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MODELLING INFORMATION ENVIRONMENT IN ECOLOGICAL CONTEXTS: A QUALITATIVE STUDY OF INFORMATION BEHAVIOUR OF RESEARCHERS IN SLOVAKIA

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Introduction

This paper presents a brief analysis of models of digital scholarship and open science in contexts of information ecology. Digital technological developments and digital data deluge have changed information behaviour and information interactions. New types of documents and genres have emerged in digital environments, ranging from blogospheres to mobile digital libraries. Thus, digital science can be understood as transformation of creative scholarly communication and information processes into digital environments. Open science refers to research processes based on transparent information practices regarding methods, data, results and democratic access to knowledge. It allows broader public access to research results. Open science includes open access to scholarly literature, open data, open institutional repositories and electronic journals. Information ecology is a concept which seeks a harmony between people, information and technologies in physical and digital spaces.

At present we can determine an ecological paradigm of information science. Information ecology is a framework based on balance among actors, information and technologies in the information environment. A number of authors emphasized ecological perspectives as response to holistic contexts of information interactions (Fidel 2012), information systems (Chowdhury 2014) and digital scholarship (Borgman 2015). The philosophical, managerial and technological approaches to

information ecology confirm diversity of emergent ecological perspectives at individual, community and social levels. Ecological perspectives were determined by Capurro (1989), Nardi and O´Day (2009), Floridi (2010), Huvila (2011) and others. They refer to common ecological principles of information, especially making information meaningful in organizations (Davenport and Prusak 1997), balance between thinking, activities, resources and technologies in information landscapes (Capurro 1989). In the socio-technological approach (Nardi and O´Day 1999) information ecologies represent procedures, goals, and community values supported by technologies. Information ecologies are places where people use tools and in social relations and information activities transform information to knowledge. Chowdhury (2014) outlined the sustainable digital information services in a model of relationships among data and content, users and technologies and analysed economic sustainability, social sustainability and environmental sustainability. Borgman (2015) emphasized big data as part of information ecosystems marked by reproducibility, reuse and sharing of data. The strength is the emphasis on making data discoverable, usable, interpretable. Ecological approach to human information behaviour is explained by Fidel (2012) as context-centred in the model of cognitive work analysis (CWA). In the context of creative information use creative ecologies cover adaptive mind in creative places (Howkins, 2010). In these ecological constructs we identified the following common ecological principles: infosphere, adaptation, diversity, information re-use, collaboration, communities, cultures, contexts and infrastructures. Ecological design produces information systems which are closer to human information activities.

In the following sections we present selected research results of a qualitative study aimed at understanding information behaviour of researchers in Slovakia and changing information infrastructure of scholarship. Our main research questions are: Which are typical information practices of researchers in different disciplines with regard to values, barriers and research creativity? Which components can be identified in the information environment of researchers and which implications can we derive for the information environment of digital scholarship?

1 Related research: brief review of models of digital scholarship

We analyzed several models of digital science and social networks of research workers. Hurd (2000) outlines the most important changes in the information process based on digital libraries (Fig. 1). Whitworth and Friedman (2009) presented rich information interactions between authors, editors, web

publishers, reviewers and readers that have changed the traditional information environment.

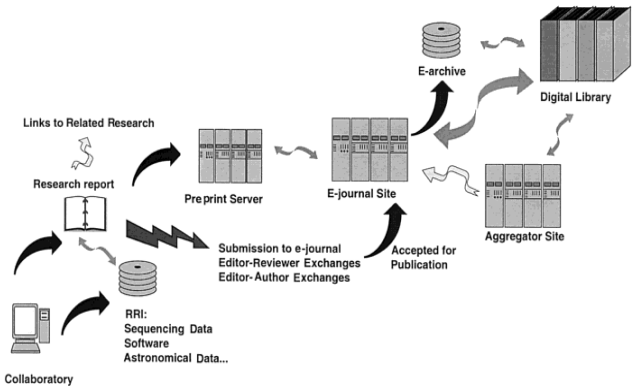

Fig. 1

Scientific Communication: A model 2020 (Hurd 2000, p.1281)

Björk (2005) designed an updated version of information flows in scholarly communications. He models both communications and information management and distribution. Borgman (2015) (Fig. 2) presented a scientific life cycle perspective on information flows based on the analysis of big data, its management and infrastructure. New topics open doors to exploration of human data interactions.

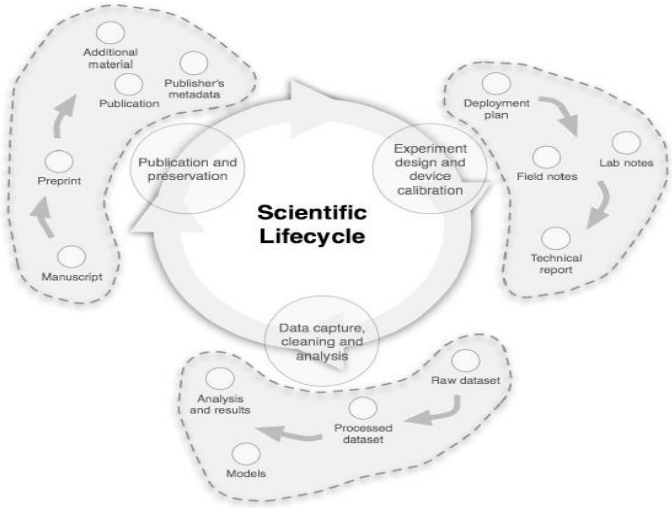

Fig. 2

Scientific life cycle example from the Center from Embedded Networked Sensing (Borgman 2015, p. 265)

Chowdhury (2014) presents a model of sustainable digital services based on sustainable information environment (Fig. 3).

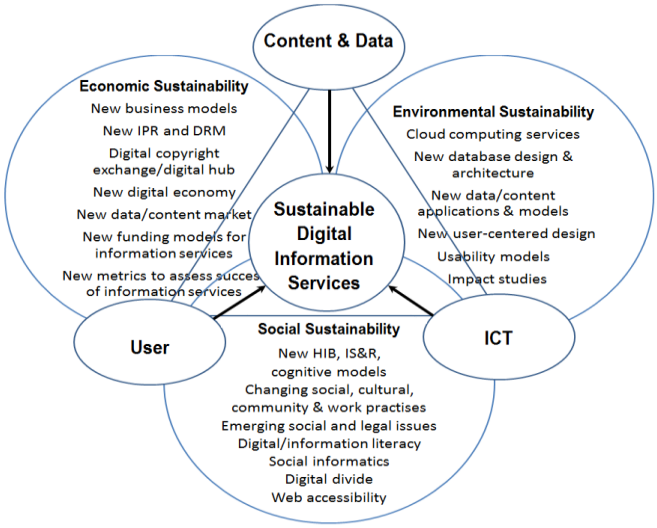

Fig. 3

Research issues and challenges in sustainable digital information services (Chowdhury 2014, p. 195)

As a result of analyses of the models we can identify three basic components in digital science and open scholarship: users and producers; knowledge infrastructures; and content, including artifacts and value-added services. These components provide a common contextual background for conceptual modelling of information behaviour of researchers (Ellis 2005; Talja 2005; Fidel 2012; Case 2012). Common background is based on rich information interactions between users and other actors, data and information and technologies.

2 Information behaviour of researchers in Slovakia: a qualitative study

In the framework of a research project on digital scholarship we carried out a qualitative study regarding the information behaviour of 19 selected researchers in Slovakia. The main research question was focused on determination of domain differences with regard to information behaviour of researchers and their perceptions of open science. We applied the methodology of semi-structured interviews. Characteristics of participants are described in Table 1.

Tab. 1

Characteristics of the participants of the study (19 participants)

Group	Discipline [17]	Research subjects	Gender
Humanities (8)	Archaeology; Archival Studies; Comparative Religionistics; Literary Studies; Sinology; Slovak Language – Linguistics; Systematic Philosophy (2) [7]	Aeneolith, Bronze Age; Written Culture History in Slovakia; Maya Culture; Slovak Literature; History of China; Slavic languages, Dialectology; Logics; Pragmaticism	F (0) M (8)
Social Sciences (4)	Ethnology; Economics, Statistics; Politology; Sociology [4]	Folk traditions, social anthropology; Megatrends, prognostics; Comparative politology, European integration; Social policy	F (4) M (0)
Sciences (5)	Astronomy, Astrophysics; Macromolecular Chemistry; Molecular Biology; Neurophysiology; Nuclear Physics [5]	Observational astronomy; Polymers; Genetics; Autism; Space Sciences	F (1) M (4)
Technical Sciences (2)	Computer Science (2) [1]	Information Systems; Software engineering	F (1) M (1)

A conceptual map was developed as a methodological tool for semi-structured interviews, content analyses and further conceptual modelling (Fig. 4). The participants of the study included selected 19 researchers in sciences and medicine, humanities, social sciences and computer science in Slovakia. The selection criteria of subjects were based on the expertise and excellence in the domain, international networks, use of big data, advanced technologies and unique characteristics of the disciplines.

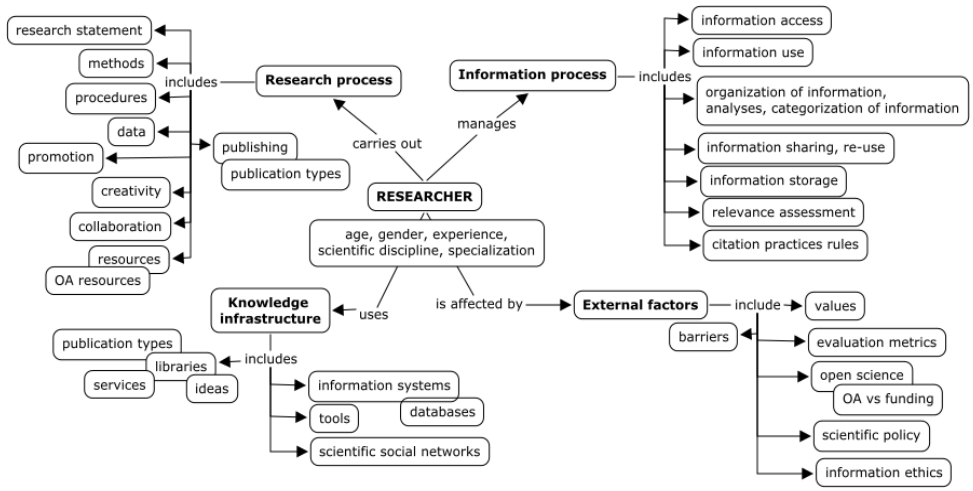

Fig. 4

Methodological design of the study (conceptual map)

The 19 respondents included 13 males (68,4 percent) and 6 females (31,6 percent), the average age was 54,4 and the average number of years of professional experience was 30 years. The representation of disciplines was composed of humanities (39 percent), sciences and medicine (28 percent), social sciences (22 percent) and technical sciences (11 percent). An averarge duration of an interview was 72 minutes. The interviews were carried out since October to December 2015 and since January to May 2016. The data were coded and frequencies of derived categories were interpreted. Deeper semantic analyses have been applied, including concept modelling and concept mapping and multiple analyses of different researchers in order to ensure the validity of results were finally integrated.

3 Initial findings

Relationships of scholarship with broader public, transparency of research processes and open access to data and publications were the topics subject to initial analyses. If we are to understand the information practices of open science in social, technological and community dimensions, we need to re-conceptualize the concept of research information interactions. Research information interactions can be determined as complex relationships between researchers and information environment. Following the ACRL Framework (2015) we can determine research information literacy as the ability to understand and use information in order to carry out research in disciplines. However, not very much attention was paid to perceptions of open science and digital scholarship. That is why we analysed the data in relation to factors of open and digital scholarship.

These analyses point to common patterns and disciplinary differences in perceptions of knowledge infrastructure. Common patterns revealed common critical analytical information practices (information fluency). Practical experience and expertise is manifested by reliance on authoritative information sources and personal international expert networks. Open science factors were identified by researchers, especially promotion of results and open access. It is also connected with international participation, collaboration, peer networking, and information sharing (17 subjects). Technological determination, special methods and software tools were found especially with "big data" sciences, i.e. astrophysics, physics, genetics, archaeology, social sciences. In humanities, the tendency towards building digital collections and digital libraries was noted (e.g. archival system PamMap, Slavic languages atlas, archaeological photographic digital collections). Further open science factors included policies, evaluation of results, access to data and publishing. Awareness of researchers' social networks has been confirmed, including alternative metrics (altmetrics). Main differences emerged from domain-specific research objects, research statements, methodologies, procedures and data management. These differences are reflected in publishing activities (humanities: monographs, sciences: journals), communication, information use and culture of disciplines. Methodological modes of social sciences, humanities, sciences and technical sciences were identified. Detailed account of analyses, interpretations and findings are summarized in a separate publication (Steinerová et al. 2018).

4 Concept mapping as representations of discourse

The process of content analyses was finalized by the method of concept mapping based on the collective discourse of 19 subjects. Concept mapping is a method which can help extract key concepts and semantic representations of main topics, categorize topics and ideas and visualize contexts and semantic relations. In line with similar research projects (Novak and Canas 2006; Kinchin et al. 2010; Steinerová et al. 2012; Whitworth 2015) we concentrated on most important representations in contexts and visualized the analyses in more than 20 concept maps related to components of the basic concept map of information behaviour of researchers (concept map methodological design, fig. 4,), including the research process, information process, information infrastructure and factors of influence. As an example, the map of research creativity is visualized (Fig. 5).

4.1 Research creativity

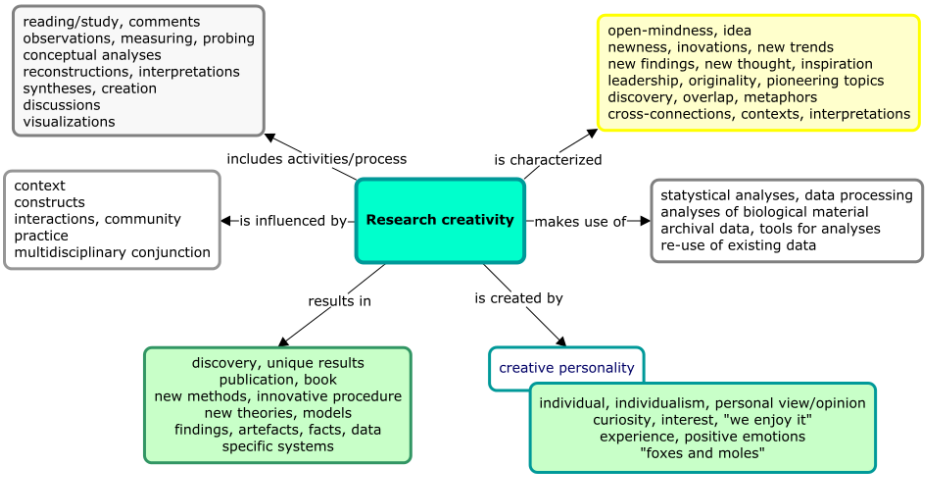

Fig. 5

Research Creativity – concept map

The map represents the collective discourse of selected 19 top researchers and experts. The question was focused on attitudes towards creativity in research work. Researchers named and identified main components of the creativity in their research work, namely creative personality, creative process, creative product, and contexts – factors of influence, tools and techniques within the research activity. Main characteristics of the research creativity are open-mind, newness, originality and innovations. It requires creative personality which can combine both individual interpretations, experience, emotions and collective collaboration.

4.2 Values of research work

Values of research work were perceived at individual and social levels (Fig. 6). The values are often embedded in everyday information practices and expertise. The common denominator of researchers´ values is the deep motivation, discovery of new perspectives, problem solving, or knowing the unknown. Generally, researchers search for values in relation with fascination by knowledge and service for society. The values are also interpreted as the ideal moral value – curiosity, characteristics of a moral learned scholar, learned society. Another value is found in education of young people and raising their interest in research topics. Several differences in interpretation of values have been noted, especially practical problem

solving and assistance in understanding of life in sciences. In humanities and social sciences, the values are determined in broader sense, such as bridging the gap in knowledge, bringing new perspectives and interpretations, including intellectual pleasure.

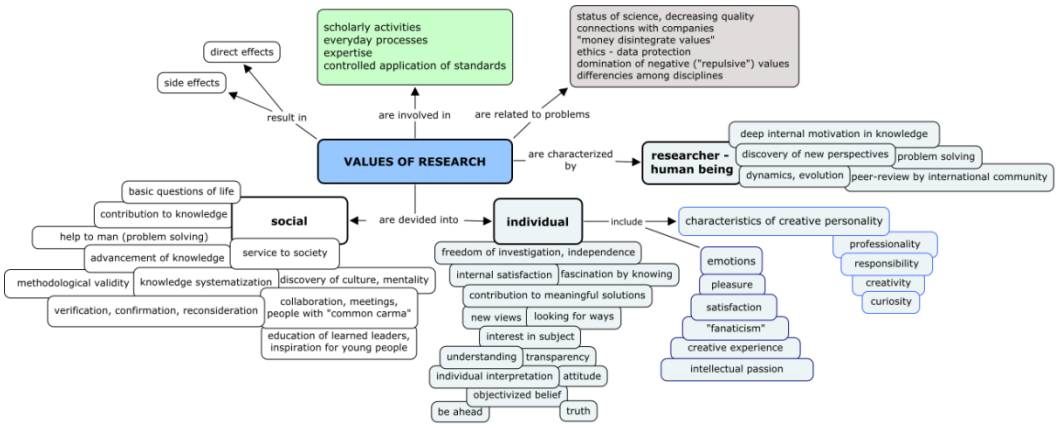

Fig. 6

Values of research work – concept map

4.3 Barriers

Basic barriers of research work expressed by researchers were administrative overload or „bureaucracy“. Several respondents identified an error in the system of scientific environment and policy. Main problematic issues mentioned in the group were inappropriate metrics and the system of categorization of publications. One model of evaluation does not fit all the disciplines. The problem of evaluation is critically perceived especially in social sciences and humanities. Many subjects mentioned lack of funding and resources (e.g. expensive journals and databases). Another category of barriers is connected with disintegrated and expensive technological infrastructures which would need more investment.

5 An ecological framework of research information interactions

Based on the following analyses we developed an ecological framework of encapsulated research information interactions, composed of methodological factors, open science factors and expertise factors (Fig.7). Factors of open science (OS) include promotion, open access and participation. Several gaps with regard to open science were identified, namely the awareness of open access (OA) potential and

promotion of research. The diagram represents intersections of processes which are relatively independent and in mutual interactions create the holistic ecology of information interactions. These factors were derived from the content analysis of semi-structured interviews. The main insight is that methodological and OS factors are common to disciplines, while differences are based on expertise.

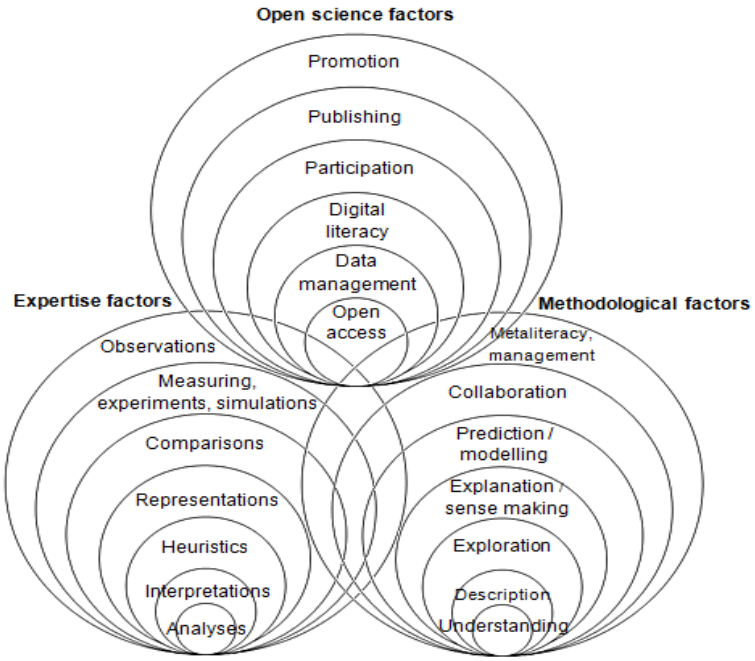

Fig. 7

An ecological framework of research information interactions

6 Ecological paradigm of information interactions for digital scholarship

One of the possible frameworks for further understanding of information interactions of researchers and digital scholarship is the ecological paradigm. It refers to the pattern of holistic perspective on information interactions composed both of the human and system components (Fig. 8). The human component includes ecological information behaviour, ecological information strategies and ecological information literacy. The system level is represented by ecological information interactions, ecological information systems (information ecosystems) and ecological information tools.

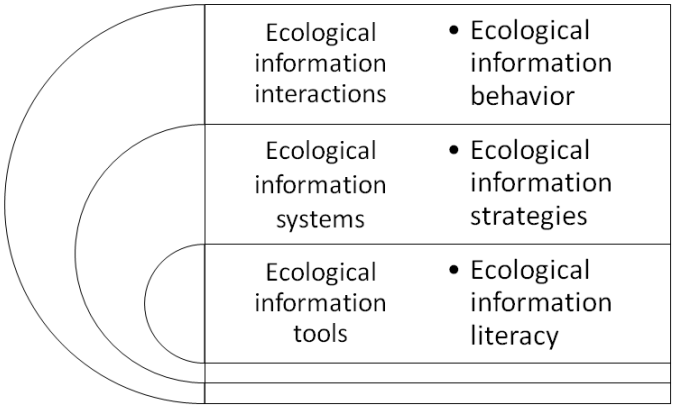

Fig.8

Categories of the information ecological paradigm in information science

Ecological information interactions are adaptations between people and information environment manifested by human information interactions (Fidel, 2012). The ecological factors of information interactions are actors, information objects, tools and resources. Integration between internal and external information and social and technological contexts can help make meaning in information use. Ecological information behaviour and ecological information strategies are close to natural patterns of cognitive styles. Factors of ecological information strategies include information overload, visibility of information resources, networking, sharing and collaborations. The common theoretical constructs are social and communication theories manifested in sense-making and construction of meaning. By making sense in the information environment digital ecological spaces can be developed including awareness of risks of information environment. Ecological factors can include information strategies, adaptations, co-existence of species and prevention from information pathologies (Steinerová 2015). Further ecological information factors are diversity, context-based information processing, use and re-use of information, collaboration, community (Steinerová 2014). Information ecology helps eliminate information pollution and information overload in human information behaviour.

The ecological paradigm of information science includes three dimensions. The social epistemological dimension means horizontal integration of knowledge construction and infrastructures. The ontological dimension means vertical integration of information objects and the social/activity dimension is represented by information behaviour and information activities. The question is how knowledge infrastructures affect information interactions. The common tools of communities of researchers use common conceptual infrastructures (e.g. concept maps,

terminologies, etc.) which can disclose implicit contexts of knowledge. Ecological information literacy is necessary for use of these tools. In theory development new categories of creativity, empathy or trust should be explored for emerging professions of data curators or digital librarians. The proposed ecological paradigm of information science presents an integrative framework for information research based on interplay between knowledge infrastructures, information behaviour and information systems.

7 Conclusions

Models of digital scholarship and open science proved the need for deeper research into information needs of researchers. Based on this we developed a conceptual map which was used as a methodological tool for the qualitative study of information behaviour of 19 researchers in Slovakia. We identified the following components of the information environment of digital scholarship: research process, information process, information infrastructures, factors of influence. Many differences among disciplines have been proved (e.g. retrospective nature and broad context of humanities, perspective nature and narrow context of sciences, specific methodologies, types of data and practices). We also identified a gap in open science awareness and promotion of results. Following the first findings the ecological framework of encapsulated research information interactions was presented. We identified three groups of factors in information behaviour of researchers, i.e. the expertise factors, methodological factors, and open science factors.

The implications of our results are interpreted in determination of the research information literacy as understanding, sense making and knowledge discovery integrated with motivation and research interests. Our framework can be useful for development of knowledge infrastructures, including systems and services which actively support researchers in information practices, communication and collaboration. Perceptions of open science can help reconstruct efficient partnerships between researchers, information professionals, librarians, research managers, institutions and research agencies.

Research information interactions can lead to changes in the workflow of the research and information processes and new models of digital environments for researchers. Support of information activities and creativity is needed in online genres and research communities of practice. Several components of digital environment (data, systems, tools, services) can be integrated in the new models of research and information processes. Further practical implications can be derived for value-added services and digital tools for researchers with respect to support of project management, data management and design of publications.

We can also articulate several recommendations for information strategies. Based on our understanding of information needs of researchers we recommend that information strategies include investments into information and technological infrastructure, especially in social sciences and humanities. New models of research assessment would help research management, including the adaptation of the existing foreign models and the system of evaluation and categorization of publications. We also recommend that new digital systems and digital services are built based on academic or subject repositories. The system should be human-centric and more effective analytical information and publishing services should be developed for researchers. The improvement of information interactions between experts and young researchers (doctoral students) is also required. Conditions for interdisciplinary connections and discussions should be improved, including management of grant schemes, standard competition, and transparent reviews. Pro-active project management support service and services of information professionals based on research assistance, data management and analyses and value-added services would help develop more effective environment for researchers in Slovakia. We can determine the information environment of digital scholarship as dynamic, creative ecologies based on adaptive information interactions, data re-use, rise of creative digital places and spaces, collaboration and community. That is why the support of research creativity in specific domains represents a critical point for further development of digital scholarship.

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Resumé

MODELOVANIE INFORMAČNÉHO PROSTREDIA V EKOLOGICKÝCH KONTEXTOCH: KVALITATÍVNA ŠTÚDIA INFORMAČNÉHO SPRÁVANIA VEDCOV NA SLOVENSKU

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Príspevok analyzuje kontexty digitálnej vedy s poukázaním na meniace sa informačné prostredie a nové požiadavky na informačné služby, systémy a informačných profesionálov. Na základe stručnej analýzy modelov digitálnej vedy a otvorenej vedy sme určili štruktúrovaný pojmový model na výskum informačného správania vedcov. Tento model obsahuje štyri zložky, najmä výskumný proces, informačný proces, informačnú infraštruktúru a faktory vplyvu. Stručne sumarizujeme zistenia kvalitatívnej štúdie informačného správania 19 vedcov z hľadiska vybraných aspektov (vedecká kreativita, bariéry a hodnoty vedeckej práce). Spoločné vzorce využívania informácií boli identifikované v metodologických a všeobecnovedných analytických procesoch vrátane vedeckej kreativity integrovanej hlbokou internou motiváciou a expertízou. Na základe analýz sme navrhli ekologický model informačných interakcií zložený z metodologických faktorov, faktorov expertízy a faktorov otvorenej vedy. Potvrdili sa rozdiely medzi prírodnými vedami, sociálnymi vedami a humanitnými vedami pri formulácii vedeckých problémov, typov (veľkých) dát, metodológií a publikačných stratégií. Na základe postojov k bariéram a návrhov na riešenie problémov navrhujeme ekologickú paradigmu informačnej vedy pre holistické chápanie informačného prostredia. Na záver prezentuje odporúčania pre stratégie a informačné a digitálne

služby s dôrazom na integrovanú informačnú infraštruktúru, služby s pridanou hodnotou a podporu vedeckej kreativity výskumníkov v rozdielnych módoch skúmania v rôznych disciplínach.

Summary

MODELLING INFORMATION ENVIRONMENT IN ECOLOGICAL CONTEXTS: A QUALITATIVE STUDY OF INFORMATION BEHAVIOUR OF RESEARCHERS IN SLOVAKIA

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The paper discusses the contexts fo digital scholarship pointing to changing information environment and new requirements for information services, systems and information professionals. Based on brief analysis of models of digital scholarship and open science we determined our structured model for reserach of information behaviour of researchers. This model include four components, namely research process, information process, information infrastructure and factors of influence. Findings of a qualitative study of information behaviour of selected 19 researchers are briefly summarized in selected aspects (research creativity, barriers, and values of research work). Common patterns were found in methodological and general analytical procedures, including research creativity integrated by deep internal motivation and expertise. Based on our analyses we proposed an ecological model of information interactions composed of methodological factors, expertise factors and open science factors, Differences between sciences, social sciences and humanities were confirmed, icnluding the problem statement, types of (big) data, methodologies and publishing strategies. Based on attitudes to barriers and proposals for improvement of the information environment we proposed the ecological paradigm for holistic understanding of the information environment. In conclusion, we present several recommendations for policies and information and digital services, including the emphasis on integrated information infrastructure, value-added services and support of research creativity of researchers with respect to differences and different modes of inquiry among different disciplines.