCDL 2008 poster competition.
- Wildemuth, B.M., Pomerantz, J., Oh, S., Yang, S., & Fox, E.A. (2008). A digital libraries curriculum: Expert review and field testing. *D-Lib Magazine*, 14(7/8).  
<http://www.dlib.org/dlib/july08/07inbrief.html#WILDEMUTH>.
- Wildemuth, B.M., Pomerantz, J., Oh, S., Yang, S., & Fox, E.A. (2009). I-schools as a natural home for digital libraries education. Poster presented at the iConference, February 9-11, 2009, Chapel Hill, NC.  
<http://curric.dlib.vt.edu/DLcurric/DLinISchools.2009-01-19.pdf>.
- Yang, S., Fox, E.A., Wildemuth, B.M., Pomerantz, J.P., & Oh, S. (2009). Digital library education module development and field-testing results from Virginia Tech. Poster presented at the Conference on Higher Education Pedagogy, February 18, 2009, Blacksburg, VA.  
<http://curric.dlib.vt.edu/DLcurric/DLcurricPoster-HigherEd-02162009-submitted.pdf>.
- Pomerantz, J., Abbas, J., & Mostafa, J. (2009). Teaching digital library concepts using digital library applications. *International Journal on Digital Libraries*, 10(1), 1-13. DOI: 10.1007/s00799-008-0049-6.
- Yang, S., Wildemuth, B.M., Pomerantz, J.P., Oh, S., & Fox, E.A. (2009). Core topics in digital library education. *Handbook of Research On Digital Libraries: Design, Development, and Impact*. IGI Global, Chapter 49.
- Wildemuth, B.M., Pomerantz, J., Oh, S., Yang, S., & Fox, E.A. (2009). The variety of ways in which instructors implement a module digital library curriculum. Poster presented at the Joint Conference on Digital Libraries, June 15-19, 2009, Austin, TX. <http://curric.dlib.vt.edu/DLcurric/JCDLposter.2009-05-16.pdf>.

- Oh, S., Wildemuth, B.M., Pomerantz, J., Yang, S., & Fox, E.A. (2009). Using a wiki as a platform for formative evaluation. Poster presented at the annual meeting of the American Society for Information Science & Technology, Vancouver, BC, November 8-11, 2009.  
<http://curric.dlib.vt.edu/DLcurric/ASISTposter.2009-10-27.pdf>.

### **3.2 Website**

Project website at <http://curric.dlib.vt.edu/>. The home page provides basic contact information. Additional pages provide updates on our module development activities; a list of, and links to, project publications; a list of our Advisory Board members; and links to press coverage of the project.

### **3.3 Wikiversity contributions for sustainability**

In anticipation of the end of the grant funding for this project, we developed a plan for the long-term sustainability of the curriculum materials developed. The heart of this plan is making the materials available (for use and for revision) via wikiversity. Thus, we developed a set of pages in wikiversity, [http://en.wikiversity.org/wiki/Curriculum\\_on\\_Digital\\_Libraries](http://en.wikiversity.org/wiki/Curriculum_on_Digital_Libraries). We will continue to evaluate the success of this approach to sustainability by monitoring the activity on these pages, including both page views and revisions.

### **3.3 Other specific products**

- The computer science DL syllabi readings analysis data are available at [http://curric.dlib.vt.edu/DLcurric\\_images/DataTablesJCDL07.pdf](http://curric.dlib.vt.edu/DLcurric_images/DataTablesJCDL07.pdf)
- The up-to-date DL module framework is available at [http://curric.dlib.vt.edu/DLcurric\\_images/ModuleFramework2008-08-23.pdf](http://curric.dlib.vt.edu/DLcurric_images/ModuleFramework2008-08-23.pdf).
- Wildemuth, B. M. (2007). Bringing digital libraries into view on an individual's information horizon [video recording]. Recorded May 22, 2007.  
<http://www.youtube.com/watch?v=PXjLBAmrd00&feature=PlayList&p=19189F4C412A6E09&index=92>
- Highlight submitted 12/30/08 to NSF from both VT and UNC-CH, entitled "Digital library curriculum modules now available", along with our logo and NSF Form 1515 allowing use of it

## **4. Contributions**

### **4.1 Contributions to the principal disciplines of the project**

This project was interdisciplinary from its inception. It is our goal that its products (the curriculum framework and modules) will bring the CS and LIS disciplines closer together in their work on digital libraries. Specifically, the final product – a high quality DL curriculum – will aid DL researchers, designers, and administrators who understand all the necessary aspects of DL systems and services, as well as their particular DL specialty

areas. The field testing of the available modules in both CS courses and LIS courses demonstrates our success in making this an interdisciplinary venture.

DLs incorporate various technologies such as database systems, information retrieval systems, advanced user interfaces, network systems, multimedia systems, recommender systems, etc. Our DL curriculum project provides students in both computer science and information and library science with opportunities to understand how each of the above technologies work and how they can interact together efficiently to support DLs.

### **Citations to project publications/works, from CS or ILS**

In addition to the contributions to computer science and information and library science described above, our work already has begun to have an impact on the scholarly output of researchers in those disciplines, as represented by the citations listed below. (Self-citations are excluded.)

Pomerantz, J., Oh, S., Yang, S., Fox, E.A., & Wildemuth, B.M. (2006). The core: Digital library education in library and information science programs. *D-Lib Magazine*, 12(11).  
<http://www.dlib.org/dlib/november06/pomerantz/11pomerantz.html>.

Cited by:

- Witten, I.H., & Bainbridge, D. (2007). A retrospective look at Greenstone: Lessons from the first decade. *Proceedings of the 2007 Joint Conference on Digital Libraries*, 147-156.
- Ma, Y., O'Brien, A., & Clegg, W. (2007). Digital library education: Some international course structure comparisons. *Proceedings of the 2007 Joint Conference on Digital Libraries*, 490.
- Cunningham, S. J., Nichols, D., McKay, D., & Bainbridge, D. (2007, 25 January). An ethnographic study of institutional repository librarians: their experiences of usability. Paper presented at the 2nd International Conference on Open Repositories, San Antonio, TX.
- Fernandez-Luna, J., Huete, J.F., MacFarlane, A., & Efthimiadis, E.N. (2009). Teaching and learning in information retrieval. *Information Retrieval*, 12(2), 201-226.
- Koltay, T., & Boda, I. (2008). Digital library issues in Hungarian LIS curricula: Examples from three library schools. *Library Review*, 57(6), 430-441.
- Gonçalves, M.A., Moreira, B.L., Fox, E.A., & Watson, L.T. (2007). "What is a good digital library?" - A quality model for digital libraries. *Information Processing & Management*, 43(5), 1416-1437.
- Guy, F. (2007). Technological advances and information education, 1982-2007: Some perspectives. *Education for Information*, 25, 63-72.

Pomerantz, J., Wildemuth, B. M., Fox, E., & Yang, S. (2006). Curriculum development for digital libraries. *Proceedings of the Joint Conference on Digital Libraries (Chapel Hill, NC, June 15, 2006)*, 175-184.

Cited by:

- Twidale, M.B., & Nichols, D.M. (2006). Computational Sense: The Role of Technology in the Education of Digital Librarians. Working Paper: 10/2006. Dept. of Computer Science, University of Waikato.
- Choi, Y., & Rasmussen, E. (2009). What qualifications and skills are important for digital librarian positions in academic libraries? A job advertisement analysis. *Journal of Academic Librarianship*, 35(5), 457-467.
- Conway, P. (2010). Preservation in the age of Google: Digitization, digital preservation, and dilemmas. *Library Quarterly*, 80(1), 61-79.
- Fernandez-Luna, J., Huete, J.F., MacFarlane, A., & Efthimiadis, E.N. (2009). Teaching and learning in information retrieval. *Information Retrieval*, 12(2), 201-226.

Pomerantz, J., Oh, S., Wildemuth, B.M., Yang, S., & Fox, E.A. (2007). Digital library education in computer science programs. Short paper presented at the Joint Conference on Digital Libraries, Vancouver, June 20-23, 2007.

Cited by:

- Fernandez-Luna, J., Huete, J.F., MacFarlane, A., & Efthimiadis, E.N. (2009). Teaching and learning in information retrieval. *Information Retrieval*, 12(2), 201-226.

Digital Library Curriculum Project home page (<http://curric.dlib.vt.edu/>).

Linked to by:

- Information Retrieval Curriculum Development project page. <http://collab.dlib.vt.edu/runwiki/wiki.pl?IsRprojInfoRetCurric>.
- JCDL 2007, Doctoral Consortium. <http://www.jcdl.org/archived-conf-sites/jcdl2007/doctoral.htm>.
- Mahey, M., Tonkin, E., & Robertson, R.J. (2007). ECDL 2007: Report on the 2007 European Conference on Research and Advanced Technology for Digital Libraries. *Ariadne*, 53. <http://www.ariadne.ac.uk/issue53/ecdl-2007-rpt/>.

The project was also described in a recent article by Joyce Ray, Associate Deputy Director for Library Services, Institute of Museum and Library Services. The article was published as:

- Ray, J. (2009). Sharks, digital curation, and the education of information professionals. *Museum Management and Curatorship*, 24(4), 357-368.

## 4.2 Contributions to other disciplines of science and engineering

Long term, our project will contribute to the other science and engineering disciplines through the work of graduates of DL programs in computer science and information and library science. Because those graduates will have a stronger education in DL development and administration, the DLs they create (in collaboration with scientists and engineers) will more effectively provide valuable knowledge for those scientists and

engineers. Our contributions should lead to the overall improvement of research efficiency and the advancement of any discipline that relies on digital libraries.

At VT, a multi-disciplinary curriculum building project called, LIKES (Living In the KnowlEdge Society), was launched by scholars in areas such as Business and Information Technology, Computer Science, etc. Based on the DL module framework concept, pluggable LIKES modules can be developed to enhance computing education as well as core / liberal arts education. This relates directly to the LIKES collaborative award to VT (lead institution – NSF CCF CPATH 0722259) – and partner sites (grants 0722276, 0722289, 0752865) to Villanova, Santa Clara U., and NC A&T.

VT also is part of a six-partner collaboration, supported by NSF DUE grants 0840713, 0840719, 0840721, 0840668, 0840597, and 0840715 – for “Ensemble: Enriching Communities and Collections to Support Education in Computing”. A \$2.5M NSDL Pathways award made 9/15/2008 will allow this team to enhance education in all areas related to computing, in connection with the National Science Digital Library. DL curricular materials fit well into the evolving collection for Ensemble, made accessible through the portal that VT runs.

At UNC, we have been cooperating with a digital curation curriculum development project, funded by the Institute for Museum and Library Services and directed by Helen Tibbo and Cal Lee. They have adopted our template for development of individual modules and Cal Lee developed a draft module on Preservation for our project. We expect to continue to collaborate with this group in the many ways in which our efforts are synergistic.

#### **4.3 Contributions to the development of human resources**

Courses created by this project will provide an improved learning experience to graduate-level students and current DL designers and administrators, increasing the possibility of improving their job performance and growth. During field testing, the modules have already affected the learning of over 120 students at five universities.

#### **4.4 Contributions to the physical, institutional, or information resources infrastructure**

Just as this project is expected to develop human resources through improved education of DL professionals, it also is expected to contribute to the development of more effective DLs. As graduates of programs using our curriculum framework and/or modules enter the workforce, they will be able to design, build, and administer digital libraries more effectively.

#### **4.5 Contributions to other aspects of public welfare**

DLs can be developed for many purposes, each benefiting the public welfare. For example, a DL that holds data about a community’s infrastructure and resources could provide critical information during an emergency, or to aid in recovery afterwards – thus,

VT has been working on related projects (NSF IIS-0736055: SGER: DL-VT416: A Digital Library Testbed for Research Related to 4/16/2007 at Virginia Tech, PI: Edward A. Fox; Co-PIs: Weiguo Fan, Christopher North, Naren Ramakrishnan, Donald Shoemaker; and NSF IIS-0916733: III:Small:Integrated Digital Library Support for Crisis, Tragedy, and Recovery, 8/1/2009 - 7/31/2012, PI Edward A. Fox. Co-PIs: Naren Ramakrishnan, Steven Sheetz, Andrea Kavanaugh, Donald Shoemaker). Use of a well-designed and well-managed digital library can lead to improved methods and reduced cost for helping those involved in such situations, whether for research, support of scholarship at all levels, or for public assistance (including recovery and healing after tragedies and crises). Our curriculum development project will contribute to the public welfare by producing DL experts who can design and administer such DLs.