Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 206 (2015) 359 – 364

Procedia
Social and Behavioral Sciences

XV International Conference "Linguistic and Cultural Studies: Traditions and Innovations", LKTI 2015, 9-11 November 2015, Tomsk, Russia

University Education in the Development of Knowledge-based Society: Network Technologies of Scientific Research and Cyberscience as Factors of Education Professionalization

Anna Kornienko[a,b]*

[a]National Research Tomsk Polytechnic University, 30 Lenin Avenue, Tomsk, 634050, Russia
[b]Tuvan State University, 36 ul. Lenina, Kyzyl, 667000, Russia

Abstract

The paper analyzes conversion factors of organization forms both in education and research under conditions of developing knowledge based society. Features of the knowledge based society as service based society were investigated. The transformation process of knowledge status in the information society, socio-cultural implications of knowledge and information powers, changing nature of power relations were regarded. The author proposed the definition of cyberscience as a fundamentally new form of science organization, considered the stages of modern science development in the context of information and communication technologies, analyzed the informatisation model of scientific process.

Peer-review under responsibility of the Scientific Committee of LKTI 2015.

Keywords: Knowledge based society; cyberscience; epistemic infrastructure; virtual lab; media vehicles; 'digital shadows'; technical infrastructure; cyberinfrastructure; online laboratories; research networks; virtual research environment; research service.

1. Introduction

Creating universities, competitive at the world level, is the most important factor of reforming education. It is difficult to overestimate the role of the world-class universities in international competition and economic

* Corresponding author.
E-mail address: anna_kornienko@mail.ru (A. Kornienko).

1877-0428 © 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Scientific Committee of LKTI 2015.
doi:10.1016/j.sbspro.2015.10.065

development, hence – the importance of developing effective strategies to create competitive world-class universities.

University education in the developing knowledge based society transformed both organization forms, educational practices and organization forms of science, contributing to the knowledge production in the university. Education theorists write about tectonic shift taking place at the beginning of the XXI century in interpretation of the 'great university' as a research institution (Salmi, 2009). Much of this tectonic shift was made possible due to cyberscience which importance in ensuring high quality of professional education can hardly be overestimated.

2. Network technologies of scientific research and cyberscience as factors of education professionalization

Knowledge based society in its developed form is a service based society, whereas the feature of this service lies in the fact that it is a service based on knowledge. By the first decade of the XXI century, the scenario of future development of the information society was created. This scenario includes a model of changes – three-stage progressive movement: creation of industries for production and distribution of knowledge and information; growth of the range of large-scale information services for industry and government; formation of a network of information resources and services at the consumer level.

In 2008 in the UK was completed the creation of 'Strategic concept of society services in the information age', which determined the vector of development and use of electronic service forms (including digital television, mobile communications, Internet, call centers). The determinant strategic vector of the program is to ensure the availability of various types of service to consumers. Digital TV and mobile communications are presented as important tools for the Internet access. It is their prevalence which will create the possibility of reducing the level of society 'digital divide'. The program provides assistance to the government in order to enhance e-qualification of citizens, as well as to facilitate supply of the Internet access.

Bell (2001) subtitled his work 'The coming post-industrial society' as 'The experience of social forecasting', trying to identify the trends that will be determinant for the shape of the world in the XXI century. Among these tendencies, there is a trend of 'service based society'. Bell applied a construct of 'information society', denoting the phase of postindustrial society. Bell writes about a new social structure based on telecommunications, - importance of this structure for social life and the ways of knowledge production. Among the most important aspects of post-industrial society, which role is essential in interpretation of the telecommunications revolution, the analysts points out the conversion of a new 'intelligent technology' into the most important tool of decision theory and systems analysis, a crucial role of codified theoretical knowledge in the implementation of the ideas of technological innovation; finally, the evolution of society towards a service based society. Herewith, knowledge and information are designated by Bell not just as 'transformation agents of post-industrial society', its strategic resources and 'basic phenomena' – knowledge and information are in the role of determinant variables of post-industrial society.

Bell writes about the status transformation of knowledge in the information society. Bell's concept tells about the importance of factors such as availability of the necessary information to individuals and groups (as opposed to an earlier stage, emphasizing the fact that the basis of processing of the massive amount of information, used in decision-making by the government, is the development of electronics and computer technology). Speculating about a wide range of the dominant characteristics of post-industrial society, the analyst mentioned, among the most important ones, the transition from the production of goods to the production of services. Herewith, service industries are criterially delimited, - by the manufacture, trade and distribution, financial services, credit and insurance, professional and business services (for example, information processing). Knowledge is called by Bell as the basic phenomenon of post-industrialism, considering the obvious priority of both the knowledge itself and the social institutions, reducing and accumulating knowledge. The Institute of Science refers to such an institution in the knowledge based society as an enhanced version of the information society.

The power of knowledge in the knowledge based society acquires the status of a dominant factor of the national product growth. Both economic and political power shifts to processing of the mass of information services, manufacturers of information and service. There was a shift to the service factor, the priority positions were occupied by the services associated with knowledge - business and professional services. Wealth is created by managers, experts on the organization of services via application of information and knowledge. Among the socio-cultural consequences of the power of knowledge and information – highly developed telecommunications networks, computer networks of the Internet, a new kind of labor activity – telerobots, the dominant role of information and telecommunication infrastructure. The latter obviously points to the development of information economy of the global scale and level. For example, network economy today uses global electronic environment where knowledge and information prevail as the most important productive forces - it is, in fact, the prototype of the global information economy.

Noteworthy is also the fact that in the proposed research project, Bell uses an 'axial principle'. The latter gives the ability to interpret social evolution as the transformation of socio-economic systems and patterns of ownership, accompanied by changes in the status and nature of knowledge. The latter, in turn, actualizes view of society as a set of services of various kinds. Theoretical knowledge is materialized in services, so 'intelligent technology' becomes the main decision-making tool. It changes the nature of power relations - they are based on scientific research and development, leading to the 'knowledge elite' development in society. Knowledge is converted into a condition for the power implementation, a strategic resource of power and control. XXI century is a century of 'knowledge based society'.

Today, service role and functions of the developing knowledge based society are reflected in cyberscience. The term came into use by researchers at the turn of XX-XXI centuries. We would suggest the following definition for this radically new form of science organization: cyberscience is artificially created by the automatic system of scientific knowledge, in fact, being a research service.

That use of the cyberscience potential as the science of management within this automatic system allows us to denote this science cyberscience. One of the prerequisites of cyberscience genesis is unusually increased total amount of digital data. Zhuravleva (2010) gives an overview of studies that revealed the extent of this volume. So, IDC Research Company analysts published a forecast (The Expanding Digital Universe. A Forecast of Worldwide Information Growth, 2010): by 2011, the total amount of data stored worldwide on all existing digital media will have exceeded 1,800 exabytes, which is 10 times more than in 2006, due to the increasing popularity of digital media carriers and volumes of graphics, audio and video files on the Internet. In its structure, the existing files are different (from 6 GB DVD-ROM images to RFID-tag metafiles, the size of which does not exceed 128 bytes). Users actively exploited less than half of all stored data, other files are so-called 'digital shadow' files which include Internet browsers caches, log files on servers, data on already committed transactions, web history, etc. Experts of Cisco company (http: /www.cisco.com/) predict an increase in digital data on the Internet, but give different figures: the amount of transferred data via the Internet will grow annually by approximately 46%, which will result in achieving the volume of 522 exabytes.

Service role and service status of the Internet are enormous in the production of scientific knowledge in the knowledge based society. One of the trends of science development in the 'knowledge based civilization' is the growing importance of technical systems in the transmission, processing and storage of knowledge. Investigating the servicing functions of information systems, Zhuravleva (2010) writes that the Internet as an emerging research structure is not widespread and available for every scientist; according to Dutch scientists, in the world about 28% of the studies are conducted using digital data storage (Foulonneau, 2008) and this figure will continue to grow. At the same time, according to the author, Internet research infrastructure is capable of playing dual role - it can be the research environment (VIS, virtual laboratories, observatories, companies); it is also capable of being the driving force for research inquiry (by means of creating scientific services and tools for visualization, simulation, data analysis; developing promising branches of science - network analysis, webometrics).

The authors investigated the service role and service status of the Internet infrastructure; beyond this definitely an important statement of the problem is no less important issue – the problem of epistemological foundations and presuppositions of current developments. Unchartedness and unstudiedness of the given problem lead to the situation, described by Pruzhinin (2010), when we speak about the automatic work with information by means of any technical device, we are not interested in the essence of message and the number of symbols the message contains. With respect to computer data processing, information is understood as the sequence of symbolic notations that conveys meaning and is displayed in the form available for a computer. Each new symbol in this sequence increases the amount of information volume of message. As if it provides objectivity for the processes of transfer and conversion of the information meaning, as if it ensures the self-containedness to its movement and transformation.

What are the service role and service status of the Internet as research infrastructure in scientific production? The problem of modern science development in the context of information and communication technologies became one of the most pressing issues for the well-known Western analysts (Muro & Saunders, 2008; Frieze, 2004; Wouters, 2002). Since the emergence of the Internet technology, they have made transformation of research practices the subject of their study, carried out under the influence of ICT in the context of global computer networks. Since 1996 the term of 'cyberscience' has come into common use by researchers; besides, other designations of research practices have been actively used: 'e-science' ('open science); 'service-focused science'; 'Science 2'; 'science of huge amounts of data' 'technoscience'; 'Modus 2'; 'post-normal science'; 'science of rapid discoveries'.

Investigating the transformation processes that took place in science in the Internet era, the scientists emphasize three groups - change phases - change in communications; change in objectives, structure, processes, products of science; finally, the third stage concerns the methodology of science – previously used methods are replaced by 'cybertools', those methods that are effectively applied in a situation of large-scale use of various kinds of data, related to cyberscience. These are, for example, numerical modeling techniques. It is obvious that in dealing with huge amounts of knowledge and information, conventional scientific methods are not efficient. There are tools for parallel information processing. The volume of experimental data is a precondition which requires new methods. Szalay & Gray (2004) point out in the history of science, by the given virtue, the following stages: stage of empirical science (prevalent method of observation and logical deduction); stage of science, inherent in a considerable amount of experimental data (theories proved using analytical models); stage of computer science (using methods of numerical modeling); stage of science, operating megavolumes of experimental arrays (new methods – 'cybertools', dominant – synthesizing theory). If Szalay & Gray (2004) base cyberscience periodization on the amount of data and methods used in science, then Rhoten (2007) uses exploratory activity as this foundation. It is different in such stages as 'Stand' (scientist investigates the problem individually), 'Big Science' (mass participation in research projects), 'Scientific team' (global project belongs to large-scale research center), and finally, 'Network structure of science' (scientists from different centers, solving the problem, are individual researchers). The network structure of science has, for example, the ability to create such organization form as a 'virtual corridor'. Cyberscience is linear. It is interpreted by researchers as the activities carried out in virtual space.

Among the models of informatisation in the scientific process, beside the model of 'cyberscience', there is a model of 'service-focused' science. Scientific communication is carried out via information tools - services (web services, web portals, databases, metadirectories). Describing the potential of 'service-focused science' Zhuravleva (2010) writes that this model of science reflects the stage of science transformation, when science and technology products are converted via statistical artifacts (articles, data) into, including more dynamic results, products (network models, structures, tools, services). At present, some scholars 'publish' their computing models and technical projects as a service with standard interface that can be accessed by all users.

Each of the existing models of informatisation in the scientific process was created on a specific technology platform; this technological foundation-platform allows implementing the idea of using global computer networks and Internet infrastructure to create new organization forms of scientific activities, - the forms that will ensure efficient interaction in the world of modern science, based on 'distributed cognitive process' (Knorr-Cetina, 2001).

Mentioned above idea is accepted as a basis for the models of 'Open science', 'E-Science' and 'Science of huge amounts of data' (today the problem of single volume of digital data is extremely acute. At least 50% of the total volume of available information is actively used, - the remaining unused information is called 'digital shadow'. The performed expert examination by IDC Research Company suggests annual growth of the digital data by 46%). As part of the latest model (Petascale Science), according to the authors of this model Wouters (2002) & Shroeder (2007), research efficiency can be achieved by means of effective use of cybertools. These cybertools underlie the use of huge amounts of digital data available to the modern cyberscience. Model of Open Science is focused on the idea of open access to the information that is available in cyber data storage of science. Model of E-Science, as its theoretical foundation, implies the idea of international cooperation that can refer to the base of computing resources, internet technologies and ideas of distributed access to resources.

Authors, investigating cyberscience issues, are working on creating categorical apparatus of science. One of the main categories shall be the category of 'Internet research infrastructure', defined by Zhuravleva (2010) as something that refers to a set of tools and instruments which provide the necessary services for scientific communities to conduct different types of research. Tools, services and installations required for the functioning of research community ('Science and Technology') and for individual researchers form the basis of 'research infrastructure'. The term of 'research infrastructure' can refer to the entire range of scientific and technological fields, from social sciences and astronomy to genetics and nanotechnology. Research infrastructure could be localized in one place, distributed or virtual (network, online, digital). In fact, the author defines research structure of the Internet as the conditions, which ensure sharing of distributed computing and technical resources and tools. These conditions allow implementing research initiatives of different levels and scale. Among the individual initiatives, the author singles out scientific self-presentations, Internet blogs, self-archiving, Internet experiment, Internet surveys, Internet questionnaire, which contribute to interactive communication, heterogeneous context of problem discussion and formation of study personnel, working in the computer network with high bandwidth capabilities. Herewith, the organization form of researchers' activity is Research Network such as National LambdaRail (http: /www.nlr.net/), Abilene Network (http: /www.internet2.edu/network/), GEANT (http: /www.geant.net/), GLORIAD (http: /www.gloriad.org/), Large Hadron Collider Computing Grid (LCG, http: /lcg.web.cern.ch/LCG/), Global Terabit Research Networks, GTRN, uniting GEANT, LambdaRail, Abilene, and Asia Pacific.

3. Conclusion

Network technology in scientific inquiry is focused both, on the formation of research environment - the context, and the new organization forms of cyberscience. Among these forms are virtual research laboratory, virtual learning lab, masterhood network, virtual research environment. There are examples of new organization forms of cyberscience, such as Russian Virtual Observatory, Virtual laboratory for simulation of living systems, Southern California Earthquake Center (SCEC), The Cancer Biomedical Informatics Grid (caBIG), The Erath System Grid (ESG), The Large Hadron Collider (LHC), nanoHUB , Biomedical Informatics Reserach Network (BIRN), Humanities, Arts, Science, and Technology Advanced Collaboratory (HASTAC), The Sloan Digital Sky Survey (SDSS), Second Life (SL) (Bubenshchikova, et al. 2015).

In current circumstances, the developing infrastructure of cyberscience will provide epistemic infrastructure of the XXI century with its capabilities, and the mentioned above situation will raise a number of purely philosophical issues, such as a problem of knowledge status and a problem of true network knowledge, as well as a question whether technological capabilities of cyberscience will play a part of the true driving force for scientific progress or optimism must be cautious?

Acknowledgements

Authors are grateful to Tomsk Polytechnic University for the opportunity to participate in this research forum.

References

Atkins, D. (2003). *Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon panel on Cyberinfrastructure. Executive summary*. http://www.communitytechnology.org/nsf_ci_report.

Bell, D. (2001) *The Coming of Post-Industrial Society.* https://www.os3.nl/_media/2011-2012/daniel_bell_-_the_coming_of_post-industrial_society.pdf.

Bubenshchikova, et al. (2015). *Virtual laboratory for simulation of living systems*. http: /www.mce.biophys.msu.ru/eng/archive/authors/person19030/doc12776.

Foulonneau, M. (2008) *Investigative Study of Standards for Digital Repositories and Related Services*. http://www.researchgate.net/publication/271834006_Investigative_study_of_standards_for_Digital_Repositories_and_related_services.

Frieze, I. H. (2004). *Cross Cultural Study of Attitudes About Work and Gender Roles*. http: /www.pitt.edu/-frieze/ccresearch/home.html.

Knorr Cetina, K. (2001) Epistemic Cultures: How the Sciences Make Knowledge. *Science, Technology, & Human Values, 26(3*), 390-393.

Muro, D., & Saunders, E. (2008) *Virtual Research Environments: What do libraries have to do with it?* http://www.alia.org.au/groups/quill/papers/di.muro.Paper.pdf

Pruzhinin, B. I. (2010). *Vladislav Lektorskiy: neklassicheskiy mir klassicheskoy epistemologii. Rossiyskaya filosofiya prodolzhayetsya: iz XX veka v XXI.* [Vladislav Lektorsky: non-classical world of classical epistemology. Russian philosophy continues: from XX to XXI century]. Moscow: ROSSPEN.

Rhoten, D. (2007). *The Dawn of Networked Science. The Chronicle of Higher Education*. http: /chronicle.com/weekly/v54/i02/02b01201.htm.

Salmi, J. (2009). *Sozdaniye universitetov mirovogo klassa. Perevod s angliyskogo* [Creating world-class universities. Translated from English]. Moscow: Ves' mir Publishers.

Schroeder, R., & Fry, J. (2007). Social Science approaches to e-Science: Framing an agenda. *Journal of Computer-Mediated Communication, 12(2)*, 563-582.

Szalay, A., & Gray, J. (2004). 2020 Computing: Science in an exponential world. *Nature, 440(7083)*, 413–414.

The Expanding Digital Universe. A Forecast of Worldwide Information Growth (2010). http://www.emc.com/about/destination/digital_universe.

Wouters P. (2002) *What is the matter with e-Science? Thinking aloud about informatisation in knowledge creation*. http://www.pantaneto.co.uk/issue23/wouters.htm.

Zhuravleva, E. Yu. (2010). *Nauchno-issledovatel'skaya struktura Internet. Voprosy filosofii* [Research structure of the Internet. Problems of Philosophy], *8(10)*, 155-166.