Information Ecology – Emerging Framework for Digital Scholarship

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Abstract

Concepts of information and information ecology are briefly reviewed with the emphasis on interconnections between social actors, information objects and information technologies. Results of a study of the academic information environment in Slovakia are reported. The main question of the study concentrates on possible benefits of the information ecology concept for new models of information activities. Information ecology is determined as harmony among social actors, information resources and systems and includes information objects re-use, value-added services, and visualizations of rich semantic and social contexts. Three methods of data acquisition were used, namely semi-structured interviews with information managers, a questionnaire survey of university repositories, and concept mapping of final theses. Data were analyzed and categorized in six categories: values, problems, community, tools, ecological elements, information literacy. Information strategies of universities should support collaboration and communication and conceptual infrastructure. Results confirmed importance of integrated approach, values, and tools (concept mapping) for learning and research. In conclusion an ecological model of digital library is presented (behavioral, semantic, and visual dimensions). Implications for digital scholarship are derived including ecological information strategies, and knowledge sharing. Benefits of ecological models of digital scholarship are interpreted as part of data-intensive science and science 2.0. New features of ecological digital libraries emerge from manipulations with scientific records, modeling of social networking, creative information strategies and roles of scholars. Ecological filtering based on conceptual modeling and digital objects management are sources for new digital scholarship framework.

Introduction

Scholarly communication has a long tradition in mapping both the structure of documents and information objects and the processes of investigation, communication and information management. As digital technologies become integral parts of the academic information environment, many traditional scholarly communication structures and processes have changed and new models for integration of social and technological are required. Digital content should be framed in new social, technical, and legal contexts.

In this paper we would like to examine if information ecology could form a possible new framework for interpretation of relationships between social actors, information technologies, and information objects. First, we briefly consider the concepts of information and information ecology. In the second part we report on results of the project of the information ecology of academic information environment in Slovakia based on empirical surveys and experiments. The main question of our study concentrated on finding ecological principles of the academic information environment as possible framework for digital scholarship. From the viewpoint of information ecology digital scholarship implies re-use of data, policies and practices of access and control to digital objects, but also interactive information behavior in communities and new information discoveries and services. Information ecology has potential for innovations based on value-added intelligent services and products with rich semantic and social contexts.

Information and information ecology

Although we cannot determine a unified definition of information in information science, we can still try to find its ecological characteristics. Information is not a unitary concept and emerges from integrative levels of interactions between people and information environment. Ecological features of information are represented by its almost endless multiple uses by many social actors (users, creators, information managers). This is caused by the fact that information is based on transformations of cognitive structures, changes of knowledge states and interactions. Many concepts of information in information science are
influenced by philosophy, logics, psychology, cognitive sciences, or informatics. Bates (2010) divided these concepts into communicative (semiotic) concept, activity concept (information as event), structural / evolutionary concept, or social concept. Neurosciences and cognitive sciences emphasize information as electro-chemical signals in brains, and as results of cognition or genetic coding. At cognitive level information is usually determined as any difference that makes difference (Gregory Bateson) (Bates 2010). At metaphysical level information relates to recognition of a structure in the environment. Ecological features of information can be found in philosophy of information (Floridi 2010, Furner 2010) when different forms, characteristics and types of information are examined.

Information embedded in changes of cognitive states becomes part of human cognition and human information behavior (Capurro, Hjørland 2003). Structural approaches emphasize information as a type of structure and pattern of ordering of information objects. For the concept of information ecology we can apply the definition of information in its lifecycle including creation, processing, and information use, as it is closely connected with different manifestations of the „substance“ of information. Environmental information is embedded in the environment and different contexts influence its different interpretations. This concept is interesting for information ecology based on evolutionary structural approaches (Bates 2005, Furner 2010). Environmental (contextual) factors help integrate cognitive, linguistic and social patterns in the concept of information which is close to the process of the concept creation. For this paper we determine information as a structure that can integrate cognitive, social, or technological bases of information environment, as it can be applied to ecological holistic framework. The concept of information is further complicated by individualistic value of information and its dynamics. Relationships between information, meaning, and value (Budd 2009) interpret information as meaningful communicative actions that aim at truth claims and conditions.

Information ecology is an established concept in information science, in information management and information behavior studies. It is based on complex relationships between people and technologies while using information in communities and organizations. Information ecology was determined by Davenport and Prusak (1997) as making information meaningful. Information ecology as a metaphor helps manage information environment with the use of information professionals and their activities (information analysis, support of information sharing, etc.).

Another concept of information ecologies is based on relationships between information technologies and people in transforming information to knowledge (Nardi and O’Day 1999). Information ecologies represent procedures, goals, community values supported by technologies. Information ecologies are places where people use tools and in social relations help each other in information activities.

Ecological model of information seeking and use (Williamson 2005) depicts a social actor involved in such settings as information needs, personal, physical, working and social contexts. Ecological features of adaptations and monitoring of information environment are here emphasized.

Based on environmental psychology an ecological constructionist model of user information behavior was developed (Nahl 2007). It integrates affective, cognitive and sensorimotoric parts of information activities (in the ACS model). Information ecology is also connected with studies of affective information behavior (Nahl and Bilal 2007). The authors explain emotions which influence perception and use of information and information technologies.

Information ecology can help better understand the notion of information and build new models which can represent both cognition and emotions that direct information behavior. The broader view on relationships between people and information environment can explain ecology of the information lifecycle. Information ecology concept helps us identify those factors that make an impact on the information environment. Critical components are tools for eliminating information overload, redundancy and risks of information use. At micro-level we determine such components as individual cognitive, affective, sensomotoric skills as part of information behavior. At macro-level information ecology includes management of information sources, systems, and environments. Social framework of the ecology of information work was analyzed with the emphasis on knowledge organization by Huvila (2006).

Ecological features of information are based on information behavior patterns, and information styles.
They map ecology of information re-use, satisficing, and optimizing of information. Ecological approach could help understand how information places and spaces in web add value to information through active information use in the electronic environment represented by personalization, filtering, collaboration and integration of information. Experts call for more studies devoted to new conceptual frameworks and features of systems for future (e.g. Vakkari 2008).

**Information ecology of the academic information environment in Slovakia: a study**

The project VEGA Academic information environment – modeling from the perspective of the information ecology focused on potential of information ecology for the improvement of academic information environment (Steinerová, 2009).

Research questions were conceptualized as follows:

- *Is information ecology beneficial for new conceptual models of the information environment?*
- *What are ecological features and components of the academic information environment?*

For the conceptual framework we used results of our previous empirical studies (information behavior styles and relevance assessment) (Steinerová and Šušol 2005, 2007, Steinerová, Grešková, Šušol 2008, Steinerová 2008). The interconnections between social actors, tools, values, and communities were modeled as a framework for further study. Detailed categories of research were designed in three dimensions: semantic, behavioral, and visual (cognitive). The semantic dimension conceptualized constructions of meanings, sense-making and relevance assessment. The behavioral dimension covered values, building of communities (social networking), and information behavior styles. The visual (cognitive) dimension included especially tools that can support information behavior and manipulations with meanings. These tools can include information horizons, concept maps and other knowledge organization tools (ontologies, taxonomies, etc.). Information culture represents explicit and implicit rules and practices that support information flows in education and research. Information strategies are set of practices in planning information sources, services and products. Academic community is shaped by information needs, behavior, interests and practices. Tools for information use were determined in a wide sense, covering information systems, knowledge organization tools, academic libraries, computing centers, and research and study offices.

The study was divided into the following three lines:

1. the survey of perceptions of the academic information environment by information managers in selected Slovak universities
2. the survey of university digital repositories in Slovak universities
3. experimental concept mapping in a database of selected final theses in Library and Information Science.

Detailed methodology and results are summarized in the published final report (Steinerová et al. 2012).

Academic information environment is regarded as a set of heterogeneous information sources, social actors, information systems, organizational components, and tools. Main factors that shape the information ecology are values, community, and tools. In final report we synthesized results of the questionnaire survey of academic repositories, results of analyses of interviews with information managers, and results of experiments with knowledge organization tools in digital environment.

Digital repositories are important as background for new ecological value-added services for the academic information environment. The improvement of the services operation is conditioned by processes of communication, cooperation, and integration. It was proved that special information organization tools which combine concept structures with advanced modeling techniques are needed. Our experiment confirmed the potential of concept mapping for support of education, research, and knowledge management and of topical maps from keywords of final theses in library and information science.

**Methodology and methods**

The concept of information ecology represented a methodological background for the research. The focus is finding harmonious relationships between single components of the information environment with the emphasis on adaptations and evolution. Multiple uses of information objects in education and research and strong and weak features of information technologies were also considered. The methodological framework concentrated on possible integrated models of information processes and community for digital scholarship.
Main tools for gathering the data were the questionnaire survey of digital repositories and the semi-structured interviews with selected information managers and directors of libraries, deans and other university managers in Slovakia. We selected major universities in large Slovak cities (Bratislava, Nitra, Trnava, Žilina, Banská Bystrica, Košice, Prešov), directors of academic and research libraries, and selected Czech experts (from Brno and Prague).

Experiments with knowledge organization tools concentrated on concept modeling and statistical modeling based on keywords. For analyses of data from interviews we applied content analysis, aggregation and interpretation of data. In conclusion we derived recommendations and resulting model of the ecological digital library.

**Findings of the survey of academic managers**

Perceptions of the academic information environment were studied in line with information behavior research (Case 2002, Choo 2006) and knowledge management (Davenport, Prusak 1997, Nardi, O’Day1999). Interviews with 17 information managers were carried out from August 2010 to March 2011. We also developed methodological rules; interviews covered 22 questions in three topics. Demographic data confirmed that interviewees were divided into 10 men, 7 women, the average age was 49; the average number of years of professional experience was 25. The review of positions of interviewees is presented in table 1. The material was analyzed in multiple phases. We used three interpretations and resulting concept models were categorized into six major categories: values, problems, tools, community, ecology, information literacy.

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
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<tbody>
<tr>
<td>Director of library</td>
<td>6</td>
</tr>
<tr>
<td>Director of IT centre</td>
<td>4</td>
</tr>
<tr>
<td>Head of the department</td>
<td>2</td>
</tr>
<tr>
<td>Vice-rector</td>
<td>2</td>
</tr>
<tr>
<td>Librarian</td>
<td>1</td>
</tr>
<tr>
<td>Dean</td>
<td>1</td>
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<tr>
<td>Project manager</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
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Table 1. Numbers and positions of interviewees

In the category of **values** open education and research are regarded as benefits of the academic information environment. Creative people and communication were identified as basic values in contexts of access to information sources within supportive technological infrastructure. The values are represented by the hierarchical conceptual model (Fig.1).

![Figure1. Relationships of value components of the academic information environment](image)

In the category of **problems**, especially information overload and lack of integration of sources and systems were mentioned. Low level of managerial communication and information inequity are embedded in problematic communication and cooperation. **Rigidity** of organization structures, information overload, and insufficient integration of sources and systems were also mentioned. As for the **tools**, more integration and electronic communication tools were required, but also establishment of strategic partnerships and information strategies. In the category of **community** people represented the critical factor. The community should be strengthened by motivating leadership and the university culture. For community building it is important to follow common goals and quality of education and research, and informal electronic communication. Some
subjects expressed the problem of low-level of transfer of managerial information. Basic factors that help build academic community include value system, active communication and institutional brand. The factors are visualized on Fig. 2.

![Figure 2. Basic factors for building and maintenance of the academic community](image)

Ecological elements were expressed metaphorically as cleaning, consistency of information worlds, or alchemy. Ecological principles are based on information sharing and multiple information uses. Emphasis is put on creativity and innovation of people (students, teachers, researchers).

For the improvement of information literacy support of interest, motivation, terminology and available technological tools were mentioned. Interesting opinions on information literacy expressed differences between the older and younger generations in access to information technologies and evaluation of information. Gaps were identified in support of creative potential of people and in building of value system and culture. Academic culture and communication in education and research were emphasized. Ecological information literacy was elaborated in detail in another work (Steinerová 2010).

Final recommendations point to cultivation of information ethics, elimination of information overload, and building new community models. Integration of resources and services and better cooperation and communication were also required.

### Findings of the questionnaire survey

Altogether 27 respondents from major Slovak universities took part in the survey (Bratislava, Trnava, Nitra, Žilina, Banská Bystrica, Košice, Prešov). Most important results of the questionnaire survey of academic repositories indicate that in most academic institutions in Slovakia there is no central repository, but that universities usually build several separately distributed repositories of electronic documents (44, 83%). Surprisingly, in most cases the academic library initiated the building of a repository (almost 70%). The role of the academic library is important for registration of publishing activities, especially textbooks, but also final theses and research outputs. In the category of problems lack of legislation and coordination were mentioned as important issues. In most universities information systems are not fully integrated (administration, registrations, e-learning, publishing, library systems). Availability of electronic documents is provided especially for academic community (45%) and intranet is not fully working. Most important obstacles to distribution of electronic documents are copyright issues and lack of internal rules. The closest cooperation was confirmed between libraries and IT departments. Generally, benefits of institutional repositories are recognized as integration and systematic access to information, and multiple uses of information for digital scholarship, but the problematic issue of real operation still persists. More support of university management and internal rules for repositories were required. Detailed results are reported in Steinerová et al. 2012.

### Results of concept modeling

In the third part of the research project we applied concept mapping for terminology of information seeking and final theses in Library and Information Science. Mapping of contexts in information science have been explained by a number of authors (e.g. Chang and Lee 2001, Hook and Börner, 2005, Allen and Kim 2001). Concept maps are an efficient tool for representation of research results and for the enhancement of students' learning. They provide students with support for information analysis and learning. For concept modeling we used the system C-maps (Novak, Canas 2008).
In the first phase we developed the concept-based terminological dictionary on the topic of information seeking and information strategies based on a textbook on Information Strategies in the Electronic Environment (Steinerová, Grešková, Ilavská 2010). Main topics of the textbook (e.g. digital libraries etc.) are represented by concept maps supplemented by definitions, schemas, models, pictures, examples.

Later we developed several concept maps based on 15 final diploma and dissertation theses in Library and Information Science. They are stored in a small experimental database and represent features of organization of information for re-use of knowledge and further elaboration of topics. These maps are presented in detail in the final report (Steinerová et al. 2012).

Finally, based on keywords extracted from selected diploma theses in the last ten years we applied the frequency analysis of keywords to form clusters and links and visualized the topics of diploma theses in 5 topic maps (for the years 2001 to 2010). We found the most frequent topics and correlations between them. While the topics in the first years (2001-2) were concentrated on internet and library services, in 2005-6 new topics of information behavior and history of book culture emerged. In 2010 the topics of theory of information science and assessment of website dominated. Most frequent topics in the last ten years revealed tendency to represent such topics as digital environment, websites, and metadata. The shift was recorded especially towards topics of information behavior and literacy.

**Implications for digital scholarship**

Changes in scholarly processes in digital environment are manifested both in collaboration in social networks and in publication processes. Digital libraries then change scholarly practices and publishing patterns. Communities of practice and epistemic cultures represented by e.g. terminology and conceptual infrastructure in disciplines are starting points for data sharing, new types of interactions and collaboratories. Ecological features of digital libraries help integrate information closely into social activities, cognitive processes, contexts and situations. This is depicted in an ecological model of digital libraries (Fig. 3).

The model comprises ecological filters in semantic, behavioral, and visual dimensions. Ecological filters can be identified both on the levels of humans and systems. The dimension of semantics means adding contexts and rich semantic relations to representations of information objects. The dimension of information behavior covers information styles and communication. On the level of human information behavior ecological information strategies include collaboration and networking. Behavioral filters can help eliminate information overload and assess relevance of information. The visual dimension uses graphic representations of concepts and categories. The main ecological strategy is the construction of meaning from visual representations of contexts which carry additional implicit information (shape, color, size, etc.). Thus, ecological digital libraries apply semantic, collaborative and visual filters into features, information objects re-use and interactions.

Ecological digital libraries comprise visual representations of concepts (concept maps) which can be built into the interfaces. In-built filters can help clean information environment and make sense, construct meanings and discover relevance. Social searching and semantic/ contextual searching emerge as tools of ecological management of information environment. Concept mapping and knowledge mapping represent strong potential for dynamic end-user interfaces and for tailoring of digital collections to users' behavior. Social activities, social contexts and interactions in collaborative information strategies become parts of information problem
solving and decision making. Behavioral filters build on social networking and community interactions. It is manifested by collaborative filtering, social navigation and knowledge sharing. Complex semantic representations can be modeled on different levels from semantic networks to complex concept models in specialized domains, e.g. ontologies. Contexts can be visualized in various forms, from concept maps to mind maps.

Another challenge of ecological strategies is integration of social media and information ecology. It is manifested in collaborative information practices in workplaces or communities. Social networking can be supported by new features of digital library spaces. This can lead to building common collaborative information horizons, re-use of collective knowledge and strategies, social learning, knowledge sharing, and information advice. Social spaces can be transformed to collaboratories with common vocabularies, rules and evolving ethics. New models of digital scholarship can emerge with culturally oriented information practices in these complex socio-technical digital spaces.

Ecological digital libraries can also better support knowledge sharing and better integration of information needs into digital libraries. It is framed in the new concept of science 2.0 determined as inclusion of intelligent technologies into cognitive and social scholarly practices, e.g. collaboration and social networks, forming trust, managing security, managing information overload. This applies to other new types of information seeking – discovery and exploratory searching, faceted searching, intelligent searching. Information practices and decision-making processes in digital scholarship place new demands on ecological digital libraries. Interesting applications are developed in digital humanities which model tools for assistance in interpretations and sophisticated collaboration, e.g. presentation of research stories, integration of digital cultural objects, simulation of events, sharing data, access and copyright management.

Implications for digital libraries confirm that new models of digital scholarship count on new information products (databases, knowledge bases), social networks, collaboratories, and mining of informal interactions. In digital humanities scholars discover new possibilities of digital libraries for keeping records of business, government, culture, for digitization of untraditional information objects (genealogy, digital photography, censuses, etc.). These data can be shared and re-used and presented for multiple audiences in new settings and simulations.

New models of digital scholarship and education are directed to support of human creativity and innovations. Information ecology of digital libraries can help in personal information management, social searching and contextual searching, and ecological filtering. Ecological digital libraries not only navigate users, but help them discover new relationships and explore ideas, share experiences, learn shortcuts, re-use successful strategies. They are part of new partnerships among social actors within the academic environment, among libraries, IT centers, and publishing houses; and in relationships between internal and external environments. Social networks and informal communicative channels lead to need of re-definition of information work for digital collections management. Reviewing processes, editorial work, integration of publishing into projects and research help define new intellectual models for knowledge representation and sharing in digital libraries. It is also connected with concepts of “open science” and open access to scholarly outputs. Ecological digital libraries and our model reflect the potential for creative innovations through new features of digital scholarship.

New framework of digital scholarship builds on cyberinfrastructure and ubiquitous digital environment. Convergence of digital libraries and intellectual work create new models of scholarship – e.g. science 2.0 (Shneiderman 2008) or data-intensive paradigm. This means support of scholars in every phase of their scholarly work and communication, since the first idea to results. Data-intensive science concentrates on the scientific record itself and its manifold uses in scientific work. Digital libraries can help build conceptual infrastructures for disciplines and domains, but also apply those affordances which find new uses of data (simulation, mining, visualization). Some examples include the notion of

Conclusions

Main information ecology drivers for digital libraries in the context of academic information environment are information strategies, information literacy, and organizational climate and culture.
scientific record of complex systems, e.g. annotated genomes, signaling pathways, robotic instrumentation, and digitalized cultural objects. Ecological digital libraries model information strategies of scholars in different disciplines, both formal and informal in social networks, and the roles of scholars (as innovators, administrators, project and financial managers), in legal and professional relations. Ecological digital libraries enhance knowledge sharing and adding value to information by combinations of theoretical investigation, experimental work and simulations.

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REFERENCES


