July, 2002

Interdisciplinarity: The Road Ahead for Education in Digital Libraries

Anita S. Coleman, *University of Arizona*

ARTICLES

D-Lib Magazine
July/August 2002

Volume 8 Number 7/8

ISSN 1082-9873

Interdisciplinarity

The Road Ahead for Education in Digital Libraries

Anita Coleman
University of Arizona
<asc@u.arizona.edu>

Abstract

This article reviews the state of education in digital libraries and curriculum planning documents from professional associations in two areas: Library and Information Science; and Computing. It examines suggestions for integration and interdisciplinarity in education for digital libraries curricula using definitions of a discipline, interdisciplinarity, and the transdisciplinary structure of a university in order to discover how such integration may be successfully accomplished. A plan to use learning communities and develop an interdisciplinary curriculum for Knowledge Organization is briefly discussed.

1. Introduction

The School of Information Resources and Library Science (SIRLS) at the University of Arizona recently approved adding a Knowledge Organization track to their graduate curriculum in Library and Information Science (LIS). Prior to developing this track, I examined the disciplinary nature, professional orientation, and research development of LIS as a field of study. I surveyed the information available on LIS professional association and school websites about specializations such as Knowledge Management, Information Architecture, and Digital Libraries. I explored the difference between these specializations and more traditional ones like Information Organization and Information Systems (what and how much new knowledge was being added). I came to the conclusion that while Information Technology (IT) skills are increasingly needed by LIS graduates, it is another concept — namely interdisciplinarity — that needs to be better addressed in our curriculum efforts. The rest of this article explains why and how. It briefly reviews the research in the area of education about digital libraries (DL) and the curriculum development guidelines of professional associations in LIS and Computing (of which Computer Science is one discipline). Definitions of disciplines and interdisciplinarity are examined as well as what it means to be a profession. Transdisciplinarity is identified as a goal of interdisciplinarity. The article also briefly discusses the organization of learning communities as one strategy towards the goal of transdisciplinarity.

2. Literature Review

I surveyed the scholarship in different areas to determine:

- What the research about education in digital libraries recommends

- What the professional associations advise
- What the research indicates about interdisciplinary learning and curriculum development

2.1 What the research about education in digital libraries recommends

Findings from two studies, Spink and Cool [Spi99] and Saracevic and Dalbello [Sar01] are relevant. Spink and Cool in 1999 recommended "an expansion of the traditional LIS and Computer Science (CS) curricula to encompass a more general digital libraries track." The hybrid curriculum would bring together complementary strengths from diverse departments such as computer science, psychology, policy studies, and library and information studies. It would also include specific curriculum areas such as Theoretical and Historical Foundations; Technical Infrastructure of the Digital Library; Knowledge Organization in Digital Libraries; Collection Development and Maintenance; Information Access and Utilization of Digital Libraries; Social, Economic and Policy Issues; and Professional Issues.

This list raises many questions:

- Would the recommended digital libraries track increase LIS fragmentation?
- Would an integrated approach that included DL not suffice?
- Would a special track in DL merely continue to split LIS graduates into traditional and IT-intensive roles?
- Should the hybrid curriculum be developed and implemented as an *independent* DL track housed within LIS but jointly taught with CS and other discipline faculty? Or should it be a set of *integrated* DL courses offered by an *interdisciplinary* DL department that includes faculty from LIS, CS, and other related disciplines?
- How many specializations could small LIS schools *pragmatically* and *intellectually* offer?
- What is the appropriate level of education for the DL track?

In 2001 using three questions [1], Saracevic and Dalbello surveyed LIS curricula and provided some answers [Sar01]:

- Only 32% of the DL courses were *independent,* while 49% (23 courses) pursued an *integrated* approach.
- DL content was integrated within another course and without another independent DL course.
- A categorization of DL topics: *tools* (tools and technologies to build digital libraries); *environment* (the context in which digital libraries operate); *objects* (representations, standards, etc.); and *combined* (tool, technologies, and objects) revealed that 13 LIS programs offered courses that fit into the DL category of *tools.*
- The predominant LIS educational approach uses an *information technology* context.

The researchers conclude that the educational needs of DL have been dictated by CS, argue that DL needs differ from LIS or CS proper, and suggest a framework around the *integrative topics* of DL concepts, content, creation, organization, technology, access, preservation, management, and context.

What Saracevic and Dalbello call *integrative,* I prefer to call *interdisciplinary* [2]. How we want to handle education for DL interdisciplinarity is not only an interesting educational problem but also one that must transcend disciplinary and professional cultures [3].

2.2 What professional associations advise

In recent years, many professional associations have published curricula guidelines (or best practices) about information technology; these include the American Library Association (ALA), Association for Information Systems (AIS), International Federation of Library Associations and Institutions (IFLA), Association for Information Science and Technology (ASIS&T), Association for Computing Machinery (ACM), and Computer Society (IEEE). Reports, curricula, new initiatives, and affiliations from all of these have some implications for DL education [4]. However, in this article, I review only guidelines from IFLA and the Computer Curricula report prepared jointly by ACM and IEEE in order to highlight the need for educational collaboration with CS [5].

The Computer Curricula report acknowledges early on that designing an undergraduate curriculum for Computing is an *interdisciplinary* task. It names four disciplines that are related: Computer Engineering, Software Engineering, Information Systems (IS), and Computer Science [COM01]. The IFLA Guidelines don't explicitly mention interdisciplinarity or specify the level of professional education for LIS graduates beyond noting that it is university level (includeing both undergraduate and graduate levels); they call for a broad general education (topics from other disciplines) and highlight the importance of a variety of information contexts in LIS educational preparation [IFL00].

As articulated by the two reports, Table 1 shows the 14 areas of knowledge for one discipline within Computing, namely Computer Science (CS), and the 10 core elements for LIS.

LIS	**CS**
Information Environment, Information Policy and Ethics, History of the Field	Discrete Structures
Information Generation, Communication, and Use	Programming Fundamentals
Assessing Information Needs and Designing Responsive Services	Algorithms and Complexity
Information Transfer Process	Architecture and Organization
Organization, Retrieval, Preservation, and Conservation of Information	Operating Systems
Research, Analysis and Interpretation of Information	Net-centric Computing
Application of Information and Communication Technologies to Library and Information Products and Services	Programming Languages
Information Resource Management and Knowledge Management	Human Computer Interaction
Management of Information Agencies	Graphics and Visual Computing
Quantitative and Qualitative Evaluation of Outcomes of Information and Library Use	Intelligent Systems
	Information Management
	Social and Professional Issues
	Software Engineering
	Computational Science

Table 1: LIS and CS Areas of Knowledge

Additionally, the Computing Curricula outlines DL as an elective area with topics such as digitization, storage and interchange, digital objects, composites and packages, metadata, cataloging, author submission, etc. [COM01].

Tennant, a professional librarian, discusses the shortage of digital librarians and explains why public service LIS professionals must become tech-savvy [Ten02]. How can you offer good public service, he asks, if you don't know the "universe of possibilities"? A digital librarian should know ASP from PHP (two different ways of creating dynamic web pages), be able to understand and evaluate a variety of information technologies for their potential use, and have the equivalent knowledge of three courses offered at the University of Michigan: Introduction to XML, Usability Methods in Web Design and Digital Librarianship. Steele and Guha sampled 30 library job advertisements in the UK, USA, and Australia between July 1997 and January 1998 [Ste00]. They found that the overwhelming number of requirements were for traditional skills and only four advertisements listed requirements for IT skills. Arguing for change Steele and Guha outline the skills and experience future public service library staff will need in areas besides information management including: pure IT, communication, training, operations planning, strategic planning, and human resources. The importance of teams in the workplace (especially as computing centers and libraries merge) is stressed and the future librarian is likened more to a software knowledge engineer than to a hardware network structures professional.

For too long, LIS schools have responded to the impact of IT in the workplace by simply adding to the existing LIS curricula courses such as Systems Analysis and Design, Database Fundamentals, Human Computer Interaction, and so on. Another approach has been to merge; often, the merger is with larger departments such as Communications and Education and less often with IT-intensive ones such as Computer Science [Koe02]. Anecdotal evidence suggests that both approaches leave novice LIS graduates with overwhelming feelings of information overload, the impression that the library profession is in chaos, and a sense that there is no real core LIS disciplinary knowledge beyond the service ethic, descriptive and procedural knowledge of information resources and their use. Since the impact of IT on all disciplines will only continue to increase, the time is ripe for different approaches — approaches that view curriculum development *intellectually* at the *unit* level (what topics and learning objectives/competencies are common across related disciplines) and how best to facilitate this development for professional graduates. At the very least, such approaches use research findings about interdisciplinary learning to improve the problem solving and competencies of graduates. They also coalesce education for the information professions [6].

2.3 What the research indicates about interdisciplinary learning and curriculum development

At the undergraduate level, interdisciplinary courses have been shown to provide students with many cognitive, as well as affective, benefits [New94]. These include:

1. Precision and clarity in reading, writing, speaking, and thinking.
2. Willingness to confront and challenge assumptions about themselves and the world.
3. Habit of asking why instead of merely memorizing facts.
4. Appreciation for other perspectives.
5. Ability to evaluate expert testimony.
6. Tolerance of ambiguity.
7. Increased sensitivity to ethical issues.
8. Ability to synthesize or integrate.

9. Increased listening skills.
10. Sensitivity to disciplinary, political, or religious bias.
11. Creative, original, unconventional thinking.
12. Enlarged horizons.

Often the starting place for designing an interdisciplinary course involves an eight-step process to interdisciplinary course and curriculum planning:

1. Assemble an interdisciplinary team.
2. Select a topic.
3. Identify disciplines from which the course needs to draw.
4. Develop the subtext for the course (subtext is the abstract issue or issues which form the substantive topic of the course).
5. Structure the course by identifying the conceptual glue that holds it together, keeping in mind not only what is taught but to whom.
6. Select the readings.
7. Design the assignments.
8. Prepare the syllabus. The syllabus must specify what disciplines are included and why.

3. Disciplines, Interdisciplinarity, and Professions

For Schoenberger, academic disciplines are both an *object* of study, as well as a *method* of study. For example, anthropologists study culture through participant observation [Sch01]. Geographers may add *place* to the criteria that define a discipline; for example, historians study in archives. *Forms of discourse,* the rhetorical strategies, also vary among the disciplines; some are linguistic, while others are mathematical. Finally, *evidence* and *epistemological commitments* define a discipline. For Hurd, disciplinarity is defined by Roy as "a field of knowledge which some minimum number of universities (say, 12-20) have established in departments labeled with the discipline's name." [Hur92]. Disciplines are thus constructs as well as ways for controlling knowledge production. *Disciplinary cultures* produce objects and methods of study, the credentialed practitioners of the discipline, values and ways of knowing, and identities.

"The impact of knowledge on action — whether in the field of social or natural phenomena — forces interaction between the disciplines and even generates new disciplines. The 'inter-discipline' of today is the 'discipline' of tomorrow." [INT72]. Therefore, proposing and structuring Digital Libraries as an academic inter-discipline is in one sense knowledge fragmentation but it also has the potential for unification. Since interdisciplinarity can be defined as the integration of concepts and epistemologies from different disciplines, digital libraries constitute a problem domain to which both LIS and Computing (among others) contribute. The only relevant question in this context is how can interdisciplinary DL education be truly achieved and disciplinary protectionism battles be avoided [7]? Explicating the nature of the disciplines and professions involved may move us closer to the goal of interdisciplinary DL education.

Heckhausen elaborates seven criteria for understanding the nature of a discipline and distinguishing between disciplines [Hec72]. The criteria are:

- *Material field* - the set of objects at the common sense level with which the discipline is concerned. On this level, disciplines overlap enormously.
- *Subject matter* - the point of view from which the discipline looks upon the set of observables (or material field) that it studies.
- *Level of theoretical integration* - how well the discipline, through its theories, has reconstructed the reality of its subject matter. Most disciplines have many different theories, some unrelated, some contradictory, and mutually exclusive levels of integration can also exist within a single discipline.
- *Methods* - the methods used to get at the observables of the discipline's subject matter or to transform observables into data that are specific to the problem. A discipline that has developed its own methods is an autonomous discipline.
- *Analytical tools* - the tools a discipline uses and that rest on logic, mathematical reasoning, modeling, etc. These tools are not useful in distinguishing between disciplines.
- *Applications of a discipline in fields of practice* - the degree of applicability to established practical applications. Disciplines with obligations to professional practice tend to be multi-disciplinary and lag behind in research.
- *Historical contingencies* - a discipline is always in a transitional state and is a product of historical developments.

When we use the above criteria to analyze disciplines, we can make a good case for moving from multi-disciplinary to inter-disciplinary teaching, research and practice.

In Table 2, Heckhausen's criteria are used to distinguish between LIS and CS as an illustration of how discipline analysis can help in understanding intellectual cores and in structuring an interdisciplinary curriculum. Similar analysis should be done with the other disciplines that have contributed to LIS innovation and can now better contribute to education in LIS (for example, Information Systems, Linguistics, Philosophy, Sociology, etc.).

Heckhausen's Disciplines Criteria	**Library & Information Science**	**Computer Science**
Material field	Human produced information	Computers
Subject matter	Recorded representations of scholarly information packaged for general human use	Hardware and software of computers; usually only digital computers
Level of theoretical integration	Still absorbed by mere description; many theories; little integration. For example, many theories exist about human information seeking behaviors. There are also classification theories, codes, and concepts about the representation and organization of human produced, recorded information.	More advanced than LIS, but still does not have — and may never have — a single theory that is widely accepted for all phenomena in its subject matter. The concept of the algorithm at the heart of every computer program, stored programs, computer as an image of the human brain, all come close to providing an overarching theory. Computer Logic [8], Human Computer Interaction, Artificial Intelligence all first emerged as theories or tools borrowed from other disciplines.
Methods	Observation Surveys Interviews	Computation Object-oriented programming Prototyping

Analytical tools	Classification Citation analysis	Mathematical reasoning Modeling
Applications	Practice environments are libraries, archives, and museums. Includes library catalogs, bibliographic databases, services, etc.	Practice environments of all kinds (financial, recreational, governmental, educational institutions). Includes databases, data warehouses, networks, agents, etc.
Historical contingencies	Established in the US in the early 1900s as professional, accredited, graduate university (humanistic) education; broad liberal arts background; impact of IT in the late 1900s changes the climate for growth of the discipline and profession; changes disciplinary interactions forcing more background and integration of social sciences; and increasingly becoming technical.	Formal undergraduate education became much sought after and recognized as needed only in the 1970s (somewhat coinciding with the IEEE Computer Society establishment of the Education group). Technical degree; strong background in mathematics and physical sciences; and social sciences, professional issues, standards, and code of ethics more recently added as important to practice and education in this area.

Table 2: The nature of LIS and CS

LIS and Computing are also professional programs of study; they train people for specific professions and occupations. LIS trains librarians and information professionals, and the study is generally at the graduate level. The Occupational Outlook Handbook 2002-2003 edition notes that librarians are increasingly an occupational group that is related to computer systems analysts and database administrators [OCC02]. On campuses, computing areas are spread across diverse disciplinary departments such as Electrical and Computer Engineering, Computer Science, Industrial Engineering, and Management Information Systems. Depending on the focus, these programs train for technical and semi-technical positions. Technical positions include computer software engineers, computer hardware engineers, programmers, computer and information systems managers, database administrators, and systems analysts; professional study for these jobs, while often terminal at the undergraduate level, increases to include graduate school for complex positions. Computer support specialists and systems administrators comprise the semi-technical group and are projected to be among the fastest growing occupations over the 2000-2010 period [op. cit.]. While most jobs in this category require a bachelor's degree in some computing area, many will accept less formal education. Certification in the specific technology (for example, NT server administration) is fast becoming essential.

Occupational projections indicate that the number of computing graduates trained or needed is much larger than the number of LIS graduates trained or needed. The levels of study, number and types of occupations and professions, and numbers of students in these programs are all potentially powerful barriers for interdisciplinary program development involving these disciplines. However, while LIS and Computing are grounded in different academic disciplines, they are increasingly related professional and occupational categories with potential for interdisciplinary curriculum development. We can look at practitioner perspectives to identify and build on similarities. For example, practitioners often articulate professional cultures and values. In software engineering, the path for the software engineer includes professional education, accreditation, skills development, certification, licensing, professional development, professional societies, a code of ethics, and professional standards [Tri02]. Standards have long played an important role in LIS too. In addition to concepts and methods, another topic for interdisciplinary DL education should therefore include computing history, standards, and shared professional values and ethics.

4. The Transdisciplinary University

Jantsch first considered inter- and transdisciplinarity as organizational principles for the university, which actively modify disciplinary concepts, principles, boundaries, and interfaces [Jan72]. Crediting Piaget also with this idea, Jantsch provides an argument based on an *integrated systems view of science, education, and innovation* for *self-renewal of society* as the purpose of education. Inter- and transdisciplinarity play major roles in the organization of the university to meet the goal of education for self-renewal.

A transdisciplinary university may be considered to be the goal of inter-disciplinarity; in interdisciplinarity, curricula and/or research and innovation are organized around a problem that is too broad to be studied/solved using just the methods and knowledge in one discipline. Jantsch distinguishes between normative and purposive interdisciplinarity. Approaches to normative interdisciplinarity are visible when we see basic themes of society or need as the focal points around which education or research is done. Thus, the National Science Foundation (NSF) funding approaches to DL research in recent years, requiring people from different disciplines to come together to work on problems in this area may be considered as attempts at organizing normative interdisciplinarity in research and innovation. In purposive interdisciplinarity, values and value dynamics are brought into play through interactive fields such as philosophy, arts, and religions. Purposive interdisciplinarity provides the feedback link between values and normative planning. It also underlies the structure of the transdisciplinary university. The basic structure of a transdisciplinary university is built on feedback interaction between three types of units.

Systems design laboratories comprise the first unit. Consider, for example, that any one of the projects funded as the DLI-1, DLI-2, and NSDL initiatives [9] can be extended to include these laboratories. Most of the projects funded were conceived as interdisciplinary projects that brought together elements of social science, physical science, computer science and engineering. Many of them (Artemis, Perseus, and the Alexandria Digital Library [10]) continue to engage in exploratory research and small- to large-scale experimental digital library/systems building.

Function-oriented departments make up the second unit. These departments focus on the functions technology performs in societal systems and provide curricula based on functions as varied as Power Generation, Housing, and Educational Technology. A function-oriented unit for DL education could be established using this rationale. Such units are harder to organize, as they must be able to deal flexibly with a variety of technologies contributing to the same function. Function-oriented departments focus on the long-range view of systemic functions in society.

In the third type of unit, education in a number of disciplines continues to be organized around the traditional discipline-oriented departments. However, a large number of funding agencies, institutions, and corporations, generally have no interest in disciplinarity, per se. They are interested in funding projects that solve what they have identified as problems in society or in specific professions. There is evidence that the scientific research enterprise is moving towards "interactive research" where interactive includes inter-disciplinary, inter-institutional, and inter-sectoral research [Roy00]. As the interest and funding levels for interdisciplinarity rise, there is a real possibility for reordering the academic community [Kle96].

LIS and Computing academics and professionals have a unique chance to reflect, articulate and re-consider the disciplinary cultures of their respective disciplines and professions, work out the internal interdisciplinarity of each, and identify when, where and how genuine integration is possible, and with which other disciplines. While functional departments may be feasible at some institutions (for example, NSF-funded DL projects may be expanded to also provide for education about digital libraries), this approach leaves many others in the cold. Similarly, establishing an Interdisciplinary Program in Digital Libraries may not be an option either. Such programs typically require faculty from two or three different academic units, sufficient research expertise, and significant numbers of students. What are other strategies for interdisciplinary education for DL? One is to integrate DL within other LIS courses (a strategy that we saw is already being pursued by the majority of the schools in the Saracevic and Dalbello study). Another solution is to identify *intellectual core areas* (also known as *problems*) and organize LIS tracks and learning communities with related disciplines. A curriculum development plan for a specialization in *knowledge organization* is presented as an example of this approach.

4.1 Learning Communities: Stepping Stones to Transdisciplinarity

Individual faculty may not easily achieve the goal of transdisciplinarity. Nevertheless, they can make small beginnings towards true interdisciplinarity, stepping towards the transdisciplinary university, by using the notion of learning communities. Learning communities are "one of a variety of curricular structures that link together several existing courses — or actually restructure the curricular material entirely — so that students have opportunities for deeper understanding of and integration of the material they are learning, and more interaction with one another and their teachers as fellow participants in the learning enterprise." [Wil00].

Gabelnick identified five models for learning communities [Gab90]. Learning communities have traditionally been widely used in the restructuring of the undergraduate general education curriculum. They can be adapted for use in graduate and professional study. The characteristics of five types of learning communities — linked courses/disciplines, clusters (connected by a common theme), freshman interest groups (FIGs), federated learning communities (FLCs), and coordinated studies — are detailed in Table 3.

Characteristic	**Linked Courses/Disciplines**	**Clusters**	**FIGs**	**FLC**	**Coordinated Studies**
Definition	Faculty teach individual courses but engage in joint curriculum planning so as to help students understand connections among courses and disciplines.	Usually three (but sometimes four) courses are connected by a common theme.	Students who are enrolled in two or three courses together are linked and participate in a weekly seminar.	Faculty member accompanies students to classes as "master learner" and facilitates a weekly seminar.	Faculty and courses are coordinated across the curriculum.
Teaching method	Single teaching	Single teaching	N/A	N/A	Joint/Team
Curriculum planning	Joint/Team	Joint/Team	N/A	N/A	Joint/Team
Assignment/Project	One joint project	N/A	N/A	N/A	Joint/Team
Shared learning experience	Shared learning is not the focus, but is facilitated.	Shared learning is not the focus, but is facilitated.	A cohort of learners (who have similar learning experiences) is the goal of this type of learning community.	Students have similar learning experiences.	Students are asked to reflect on learning experiences. across the curriculum

Table 3: Types and characteristics of learning communities

4.2 Specialization in Knowledge Organization

The School of Information Resources and Library Science at the University of Arizona offers an ALA-accredited graduate program of study in LIS. A total 36 units of coursework in five core LIS areas and electives is required (approximately 12 courses of 3 units each). These are shown below with the number of units in parentheses.

1. Organization of Information (3)
2. Information Ethics (3)
3. Research Methods (3)
4. Evaluation of Information (3)
5. Management of Information (3)
6. Outside department elective (6)

This leaves the students with a minimum 15 units (5 courses) that they can apply towards a specialization (some specializations require more then 15 units).

The impetus for developing a track in Knowledge Organization in LIS came from many sources. Professional associations and LIS educators have continued to call for increasing alignment between education and employer needs, especially in areas such as organization of information (traditionally called Cataloging and Classification) and library systems. Technical services continue to be an area in which more jobs are consistently available than are the number of LIS graduates/job applicants [Mor02]. There is increasing recognition by both LIS practitioners and educators that knowledge organization is a core, intellectual area in LIS, and one that continues to be a significant problem for study and research.

Table 4 shows the courses proposed for a specialization in Knowledge Organization. Disciplinary affiliations or collaborations to design linked courses are derived from these related disciplines. Linked courses build learning communities of students who are registered for different courses in LIS and related disciplines at specified, pre-determined points during the learning process. Students work together to solve selected problems. The proposed points are indicated in parenthesis by the name of the unit area in the Related Disciplines column (i.e., the topic or content area at which the interdisciplinary collaboration is to be achieved). For CS, I have tried to use the topics/units from the Computing Curricula [COM01] where possible. The ideal Knowledge Organization course sequencing is indicated by the numbers 1-5 (i.e., 1,2,3 must be taken prior to enrolling in 5). This is a proposal by a single LIS faculty for interdisciplinary implementation over a period of time — five years at least. An interdisciplinary team of faculty must be assembled for discussing and fleshing out the actual possibilities of implementing the curriculum across different departments/courses and using clustered or linked-course learning communities.

Course	Library & Information Science	Related Disciplines
1. Intro. To Organization of Information	Sample Units: Information Environments, Bibliographic and Non-bibliographic Standards for Organizing Information. Learning Objective: Understanding of the basic characteristics of	Computer Science (Unit: Fundamental data structures)

	heterogeneous information and knowledge organization.	
2. Theory of Classification	Sample Units: Scientific vs. Library classification, Categorization, Faceted classification. Learning Objective: Awareness of the different types of classification and the relevance of each for information and knowledge organization.	Linguistics (Unit: Concepts and categories) Philosophy (Unit: Categories)
3. Cataloging and Metadata Mgmt.	Sample Units: Information Resources, Descriptive Cataloging, Subject Cataloging, Authority Work, Technologies and Standards (MARC, CSDGM, XML). Learning Objective: Knowledge of the wide variety of disciplinary and formats-based standards and technologies emerging for information and knowledge organization.	Geographic Information Science (Unit: Spatial metadata)
4. Controlled Vocabularies	Sample Units: Disambiguation, Poly-hierarchies, Z39.19 standard. Learning Objective: Knowledge and skills in constructing controlled vocabularies.	Linguistics [Natural Language Processing] (Units: Syntactic analysis, Universals and/or Topic: Parsing algorithms)
5. Indexing and Abstracting	Sample Units: Text processing, Automatic Indexing, Information Extraction. Learning Objective: Knowledge and skills in automatic and manual methods for index construction, text summarization and abstraction.	Computer Science (Topics: Problem spaces, Brute-force searches)
6. Knowledge Structures	Sample Units: Systems for knowledge organization, knowledge representation, social epistemology, Relationships between classification, taxonomies, ontologies. Learning Objective: Understanding of the mechanics and principles of individual and public structures of knowledge.	Cognitive Science (Unit: Cognition) Artificial Intelligence (Topics: Structured representation, Uncertainty)
7. Digital Libraries (not part of the sequence; but intended to attract and strengthen CS-LIS-IS collaboration)	Sample Units: Repositories, Archives, Databases, Architectures, Digital Preservation, Content vs. Encoding Standards, Application Profiles.	Computer Science (Topics: Digitization, Digital objects, Spaces, Interoperability)

	Learning Objective: Knowledge and skills in organization of information and knowledge for knowledge storehouses (archives, libraries, museums).	

Table 4: Interdisciplinarity in Knowledge Organization

5. Conclusion

Academic disciplines have long been used to organize knowledge for teaching purposes. They are also the basis of organizing higher education and the professions engaged in teaching and research. The division of knowledge into disciplines, however, doesn't impose a pre-ordained order and doesn't easily transfer to the modern workplace. Many reports have stressed the importance of incorporating interdisciplinarity into the undergraduate experience at the research university. Professional schools such as LIS need to focus even more on interdisciplinarity because of the wealth of competencies such as improved technology and social interaction skills that interdisciplinarity provides. Successful teamwork and performance in technologically rich workplaces and socio-technical systems like digital libraries requires graduates who are not confused by education that seeks to protect disciplinary knowledge boundaries or to add new knowledge about innumerable passing trends without rethinking old ones. This article has proposed a modest plan for interdisciplinarity in LIS professional education based on a core area of LIS — Knowledge Organization — that links collaborative educational opportunities among LIS, Computing and other social science disciplines.

6. Notes

[1] The three questions asked by Saracevic and Dalbello are:

1. *Why teach digital libraries?*
2. *What to teach about digital libraries?*
3. *How to teach about digital libraries?*

[2] Klein uses the terms *interdisciplinary* and *integrative* interchangeably; interdisciplinary concepts in DL was also the theme of the CoLIS3 conference [DIG99].

[3] I am not arguing that other problems, such as lack of funding, don't exist for DL education; they do. But, accepting that interdisciplinarity is a *major* and *defining* characteristic of knowledge in this area may help us identify solutions that work.

[4] For example, AIS participated in the development of the IS curriculum and recently acquired a seat on the Computer Sciences Accreditation Board (see, <http://www.aisnet.org/Curriculum/index.htm>); there's a call to form a new discipline known as Informing Science [Coh99]; and, ALA has established a separate body to certify specializations beyond the basic professional degree for librarians, <http://www.ala.org/hrdr/ala_apa_council.html>.

[5] The relatedness of disciplines (how subjects fit together) has not led to the mergers of LIS with other departments. Only two ALA-accredited LIS schools have merged with CS despite LIS work becoming more technical. There is very little innovation in curriculum development as a result of mergers [Koe02].

[6] When jurisdiction of quantitative and qualitative information was combined because of advances facilitated by the computer, one of the areas that had once been the domain of librarians, hybridized to

include two warring factions: Information Science and Information Systems. Abbott calls these (among others) the information professions [Abb87].

[7] Abbott provides a discussion of why collaboration rather than inter-professional competition is to be cultivated [op.cit.].

[8] Logic provides an interesting example of pre-disciplinary development and interdisciplinary use as a tool. In the Middle Ages, Logic (along with Grammar and Rhetoric) comprised the Trivium (three roads to learning or tools of learning). Today, almost every discipline incorporates logic.

[9] These abbreviations stand for the National Science Foundation's research programs about digital libraries since the early 1990s - Digital Library Initiative Phase 1, Digital Library Phase 2, and the National SMETE Digital Library. More information is available from <http://www.dli2.nsf.gov> and <http://www.nsdl.nsf.gov/indexx.html>.

[10] These are web-accessible digital libraries. Artemis, <http://webartemis.org>, Perseus, <http://www.perseus.tufts.edu>, Alexandria, <http://webclient.alexandria.ucsb.edu>.

7. References

[Abb87] A. Abbott. *The System of Professions: An Essay on the Division of Expert Labor.* Chicago, University of Chicago Press, 1987.

[Coh99] E. Cohen. Reconceptualizing Information Systems as a Field of the Transdiscipline Informing Science: From Ugly Duckling to Swan. *Journal of Computing and Information Technology,* 7 (3): 213-219, 1999. <http://informingscience.com/WhatsIS.htm>.

[COM01] *Computing Curricula 2001.* <http://www.computer.org/education/cc2001/index.htm>.

[DIG99] Digital Libraries: Interdisciplinary Concepts, Challenges: Proceedings of the Third International Conference on Conceptions of Library and Information Science, Dubrovnik, Croatia, May 23-26, 1999. Zagreb : Zavod za informacijke studije Odsjeka za informacijske znanosti. <http://www.ffzg.hr/infoz/colis3>.

[Gab90] F. Gabelnick, J. et al. *Learning Communities: Creating Connections among Students, Faculty, and Disciplines.* San Francisco, Jossey-Bass, 1990.

[Hec72] H. Heckhausen. Discipline and Interdisciplinarity. *Interdisciplinarity: Problems of Teaching and Research in Universities.* Paris, OECD, 1972.

[Hur92] J. Hurd. The Future of University Science and Technology Libraries: Implications of Increasing Interdisciplinarity. *Science and Technology Libraries,* 13 (1): 17-32, Fall 1992.

[IFL00] IFLA. *Guidelines for Professional Library/Information Educational Programs - 2000.* <http://www.ifla.org/VII/s23/bulletin/guidelines.htm>.

[Imp99] J. Impagliazzo et al. *Report: History in the Computing Curriculum.* <http://www.hofstra.edu/pdf/CompHist_9810rprt.PDF>.

[INT72] *Interdisciplinarity: Problems of Teaching and Research in Universities.* Paris, OECD, 1972.

[Jan72] E. Jantsch, E. Towards Interdisciplinarity and Transdisciplinarity in Education and Innovation. In *Interdisciplinarity: Problems of Teaching and Research in Universities.* Paris, OECD, 1972.

[Kle90] J.T. Klein. *Interdisciplinarity: History, Theory and Practice.* Detroit, Wayne State University Press, 1990.

[Kle96] J.T. Klein. Interdisciplinary Needs: The Current Context. *Library Trends* 45 (2): 134-154, Fall 1996.

[Koe02] M.D. Koenig and C. Hildreth, The End of the Standalone "Library School." *Library Journal,* June 15, 2002. <http://libraryjournal.reviewsnews.com/index.asp?layout=article&articleid=CA220870>.

[Mor02] B. Moran. Practitioners vs. LIS Educators: Time to Reconnect. *IFLA SET (Section on Education and Training) Bulletin,* 3 (1), January 2002. <http://www.ifla.org/VII/s23/bulletin/vol3-1.pdf>.

[New94] A. Newell. Designing Interdisciplinary Courses. *Interdisciplinary Studies Today.* Edited by J. T. Klein and W. G. Doty. San Francisco, Jossey-Bass. Also published as New Directions for Teaching and Learning 58 (Summer): 35-51, 1994.

[OCC02] *Occupational Outlook Handbook,* 2002-2003 edition. Washington, D.C., U.S. Bureau of Labor Statistics. <http://www.bls.gov/oco/>.

[Roy00] R. Roy. *The Interdisciplinary Imperative: Interactive Research and Education, Still an Elusive Goal in Academia.* San Jose, Writers Club Press, 2000.

[Sar01] T. Saracevic and M. Dalbello. A Survey of Digital Library Education. *Libraries in the Digital Age, LIDA 2001,* Dubrovnik, Croatia, 23-26 May 2001. <http://www.ffzg.hr/infoz/lida/lida2001/present/saracevic_dalbello.doc>.

[Sch01] E. Schoenberger. Interdisciplinarity and Social Power. *Progress in Human Geography,* 25 (3): 365-382, 2001.

[Spi99] A. Spink and C. Cool. Education for Digital Libraries. *D-Lib Magazine,* 5 (5) May 1999. <http://www.dlib.org/dlib/may99/05spink.html>.

[Ste00] C. Steele and M. Guha. *Staffing the Digital Library in the 21st century.* <http://anulib.anu.edu.au/about/steele/digital_library.html>.

[Ten02] R. Tennant. Digital Libraries: The Digital Librarian Shortage. *Library Journal,* March 15, 2002. <http://libraryjournal.reviewsnews.com/index.asp?layout=article&articleid=CA199859&display=Digital+LibrariesNews&industry=Digital+Libraries&verticalid=151>.

[Tr02] L. Tripp. Benefits of Certification. *Computer,* 35 (6): 31-33, June 2002.

[Wil00] A. Williams. Learning Communities: An Overview. *Inventio: Creative Thinking about Learning and Teaching,* 2 (2), Fall 2000. <http://www.doit.gmu.edu/Archives/fall00/awilliams.htm>.

Acknowledgements

Discussions with the Curriculum Committee and feedback on this article from Cheryl Malone, Brooke Sheldon, April Rice, Betty Marcoux and Jenna Johnson are gratefully acknowledged.

DOI: 10.1045/july2002-coleman