

Kontynent europejski wobec wyzwań współczesności

Tom 3

Redakcja

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Lwów-Olsztyn 2018

Przyjęto do druku Uchwałą Rady Wydziału Stosunków Międzynarodowych, Lwowski Uniwersytet Narodowy im. Iwana Franki we współpracy z Instytutem Nauk Politycznych, Uniwersytet Warmińsko-Mazurski w Olsztynie (Protokół nr 4 z dnia 23.04.2018 r.)

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Kontynent europejski wobec wyzwań współczesności, Tom 3,

R. Kordonski, A. Kordonska, Ł. Muszyński (red.), Lwowski Uniwersytet Narodowy im. Iwana Franki, Lwów-Olsztyn 2018, 418 s.

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ISBN 978-617-7448-37-1

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LIBRARY IN EPOCH OF DIGITAL SCIENCE

The study contains the argumentation of the importance of the cooperation between librarian-informational activity and scientific researches. The author defines the informational basis and resources of the digital science and focuses on the importance of the involving libraries in the forming of the scientific data. The synergetic approaches to the cooperation between libraries and digital science are created. The librarian studies' fundamentals of the cognitive conception of the scientific communication are developed to contribute to the exchanging of the scientists' knowledge in the electronic environment. The author analyses the librarian development, which is oriented on the joining the various researches. In addition, the author points out the necessity to train professionals of the new generation for the digital science.

Digital science is a challenge to the library

The term *digital science* appeared in 2013 in the documents of the EU program „Horizon 2020” to summarize the areas of research, previously developed within e-science, open science and science 2.0². Digital science takes for its ground the use of infrastructures, services and tools based on information and communication technology. It offers qualitatively more effective tools for scientific collaboration, conducting experiments and their analysis, making scientific knowledge more accessible. The foreseen by the digital science acceleration of the transition of research into the global communications space, makes libraries face new challenges.

In the XXI century the social institute of the scientific library has undergone significant changes. Therefore, on the one hand, the scien-

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² М.З.°Згуровский, А.И.°Петренко, *Становление и горизонты цифровой науки*, „Системні дослідження та інформаційні технології” 2014, № 4, с. 7–19.

tific library has been transformed from a traditional library collection into a modern information institution (all the national, regional and most of the special libraries have electronic catalogs and collections of full-text e-documents). On the other hand, prestige and the role of the library in society is constantly decreasing. This suggests that technological modernization could not guarantee that it retains its high status, acquired over the centuries. One of the reasons for this situation is the lack of attention to the development of theoretical and methodological problems that determine the long-term perspective of the development of a scientific library in a rapidly changing society. The latter can be explained by the fact that it continues to assume its mission to provide information support to the research field, ignoring the emergence of such a powerful competitor as the Internet.

Thus, it is necessary to define a new vector for the development of a scientific library. The urgency of solving the above problem is stated in O. Onishchenko's publication „Library and Digital Generation: A New Situation is New Forms of Work”³. It is necessary to agree with the thesis above, in which the emphasis is made on the necessity of coming to urgent decisions regarding the development of a new paradigm of librarian-informational activity.

A lot of publications are devoted to the development of libraries and their place in digital science and society of knowledge. However, most of them address the functional and structural transformations of the library, related to the implementation of information and communication technologies. Let's note the work „The Role of Libraries as Social Institutions in the Information Support of e-Science”, which considers their functions when conducting research in the electronic environment⁴.

Special interest evokes the article „The scientific library: from the e-catalog to e-science”, in which the concepts of scientific library's transition from disparate technological upgrades to system functional and structural transformations are analyzed, which in their turn pro-

³ О.°Онищенко, *Бібліотека і цифрове покоління: нова ситуація – нові форми роботи*, „Бібліотечний вісник” 2016, № 5, с. 3–6.

⁴ А.°Ржеуський, Н.°Веретеннікова, О.°Малиновський, Н.°Кунанець, *Роль бібліотек як соціальних інститутів в інформаційному забезпеченні e-Science*, „Бібліотечний вісник” 2016, № 3, с. 3–9.

vide: full-text extension of the electronic catalog; creation of an institutional repository; archiving of fluid Internet resources; bibliometric monitoring of scientific communications and preparation of analytical and prognostic materials⁵.

One of the attempts to revise the conceptual foundations of the library concern was made by L.°Kostenko in his work „Library of the Knowledge Society” [5], in which he defines the essence of the society’s requirements for all its institutions, which is the focus on the science-intensive technology. On the basis of this, it was concluded that „the library has to master the integrated technological cycle, which includes all the knowledge-intensive processes of handling of documentary arrays, from bibliography to extraction of new knowledge from data warehouses. The latter is a determining ideologue of its development and, at the same time, an indispensable condition for existence, otherwise the library will become a museum of books in the XXI century”⁶.

D. Solovyanenko conducted solid research in the development of a strategy for interaction of a library with digital science. He notes that „the infrastructure assurance of the research (and educational) process continues to be considered by the majority of librarians as a core feature of the 21st century scientific library (...) However, its role is bigger and is determined at the level of the general processes of knowledge transit in society”. The peculiarity of this article is the emphasis on the inclusion of the library in the process of forming the bases of primary scientific data⁷.

Therefore, the involvement of libraries in the collection, storage and spread of research results precisely in the initial phases of the research process offers them unique opportunities for a global review of their role and significance as managers of the entire intellectual capital of a society. Noting the presence of a significant development in the field of „The librarian studies of the e-science”, we can state that the library

⁵ В.О.°Копанева, *Наукова бібліотека: від е-каталогу до е-науки*, „Бібліотекознавство. Документознавство. Інформологія” 2016, № 1, с. 23–28.

⁶ Л.Й.°Костенко, *Бібліотека суспільства знань: концептуальна модель*, „Бібліотекознавство. Документознавство. Інформологія” 2006, № 1, с. 23–28.

⁷ Д.°Соловяненко, *Академічні бібліотеки у новому соціотехнічному вимірі, Частина 4: Сучасний рівень дискурсу академічного бібліотекознавства та поступ е-науки*, „Бібліотечний вісник” 2011, № 1, с. 8–24.

in *e-science* is considered to be an infrastructure (external) element of digital science.

In this article we will try to give theoretical and methodological substantiation of the strategy of system integration cooperation of the library and digital science while relying upon synergetic, cognitive and systematic approaches and principles for determining the conceptual foundations of library operation in the digital science environment. The synergetic approach is aimed at the development of integration trends in the interaction of the library and digital science. The cognitive approach is aimed at promoting the exchange of knowledge between scientists in scientific communication, and the systematic one is aimed at the establishment of the library as a participant in the research process.

The necessity to use a systematic approach arises from the necessity of „considering phenomena and objects being studied not only as an independent system, but also as a subsystem of a larger system (regarding which this system can not be considered to be closed)”⁸. Science is the higher-level system regarding the library of digital science as it defines the goals and objectives of the library. Therefore, the discovery of innovations related to the development of this science should be considered the first stage of developing a strategy of transformation processes in the library.

In 1999, D. Taylor, the head of the UK Office of Science and Technology introduced the term *e-science*. This term was intended to define a new direction in organizing scientific work⁹. In the United States, the term *cyber-infrastructure* has become widespread. It is understood as a complex of hardware and software, services, employees and organizations that serve as components of the socio-technical basis for cooperation, not limited by geographical, disciplinary and time factors¹⁰. The concept of *e-science* is usually associated with the innovations of the scientific process itself, and the term *cyber-infrastructure*

⁸ В.М. Глушков (ред.), *Енциклопедія кібернетики*, т. 2, Київ 1973, с. 528.

⁹ М.З. Згуровский, А.И. Петренко, *Становление и горизонты цифровой науки*, „Системні дослідження та інформаційні технології” 2014, № 4, с. 7–19.

¹⁰ А.°Gold, *Cyberinfrastructure*, Part 1: *A Cyberinfrastructure Primer for Librarians*, „D-Lib Magazine” 2007, 13(9/10), <http://dx.doi.org/10.1045/september2007-gold-pt1/>.

is more about the technological prospects for the application of super-computer calculation.

The development of open repositories led to the emergence of the concept of *open science*. The core idea of this phenomenon is to increase the transparency and openness of the research process, to improve the quality and efficiency of the scientific system as a whole. Usually, this term is understood as scientific knowledge that can be used and spread without significant legal, technological or other social constraints. An important consequence of openness is the development of expertise in the quality of science in general and the formation of expert body.

Science 2.0 is another term and a new approach to science, which is centered on the collaboration of scientists based on the use of network technologies. It is characterized by many features of e-science and open science, but there are several new aspects such as open network collaboration, open network data. That is why it is not only more collegial, but also much more productive.

Digital science takes into consideration all intrinsic aspects of e-science, open science and science 2.0. Various terms represent the development of its capabilities to research, including the properties of previous concepts and adding new ones. There have also been introduced the term „*digital humanities*” which generalizes the use of information and communication technologies as a means of supporting and developing of humanities.

The environment of primary scientific data is fundamentally important for scientific libraries. Involving libraries in the collecting of research results at the initial stages of scientific work creates the necessity to revise their role and status. They are transformed from the elements of the information infrastructure into one of the participants in the research activity. Primary scientific data starts to be considered as the full results of the professional activity of scientists, which should be taken into account in assessing the effectiveness of their work. The need for such an approach is mentioned in the work „Cyberinfrastructure, Data, and Libraries” written by A. Gold: „If publications are still the currency of scientific recognition, then data is the true currency of science”¹¹.

¹¹ Ibidem.

In order to stir into action the processes of formation of the primary scientific data bases, it is necessary to have the universal coherent citation policy for sets of data. The first steps in this direction have already been made. In 2003, within the framework of developing the national e-science infrastructure, the German Research Foundation (DFG) supported the project „Publication and citation of primary scientific data”. Its idea was to create a national system of distributed primary science databases with an integrated reference search engine¹². Their citation rates are calculated using the DOI (Digital Object Identifier). Subsequently, the project turned into an international one, its geography expanded, joined profile scientific information institutions and scientific libraries in the United States, Canada, France and other countries. This consortium, called DataCite (International Consortium for Data Citation).

Management of primary scientific data has proven to be attractive to libraries of research institutes. This activity, aimed at supporting the formation, storage and reuse of scientific data, is called Data Curation¹³. Implementation of Data Curation functions requires not only rethinking the priorities in the work of libraries, but also gaining of relevant skills by staff. Therefore, a new term „*librarian-researcher*” appeared in librarianship. A significant part of his working time is spent with scientists on solving their scientific tasks or providing an examination of the results. Such a transformation of the mission of librarians is seen as promising, although it requires an upgrade of their qualifications.

Data Curation services have not yet gotten widespread in Ukraine. However, there are certain achievements. For example, the virtual lexicographic laboratory „Dictionary of the Ukrainian Language”, was developed by the Ukrainian Lingua-Information Fund, NAS of Ukraine for the concluding of Ukrainian dictionaries in virtual mode by a group of geographically distributed lexicographers¹⁴. Moreo-

¹² Д.°Соловяненко, *Академічні бібліотеки у новому соціотехнічному вимірі*, Частина 4: *Сучасний рівень дискурсу академічного бібліотекознавства та поступ е-науки*, „Бібліотечний вісник” 2011, № 1, с. 8–24.

¹³ А.И.°Земсков, *Data Curation – хранение научных данных и обслуживание ими – новое направление деятельности библиотек*, „Научные и технические библиотеки” 2013, № 2, с. 85–101.

¹⁴ *Virtual lexicographic laboratory „Dictionary of the Ukrainian language”*, <http://files.nas.gov.ua/NASDevelopmentsBook/PDF/0403.pdf/>, [11.02.2018].

ver, there was created a database of scientific experiments and observations created by Institute for Nuclear Research of the National Academy of Sciences of Ukraine¹⁵. It is necessary to involve Data Curation technologies in the primary processing of data in academic centers of collective use of unique scientific equipment. This will allow monitoring the processes in the system of scientific communication and form the data basis for expert assessment of development of science.

If the first steps in collecting primary scientific data of the library are taken, then significant results in the sphere of creation of high-tech technologies for the processing of the incoming documentary information flow have already been achieved. In the concentrated form their essence lies in the implementation of an integrated cycle of library processes, from the cataloging and referencing of books and magazines to the conduct of science-based research. The development of such a cycle was facilitated by the use of methodology of synergy¹⁶.

A synergetic approach to cataloging allowed organizing its technological processes in the form of an „information conveyor”. Its input is the entry of identification data of documents (with their ordering and registration). The subsequent addition of bibliographic data with missing elements (in particular, class number) is performed on other sections of the „conveyor”¹⁷. The use of the principle of information interaction during abstracting allowed creation of a branched, differentiated by branches of knowledge, integrated in the scale of the state system of abstracting of Ukrainian scientific literature. It ensures a one-time, meaningful processing of the flow of local publications by a certain circle of subjects of the system of documentary communication (libraries, research institutes, publishing) mainly on the basis of author's abstracts or annotations, and cumulative and centralized support for coopera-

¹⁵ О.В. Коваленко, *Концептуальні основи створення бази даних наукового експерименту та спостереження*, „Математичні машини і системи” 2016, № 2, с. 91–101.

¹⁶ В.Г. Буданов, *Методология синергетики в постнеклассической науке и в образовании*, Москва 2017.

¹⁷ Л.Й. Костенко, *Онлайніві ресурси бібліотеки: створення, використання*, „Бібліотечний вісник” 2003, № 1, с. 13–17.

tively created arrays in the national referral database „Ukrainika is scientific”¹⁸.

Taking into account expediency of co-operative interaction, the technology of filling up the full-text collection „Ukrainian Research and Academic Network”¹⁹ and the concept of archiving of streaming resources of the Internet²⁰ were developed. This concept lies in combining the principles of decentralized collection and primary processing of sectoral and regional fragments of information networks with centralized support for a consolidated search tool for distributed resources. The legal framework for these works is, in particular, licenses of Creative Commons that allow one to move from the forbidden paradigm of classical copyright to the permissive system of knowledge dissemination in the global informational space, taking into account the noncommercial rights of intellectual property owners.

The scientific and analytical activity of libraries is also carried out on the basis of integration. Today it develops in the direction of creation of geoinformational technologies and systems that integrate work with databases, mathematical analysis procedures and methods of visual-spatial pointing out results of the accumulation tasks, processing and providing users with geospatial information. The need to create such technologies is conditioned by the need to use multivariate models of events development, which requires not only the statement of facts to prove one or another thesis, but also the system approach of solving the problem in general.

System-integration approaches are also used in the organization of science-research activities of libraries. Their essence lies in the interaction of the scientific community, which forms the primary bibliometric data, and information institutions (primarily libraries) that carry out their analytical work. The result of such cooperation is „Bib-

¹⁸ В.В. Петров, А.А.°Крючин, Л.И.°Костенко, Н.Н.° Минина, Н.Я.°Зайченко, *Формирование баз данных реферативной информации – путь к оперативному обмену результатами научных исследований*, „Библиотеки национальных академий наук: проблемы функционирования, тенденции развития” 2009, Вып. 8, с. 103–109.

¹⁹ Л.Й.°Костенко, О.І.°Жабін, Є.О.°Копанєва, Т.В.°Симоненко, *Наукова періодика України та бібліометричні дослідження*, Київ 2014.

²⁰ В.О.°Копанєва, *Бібліотека як центр збереження інформаційних ресурсів Інтернету*, Київ 2009.

liometrics of Ukrainian Science". That is a public system of published results of research activities and software and technological means used for its expert assessment and forecasting of the science development²¹. We note that in general, the synergy methodology contributed to the convergence of academic publishing, librarian-informational, overview-analytical and scientometric processes and technologies.

Scientists provide new knowledge and their use in society. Professional interaction between them is called scientific communication. Recently, their cognitive aspects play an increasingly important role in the studying of these communications. Today the term cognition, which appeared in the 50's of the 20th century, means a multidisciplinary scientific field that combines philosophy (the theory of perception), cognitive psychology and linguistics, neurophysiology, anthropology, and Theory of Artificial Intelligence. However, the birth of cognitive research occurred in the work of the librarian M.°Rubain significantly earlier, in the beginning of XX century. He creatively worked out the views of linguists, psychologists and experts in the field of librarianship on the interrelations between subjects and objects of social communication. He also introduced a new term *bibliopsychology*²². It is possible to assume that today M. Rubakin would use instead the concept of cognitive problems. Yet at the beginning of the XX century such a term as cognition has not existed. It appeared and developed in the second half of the 20th century²³.

M. Rubakin's formulated fundamentals of bibliopsychology in five laws: *Semon's law*, *Humboldt-Potebnja's law*, *Ten's law*, *the law of consonance and dissonance of emotions*, and *Hennequin's law*. According to the first one, each person in his reading process builds his own projection of the book. *Humboldt- Potebnja's law* relies on the linguophilosophical V. von Humboldt's (one of the founders of linguistics) concept, according to which any word is perceived by one individual not the same as by the other. O. Potebnja formulates this thesis as following: „Speaking means not passing one's opinion to another,

²¹ Л.°Костенко, О.°Жабін, О.°Кузнецов, Є.°Кухарчук, Т.°Симоненко, *Бібліометрика української науки: інформаційно-аналітична система*, „Бібліотечний вісник” 2014, № 4, с. 8–12.

²² Н.А.°Рубакин, *Психология читателя и книги*, Москва 1977.

²³ В.Н. Ручкин, В.А. Романчук, В.А. Фулин, *Когнитология и искусственный интеллект*, Рязань 2012.

but arousing own thoughts in somebody. Understanding is not the process of transferring content from one head to another. The matter is, that because of a particular structure of human thought, any sign, word, image, musical sound serves as a means of transforming another, independent content, which is in the thought of that who understands"²⁴. *Ten's law* states that perception of information is largely determined by the environment and time. M. Rubakin explains this on such an example: the perception of one and the same book in different periods of life of the user can vary significantly. *The law of consonance and dissonance of emotions* emphasizes the fact that printed, handwritten and oral word is understood positively or negatively depending on what emotions prevail over the reader or listener. Therefore, in a number of cases, emotions are becoming more important than common sense. According to *Hennequin's law*, „a literary work has the strongest influence on the person whose mental organization is closest to it, that is, represents the highest degree of similarity to the mental organization of the author of this work"²⁵.

In general, M.°Rubakin's bibliopsychological theory states that there is no definite correspondence between the knowledge of a certain person, documented information obtained as a result of the verbalization of this knowledge, and the perception of such information by another person. M.°Rubakin's ideas were ahead of their time and were not properly used. They were further developed in the work written by J. Schrader, who studied the cognitive aspects of scientific communication with the use of computer systems²⁶. The researcher analyzed the category of *information and knowledge* and came to the conclusion that in the general case they are not identical. Knowledge correlates with a person and is inseparable from her personality, information is a verbalized form of knowledge and has a social character. In general, the information obtained as a result of the verbalization and documentation of the scientist's knowledge is not the same as this knowledge.

The same analogy is observed in the process of receiving information by other scientist. The knowledge gained by him/her also can

²⁴ А.А. Потебня, *Мысль и язык*, Київ 1993.

²⁵ Н.А. Рубакин, *Психология читателя и книги*, Москва 1977.

²⁶ Ю.А. Шрейдер, *Социальные аспекты информатики*, „Информационные процессы и системы” 2010, № 2, с. 18–27.

not be identical to it, taking into account cognitive aspects of perception of information. Therefore, the spread of knowledge in the process of scientific communication is an entropy process. That is, it is accompanied by certain loss of information. Moreover, additional information-cognitive resources and means are needed to adequately reproduce this knowledge. They can be represented by information about the concept-categorical apparatus of science, encyclopaedic and other data that form the basis of library research resources, as well as means of morphological analysis and grammatical normalization of vocabulary, which enable formal communication in a language close to the natural one. Awareness of the primacy of a personal aspect in scientific communications leads to a change in the view on the design of information systems from the technical plane to the socio-technical.

The problem of information-cognitive resources should be considered within the framework of NBIC-convergence (N-nanotechnology, B-biotechnology, I-information technologies, C-cognitive technologies). Information technologies in NBIC-convergence provide accumulation, storage and processing of large amounts of information, and cognitive promote the development of intellectual abilities of a person. The convergence of these technologies is seen as one of the most important components of scientific and technological progress, since it will allow new knowledge to be isolated from the information arrays.

One of the directions for the further development of knowledge-intensive technologies in libraries is the infometric research of digital resources to detect latent patterns in them and to allocate new knowledge. This area of work is adjacent to the problem of artificial intelligence and requires cooperation with specialists in the field of computer science. Data Mining and Text Mining Among are ones of technologies of infometric research. Data Mining is the process of identifying of unknown, non-trivial, practically useful and accessible for interpreting the knowledge that is required for decision-making in various spheres of human activity in poorly structured data.

Expansion of the functions of the digital science library will lead to its structural transformation. Technologies of the formation of primary scientific data and the allocation of new knowledge will provide libraries with the essential features of a scientific institution and an

analytical center. The integration of technologies for the production of knowledge of the humanitarian orientation with the traditional function of the library as a cultural center will contribute to the acquisition of its culturological features. The need for personnel provision of knowledge production technologies will require a radical enhancement of the educational focus of the library, as qualitative training and an upgrade of qualifications of specialists in this field can be carried out only with the participation of the library and on its base. There are also various forms of organization of the educational process. For example, there is the approach in which, in the first years of study, students study directly in specialized universities where they learn basic knowledge, and the rest years of studying spend a significant amount of time in the library.

The combination of such functional and structural units as a library, scientific, analytical and cultural centers in one institution, is seen as an innovation. However, history shows the existence of a library, which included structures where fundamental research was carried out, masterpieces of art were created, training of highly skilled personnel was carried out. An example of such a public institution is the Bibliotheca Alexandrina, founded at the beginning of III. BC, and existed for more than 300 years²⁷. It was the largest library for its time in terms of funds, while it included 400-700 thousand manuscripts. It should be emphasized that the library gained worldwide fame thanks to prominent personalities who worked in its walls. Here Euclid laid the foundations of mathematics, Eratosthenes determined the diameter of the globe, and Apollonius of Rhodes created „Argonaut”. The Bibliotheca Alexandrina also included an antecedent of a today's higher educational institution. One of its graduates was Archimedes, the founder of the engineering.

Conclusions

The strategy of the system-integration cooperation of the library and digital science should include:

²⁷ А.М.° Лямець, *Александрійська бібліотека: формування спеціальних фондів, критерії відбору матеріалів, функціонування підсистеми читацького складу*, „Східний світ” 2015, № 4, с. 147–153.

- convergence of academic publishing, librarian-informational, overview-analytical and scientometric processes and technologies;
- conducting of infometric researches in digital resources for revealing of latent patterns in them and allocation of new knowledge;
- creation of information-cognitive resources and means for transition from entropy data transmission to facilitation of the exchange of knowledge between subjects of scientific communication;
- organization of new structures for the formation of primary scientific data, infometric studies and preparation of library specialists of the new generation.

In general, the development of the library in the digital science environment should be oriented on its functional and structural transformation from the element of scientific infrastructure into the participant of the research activity at all stages. That is from the collection and processing of the primary data to the acquisition of new knowledge.

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