Using ICT in Training Scientific Personnel in Ukraine: Status and Perspectives

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Abstract. Today an enormous amount of problems in building a system of efficient education and science is on the discussion agenda in Ukraine. A decrease in the number of scientists in the country has been observed in the last 15 years. At the same time, the amount of postgraduate students and people aiming at obtaining their doctorate is increasing. Notably, similar indicators are also observed in the majority of post-soviet countries. One complicating factor is that the system of scientific personnel training in Ukraine is very restrictive and closed. The proportion of research results published using a free access scheme to the overall bulk of publications is still very small, in particular if compared to the level of ICT development. Therefore, a major part of the publications still remains inaccessible from the outside. In this study we investigate the openness and accessibility of the preparation of the academic staff in Ukraine. As a result we come up with a proposal of requirements to the ICT infrastructure in this area.

Keywords: Information and communication technology, Education and learning process, ICT infrastructure, Open Science.

Key Terms: ICT Infrastructure, Research.

"If it's not on the Web, it doesn't exist at all"
Sarah Stevens-Rayburn & Ellen N. Bouton, 1997

1 Introduction

The main catalyst for socio-economic development of a state potential is the ability to create, collect, and effectively manage knowledge that is comes out from the best scholarly research practices. The countries which have made it to their development strategy and implemented the effective interaction with the business enjoy TOP ratings in the World rankings. In the age of information technologies, it takes one not years, but rather days to bear the bell of scientific research and excel the competitors. The companies which are the first in the market are more likely to benefit from a positive effect caused by the introduction of new knowledge. Globalization is adjusting the cooperation between science and industry. More and more funds are invested in scientific research and development to capture the leadership in the market. A modern country's development is stimulated by the transition from a resource-based economy to hi-tech. There is an opportunity to create “intellectual

dollars" without any resource, but people. The results of intellectual work become a hard currency. For example, Japan, though it had no natural resources, managed to become the leader in world's economy. The monetary value of the biggest hi-tech (IT) companies is at a scale of the budgets of some developed countries (Apple – $ 711 billion, Microsoft – $ 349 billion, Google – $ 365 billion).

The Open Science (OS) movement gains popularity in the world of clerisy, aiming to make research results and source data accessible to public at all levels. However, there is a conflict between the desire of scientists to have access to shared resources and make profit by using these resources [1]. In recent years, many governments try to impose the policy of openness regarding scientific knowledge, especially, if it is funded with public money. One way is the enforcement of providing open access to the results of all research projects performed at public expense. An indicative example is the US, which grant annually about $ 60 billion for research. In 2008, the US Congress imposed the obligation to grant free access in a year after the first publication to all the research papers based on the studies conducted by the National Institute for Health (which receives circa the half of the total public funding for science). Similar measures are now considered by many other countries.

Today, a lot of research in Ukraine is devoted to the problems of higher education and, in particular, the use of ICT for training students, creating information and communication environments in the universities, etc. However, in the scholarly literature insufficient attention is paid to the development of information and communication models of interaction with ICT in academic staff training. Moreover, today we are talking about the need for openness and accessibility of scientific activity, whereas a substantial part of the scholarly output never reaches its reader within and even more outside the professional academic community. This problem is particularly acute in the post-soviet countries. Regionalism of entire areas in science, convention, low connection with contemporary scientific trends, low level of foreign language knowledge by scientists, lack of self-developing scientific community, low competition with other countries, lack of motivation, poor funding, brain drain, and a number of other factors result in the continuing archaism of scientific brainpower training in Ukraine.

Scientometrics is rapidly developing nowadays. Using information technology allows creating new services for the development of scientific and research activity. Many global companies invest billions of dollars in services to support research activity, thereby creating a serious market not for the research results but for the research process support. Herewith the trend shifts toward commercial projects. The examples of such companies are Apple, Microsoft, Google, Elsevier, Thomson Reuters, not to mention many others. The most outstanding services with rapidly growing impact are Google Scholar, Scopus, Orcid, Academia.edu, Research Gate, Mendeley, arXiv.org, cs2n, Epernicus, Myexperiment, Network.nature, Science-community. These services contribute to satisfying the needs of the scientific community. In fact, these positively influence scientific and technical progress and create a new paradigm of scientific research. A big number of the recently created scientometric services allow assessing the relevance of the research results by a scientist, the number of his publications, citations, storage, etc. Having these measurements at hand opens up new opportunities and prospects. Our time is characterized by the high rates of the accumulation of new knowledge, in particular in

the form of research results. Provided that the integration of research activities is currently (and naturally) low, a huge amount of scientific and research information falls out of search visibility and accessibility. Information technology is the only way to arrange and create effective search tools for acquiring the necessary knowledge. The objective of our research is to investigate the transparency of specialized scientific bodies and offer the vision of their supporting ICT infrastructure. Accordingly, the rest of the paper is structured as follows.

Present article includes such sections, as description of the methodological and experimental parts (2-4), discussion of basic components of DC's ICT infrastructure and main ways and methods of their realization (5).

2 Related Work

David [2] mentions that the goal of Open Science is to do scientific research in a way that facts and their distribution is made available at all the levels of the concerned public. The same article states that the movement arose in the XVII century. Due to the fact that the public demand for access to scientific knowledge has become so large that there was a need for a group of scientists to share their resources with each other, so that they could conduct research collectively [2].

The term E-Science (or eScience) was proposed by John Taylor, the Director-General of the United Kingdom Office of Science and Technology in 1999 and was used to describe a large funding initiative, starting from November 2000. E-Science has been interpreted more broadly since as "the application of computer technology to the implementation of modern scientific research, including training, experimentation, accumulation, dissemination of results and long-term storage and access to all materials obtained through the scientific process. These may include modeling and analysis of facts, electronic/digitized laboratory notebooks, raw materials and built-in data sets, handwritten production and design options, preprints and print and/or electronic publications"[3].

Koichiro Matsuura, the President of UNESCO, wrote in his preface to [4]: "Societies that are based on the knowledge will need to share them to keep their human nature".

In 2014, the IEEE eScience community proposed a condensed definition [5]: "eScience encourages innovation in collaborative, computationally or facts intensive research in all the disciplines throughout the research life cycle".

Michael Nielsen, a physicist and propagandist of Open Science, colorfully describes in [6] the way the new instruments need to look like to facilitate the dissemination of the culture of cooperation and openness among scientists. One of such tools exists now. This is arXiv – a site that allows physicists to publish preprints of their works before the official publication of the article. This promotes to get in faster feedback and to disseminate the new discoveries. Nielsen also acts for publishing not only conclusions, but all the original data – this is the thing physicists have been dreaming of for a long time. Journals could help them do that if they wanted to [6].

The peer review system for scientific papers on one hand offers an opportunity to obtain a (preliminary) critical assessment of a manuscript, but on the other hand it slows down the publication of research results. In this system, a review process is rarely accomplished in less than a month. The reviewers often request authors to revise some parts of the material or conduct additional studies. As a result, the time before the publication stretches for about six months or more. However, Michael Eisen, the co-founder of the Public Library of Science (PLoS), mentioned that according to his experience the "most serious incompletes are detected only after the article is published." The same applies to other scientific works, including dissertations for a degree [7]. The cases are known in history when after many years after the defense a person was divested a degree and even was fired after the examination of his work regarding qualitative or even plagiarism.

Tugo Pagano and Maria Alessandra Rossi suggest [8] that politics aimed at overcoming the disadvantages of excessive privatization of knowledge can play an important role in stimulating the economy. Efforts should be focused to maintain and enhance the role of open science. The institutions of open science have allowed the flourishing of industrial development from the beginning, and should have a much more important role in the architecture of the future post-crisis global economy. This can be achieved through the institute of World Research Organization (WRO) which can master some of the benefits of open science to overcome the well-known free rider problem associated with contributions to the last.

In 2004, the research group Laboratorio de Internet from Spain, which studies educational and scientific activities on the Internet, started the Webometrics (www.webometrics.info) project with the aim to rate University web sites. The subject of their analysis is the university domain. Webometrics researchers emphasize that the presence of a university website allows to simplify the publication of scientific works by faculty and research staff, compared to the publication in print, and also provides the information the fields of their professional activities. Online publications are much cheaper than paper publications and have broader potential audience. Publishing online facilitates to broadening the access to academic resources for scientific, commercial, political, and cultural organizations both from within a country and abroad. The rating scale is based on the four criteria that take into account the entire Web data within the university domain: Visibility, Presence, Openness, and Excellence. Each criterion has a weight corresponding to its importance [9].

The report by UNESCO on information technology in education [4] shows that in Ukraine there is a “rapid advancement of ICT into the sphere of education, which needs continuous improvement in the efficiency of use of the new ICT in the educational process, timely updates of educational content, and an increase in the quality of ICT training”. However, there are some problems which are primarily associated with the low psychological, methodological, and pedagogical readiness of teachers to the rapid changes in information technology.

The issue of the openness of an education system and science often comes up in relation to international research funding instruments, such as Tempus, Erasmus, and others, and related projects. Every year, they attract the attention of many Ukrainian and foreign universities, research organizations and structures.

In 2006-2008 our Kherson State University (KSU) participated in the following European projects: Tempus TACIS CP No 20069-1998 “Information Infrastructure of Higher Education Institutions”; Tempus TACIS MP JEP 23010-2002 “UniT-Net: Information Technologies in the University Management Network”; US Department of State Freedom Grant S-ECAAS-03-GR-214(DD) “Nothern New York and Southern Ukraine: New Partnership of University for Business and Economics Development”, which resulted in the development and implementation of scientific and management processes of analytical information systems and services. More detailed information can be found in the articles by G. Gardner [10], V. Ermolayev [11], A. Spivakovsky [12].

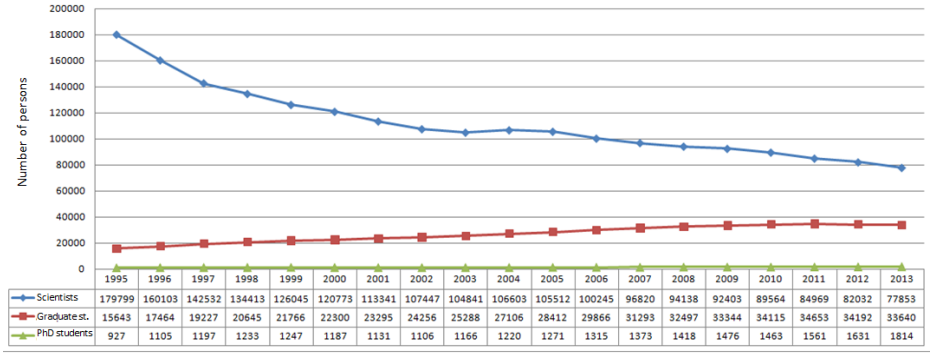
The results on the interrelation of ICT and educational process and the influence of ICT on professional and information competencies of the future university graduates have been presented in our previous publications [13, 14]. The authors have also conducted the investigation of the technical component of the feedback services implementation in KSU [15] and their impact on the preparedness of the students to use ICT for educational and non-educational purposes, and forming the ICT infrastructure in a higher educational institution [16, 17].

3 Experimental Settings

Today, Ukraine possesses a historically established system of scientific training. The foundations of this system were laid in the Soviet Union. This system is very similar to the system of post-soviet countries.

According to the State Statistics Service, 2011 [18], Ukraine had 14 895 “doctors of science” and 84 979 “candidates of science” (the analog of a PhD) covering arts, legal studies, and sciences. Among them 4 417 doctors and 16 176 candidates of science work in sciences. In addition, as reported by the ”Voice of Ukraine” newspaper, the National Academy of Sciences of Ukraine employs today 2 564 doctors and 7 956 candidates of science [18].

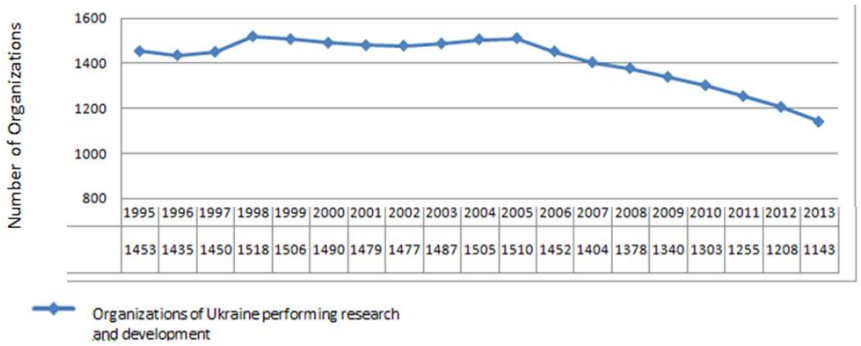
In the last 19 years the number of researchers in Ukraine, decreased by more than 100 thousand people, while the number of graduate students increased by almost 2 times (Fig. 1 shows an example). The trend similar to the decrease in the research staff members can be observed in the numbers of domestic research and development organizations (Fig. 2 shows an example).



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Scientists	179799	160103	142532	134413	126045	120773	113341	107447	104841	106603	105512	100245	96820	94138	92403	89564	84969	82032	77853
Graduate st.	15643	17464	19227	20645	21766	22300	23295	24256	25288	27106	28412	29866	31293	32497	33344	34115	34653	34192	33640
PhD students	927	1105	1197	1233	1247	1187	1131	1106	1166	1220	1271	1315	1373	1418	1476	1463	1561	1631	1814

Fig. 1. The dynamics in the numbers of research staff, PhD students, and university graduates in Ukraine (1995-2013).

In Ukraine there are 988 Dissertation Committees (DC) [19]. DC are the expert councils in different scientific domains which form the National organizational infrastructure, accepting candidate and doctoral dissertations for examination, doing the expertise, hosting the defenses of dissertations, and further awarding advanced academic degrees. The aim of this infrastructure is to foster the development of the innovative elite of Ukraine which is considered as a driving force for scientific and technological progress.



1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1453	1435	1450	1518	1506	1490	1479	1477	1487	1505	1510	1452	1404	1378	1340	1303	1255	1208	1143

Organizations of Ukraine performing research and development

Fig. 2. The dynamics in the numbers of Ukrainian organizations performing research and development (1995-2013).

Given the importance of the DC infrastructure, the foci of this study are to:

- Assess the openness and accessibility of the preparation of academic staff in Ukraine within the system using the DC.
- Specify the requirements for the construction of the ICT infrastructure in this area We will analyze the performance of DC based on the following principles:

1. The availability of information;
2. Openness;

3. Weight;
4. Scientific;
5. Social significance.

The research into the current state of the system of interaction with ICT of the DC, the Higher Attestation Commission of Ukraine, and graduate students is impossible without the analysis, comparison and synthesis, abstract approach to the definition of the basic patterns of the use of information technologies, and logical approach to the description of possible implementations of innovative teaching methods. Hence, the study of this issue requires the use a carefully designed combination of exploratory, empirical, and statistical methods. Therefore, several methods are used:

- Exploratory – the analysis, synthesis, comparison, generalization and systematization of relevant information acquired from psychological and educational literature legal documents, standards and information resources. These sources are consulted and further generalized to define the essence of the information competency of university students and assess the theoretical and methodological bases of information competency formation. Pedagogical modeling is employed to build the model of informatics competency.
- Empirical – questionnaires, surveys, testing, and self-esteem; pedagogical experiments are used to test the hypotheses of the study
- Statistical – the methods of mathematical statistics are employed to determine the reliability of the results on the basis of quantitative and qualitative analysis of the empirical data

The analysis of the public (available on the Internet) information on the availability of data on DC, and collecting the opinions of graduate students using a questionnaire on the use of information technology in their dissertation projects are the main research methods.

Considering that the DCs function as university bodies, such sites as Top 100 universities in the World, Top 10 European universities, Top 50 universities in Russia, Top 25 universities in Poland, Top 10 universities in the USA, Top 15 universities in UK, Top 20 universities in Asia [20], Specialized DC of Ukraine were the object of information analysis. Overall, 300 university sites were analyzed in the reported research.

The study of the current status the use of ICT to support the activities of DC the following assessment aspects:

1. The availability of a web site for a DC and its analysis;
2. The degree of openness of the information provided for a DC: information about the members, dissertation abstracts, theses, etc;
3. Information security;
4. The existence of DC pages in social networks;
5. The availability of a feedback service.

Let us consider in more detail each of the assessment aspects.

1. While exploring the web sites of universities regarding the availability of information about the activities of the respective DC, we have selected to use the following four criteria:

- A university web site provides the information on the DC and a link to its own website
- A DC does not have a separate web site, but it has a page on the university web site
- A University website provides a brief information about the DC
- There is no information about the DC neither on the university website nor in social networks

2. The openness to the information about a DC for public:

- Any Internet user can see the information
- A user can view the data only after registration on the web site
- Only the staff and students of the university can see the information

3. Feedback facilities:

- Providing a contact phone number;
- Providing a contact e-mail address(es);
- Providing the list of contact persons;
- Providing the Skype ID for contacts;
- Providing the schedule of DC works.

4. The availability of information (pages) in social networks:

- Due to a substantial impact of social networks on the communication among people today, it has been decided to account for the relevant indicators in our study an analysis of the availability of information about DC: the availability of accounts or groups in social networks such as Vkontakte, Facebook, Google+, Twitter
- To analyze the availability of video records of defense meetings the analysis of the YouTube content relevant to a DC has been also undertaken

5. The technical characteristics of DC web sites used in our study are detailed in Table 1.

Table 1. Technical criteria for the analysis and evaluation of DC websites.

Criterion	Description
Number of Web Pages	The number of DC-relevant pages on a web site is the indicator influencing the ranking of the site in search results.
Frequency of Updates	The frequency of updating information about the activities of a DC is analyzed using the scale: weekly, monthly or annually
Authentication System	The main elements and authentication mechanism are analyzed under this aspect.
Usability	The assessment of ease of use and operation of the system is done under this aspect, namely how well, clearly and correctly the interface is implemented and web site is structured. It is also assessed if a user can quickly find the information he or she needs. We conducted a brief analysis of layout. We also checked the availability dynamic elements and search functionality.

Platform	The web sites were categorized as implemented using CMS and hand-coded.
SEO	Under this aspect the ranking of a web site by search engines for specific user requests was analyzed.
Validity	Under this aspect we looked at the number of errors found by the web site validator (http://validator.w3.org/).
Multimedia content	A study on the website of the libraries of audio and video recordings protections scientific papers, photographs, etc.

The questionnaire which has been used to survey the use of ICT by graduate students in their preparation to defense consisted of 3 components:

- Quantitative indicators of the use of ICT by graduate students in the process of working with their DC.
- The availability of training courses for the use of ICT in the preparation to defense
- The readiness of the subjects to authorize the open storage of their research results (articles, theses, dissertations) and review materials such as audio, video, etc.

4 Experimental Results

The result of the analysis of the websites of the universities of Ukraine regarding the information on DC, personal web pages and sites of DC members is pictured in Fig. 3. Only 9% of the reviewed DC have their own web sites. 84% of DC related information can be found on University web sites, taking into account that full information concerning the DC activities has been found only for 47% of the reviewed DC. 7% of the reviewed DC have no presence on the Internet. These results pinpoint the major problems in the transformation of the contemporary Ukrainian scientific community into the Open Science community.

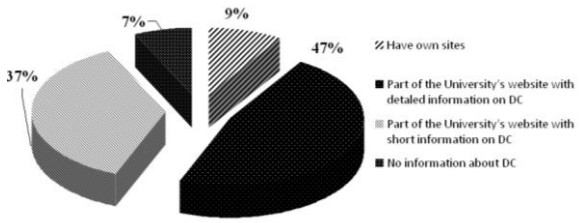


Fig. 3. The availability of DC related information on the web sites.

Only 4 DC web sites exploit a user authentication functionality distinguishing user roles. So, it can be stated that only 1% of the reviewed DC have created some ICT based prototypes for the interaction between the applicants and the Ministry of Education.

About 30% of the reviewed DC update the information on their web sites every week, whereas 51% of the information on these sites is updated several times per year

(Fig. 4 shows an example). Consequently, the question arises on the reliability and relevance of this information.

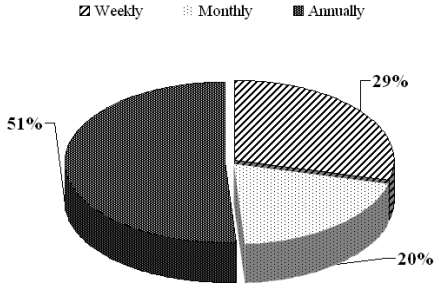


Fig.4. Frequency of updates.

As per the information on the reviewed web sites, the DC have no means to track scientometric indicators of the members of the DC, the candidates for a degree, and persons that had defended their theses in a particular DC, not to mention the presence of analysts defended dissertations and access to them, which makes the qualitative assessment of their activities impossible. 32 websites have usability problems in terms of the ease of use of their interfaces and poorly implemented site (keyword-based) search functionality. The latter is implemented on only 27 of the reviewed resources. Only 17 of the examined web sites provide the information on or references to resources like a "library".

Regarding the minimally present contact information of a DC (a phone number, address, contact person name, document templates), it is provided only on 4 of the reviewed web sites. Moreover, the contact phone number is mentioned only on 2 of them. Thus, in order to find the information a DC of relevance to a PhD project, one should get their list and addresses in the Ministry of Education and Science of Ukraine (where one also needs to go) and search for a relevant DC at the specified address. This is only the first problem in the application process. The required documents have also to be submitted to a DC by coming in person, since there is not a single web site that allows you to exchange the information and documents with a DC in the process of registration, filing and review of the thesis and so on.

The results of the review of the availability of information about Ukrainian DC in social networks are shown in Fig. 5.

As can be seen in Fig. 5, 14 DC have a personal group or page in Vkontakte, 11 – in Facebook, 7 – in Twitter and 4 – in Google+. It is also important that YouTube is used, though to a small degree. So, a certain degree of openness of our science may be noted, in particular the openness of the preparation of the scientific staff.

The analysis of quantitative indicators of the use of ICT by graduate students for working with a DC is shown in Table 2.

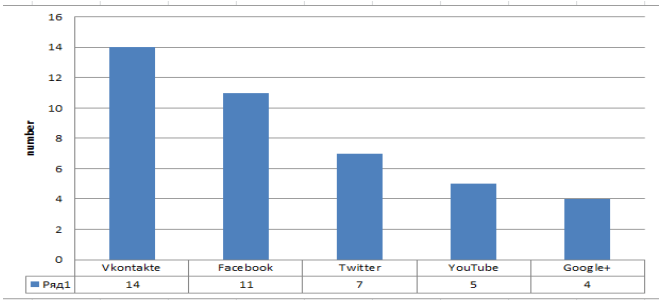


Fig. 5. The use of social networks in the work of DC.

The study reveals that only 2-3% of the respondents know what is a scientific database (SDB) or a citation index, 7% use these systems from time to time to find the necessary information, and only 4% have their own profiles in such scientometric systems and databases like Scopus, Google Scholar, Mendeley, RSCI or others. It is important that the majority of the respondents are not interested in creating their own profiles in such scientometric systems. The main reason for that is the lack of recognition of their utility. Moreover, some of the profiles were created directly by the organizations where scientists work, or automatically by the systems that store their scientific articles. Thus the majority of respondents did not know whether they have a profile in any of the systems, whether these exist or not.

80% of respondents do not think much about how their scientific publications are stored –in a paper or electronic form, and they believe that it is not of great importance. Thus, the majority of publications are going out of press in a paper form and are not further digitized – so remain unavailable to the scientific world.

Table 2. Quantitative indicators of the use of ICT by graduate students for working with a DC.

		Do not Use	Rarely Use	Always use
Use of the Internet to search for information about DC	Working with DC website	80%	15%	5%
	Search of information about the members of DC in SDB	93%	5%	2%
	Own profiles in SDB	95%	4%	1%
	Work with electronic repositories (theses and abstracts)	40%	50%	10%
Use of email		30%	40%	30%
Use of Skype		84%	10%	6%

93% of respondents answered negatively about attending any course (or lectures) to get prepared for the use of ICT in their dissertation project (SDB, repositories, etc.).

Analyzing the readiness to the open storage of research results (articles, theses, dissertations) and materials of dissertation defense such as audio or video, we observes the following:

1. The majority of the respondents (80%) support the publication of electronic copies of their scientific papers on the Internet, but at the same time consider it unnecessary and inconvenient. Further, all the respondents point out that the Ministry of Education and Science of Ukraine (MESU) has the publication requirements (regarding the number of papers and form of publication, paper or electronic) to qualify for a degree which do not motivate providing open access. MESU requires that a qualified candidate has 5 publications at the MESU approved venues, one of which can only be published in an electronic edition and another one in an international or indexed international SDB. Thus, none of the applicants target to publish the electronic copies of their papers on the Internet. In some cases, this problem is solved by posting electronic copies on a digest web site or putting these into an electronic repository of a scientific institution of the applicant. Otherwise the articles remain inaccessible to the outside world.
2. The Problem with open access to the protected dissertations and abstracts is identical to the previous. In addition, the human factor needs to be taken in consideration. Providing free access to abstracts or theses means making these open for further examination after publication, hence the increase of the author's responsibility for its contents and quality. Therefore, open storage of scientific work of this type stimulates quality improvement. We see it in the results of the evaluation of the respondents ' answers to this question. Notably, 80% of the respondents agree that the understanding that their work could be read by any other scientist clearly affects the quality of publications.

As an example, let us compare the quantities of the full versions of theses and abstracts stored in the repositories in Ukraine to numbers in the repositories in Germany, Great Britain, and Spain (top 30 repositories of each country rated by Webometrics, http://www.webometrics.info, were examined) – see Table 3. Ukraine has 38 repositories in total while having more than 400 universities.

Table 3. Numbers of dissertations and abstracts in open access repositories.

	UKRAINE	**GERMANY**	**UK**	**SPAIN**
Dissertation	1858	71656	16724	3586
Abstract	3532	22882	23617	18582

Only 15% of the respondents agree that online video protection is useful, 30% – to deposit their audio and video files providing open access, while the remaining 45% believe that audio and video recording is unnecessary or even harmful as it bothers and disturbs focusing on the defense talk. To the question "if they would like and are ready to use specialized systems to work with a DC and MESU" 90% of the respondents gave a positive answer. The most significant motive to this answer is potential reduction of time and financial expenses for data processing (sending and receiving documents, access to the proper information and so on).

5 Our Vision of an ICT Infrastructure for a DC

As experimentally proven above, the effective implementation of the elements of OS must assume the existence of an appropriate ICT infrastructure as a scientific and educational system as a whole and its component parts (schools, universities, DC, and others) in particular.

The main elements of the ICT infrastructure of OS are researchers (academic staff), data and processes.

Speaking of ICT infrastructure DC we can determine its components as follows:

- Researcher – the applicants, the members of a DC, the employees of MESU, and other users of the system have access to relevant information and participate in information processing, communication, and computing processes
- Data – information about the work of DC, their employees, applicants, archives of theses, scientific publications, etc. as a tool to open exchange, recombination, and reuse are the important components of the infrastructure;
- Process – the procedures, services, tools, and methodologies that are used to collect, perform the transformation, analysis, visualization and storage of data, build models and simulations. The management of these processes is done both on the side of users (researchers) and of the specialized services and systems.

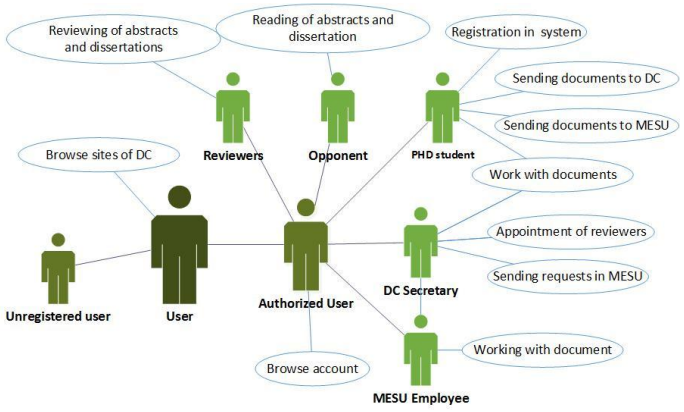


Fig.7. User roles and their main features.

As pictured in Fig. 7, all the user roles have both generic and specific abilities in using the system. All roles can retrieve publicly available information while working with documentation is allowed only to certain roles.

The workflow of the system is presented in Fig. 8 and proposes almost complete automation of all communication processes. It should be noted that the implementation of a similar service involves not only the functionality described above, but also the implementation of some add-ons and extra features. One of the additional features of interest is related to solving the problem of retrieving the information about the available DC discussed above. The task of collecting correct and complete scientometric data regarding the DC members, candidates, and

graduates is of particular importance and interest. It is difficult to compile by hand a report for an individual DC based on the scientometric information even if all the mentioned actors have their profiles, say at Google Scholar. The task of reporting about all relevant DC, or the graduates interested in applying to a relevant DC, is even more complicated.

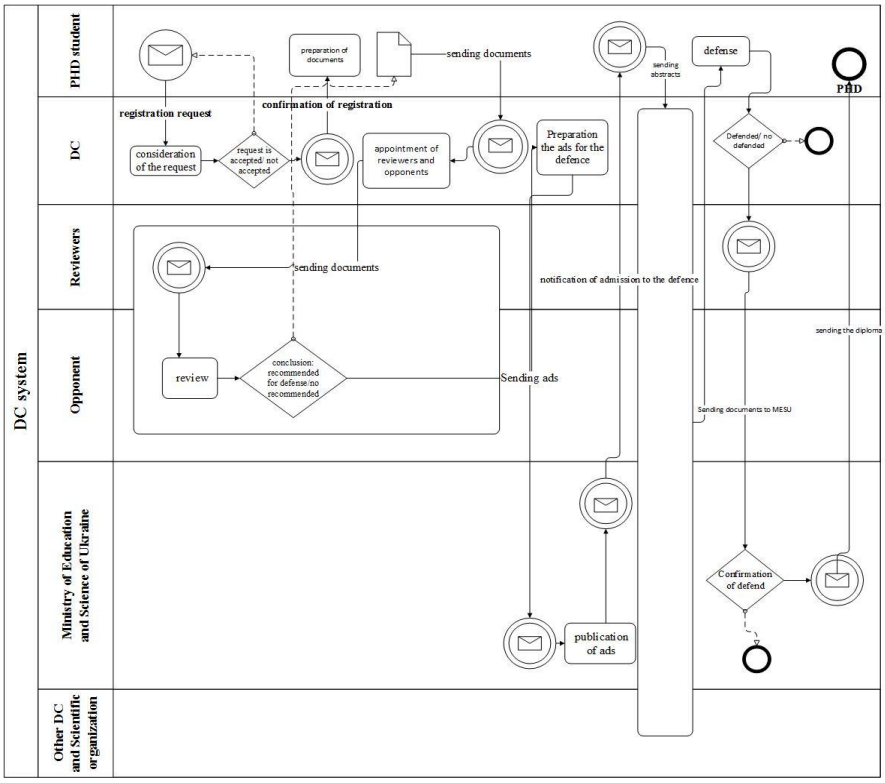


Fig. 8. Algorithm of DC system work.

We currently possess a number of modules relevant for the solution of this problem. For example, the problem outlined above may be solved using our publication.kspu.edu service. The main task of this service is automating the collection and processing of information on scientometric indicators of scientist retrieved from his or her Scopus and Google Scholar profiles and building consolidated ratings for departments, institutes, and universities.

The service provides the possibility to generate the required scientometric indicators and ratings on the DC web site, hence offering an additional degree of openness of their activities. In addition, we assume that this form of presenting information contributes to establishing vigorous competition in the research staff training market, and therefore has an impact on the quality indicators.

An electronic repository of a DC is also a mandatory component of the system which store all theses and abstracts in electronic form and, if possible, in the public domain.

The competition on the market puts in front the requirement of using social networks in the activities of a DC. The results of the study presented in Section 4 provide clear evidence about their rare use. We believe that the inclusion of the use of social networks in the workflow will provide a valuable addition to the information and communication services of the architected infrastructure.

6 Concluding Remarks and Future Work

Building a system of efficient education and science in Ukraine today is complicated by many serious problems. In the last 15 years we observed a decrease in the number of scientists in the country. At the same time, the numbers of postgraduates and doctorates are increasing.

A system of training of scientific personnel in Ukraine is among the most restrictive and closed ones in the world. A similar trend is observed in the majority of post-soviet countries. The proportion of scientific research results published under a open access is still very small compared to the level of ICT development. The main part of research results still remains inaccessible for an external users.

The use of ICT in training scientific personnel and representing the results of their research appears to be extremely weak. The preparation, protection and storage of information is done without using ICT, therefore it requires significant time and resource.

To partly overcome some of the problems, we propose a concept of the ICT infrastructure for the interaction of researchers, a DC, and the Ministry of Education and Science of Ukraine. The main elements of this infrastructure are the following: the web sites and services for supporting the applicants to a DC; the services and systems of interaction between a DC and the Ministry of Education and Science of Ukraine; electronic data storages for publications, theses, and abstracts; decreasing of time spent on a research process without harming its quality; additional expertise; transparency and credibility of research; building qualitatively new communications between scientists; ability to obtain research information swiftly and in required forms (especially government); fighting corruption (decreasing human factor in DC activities).

An important and influential part of establishing an effective process for training scientists is training researchers to use this process and respective tools based on ICT. Training scientists to use ICT in their research activities creates additional opportunities for scientific and technical progress. This training can be conducted in magistrates, postgraduate and doctorate curricula. In this research we presented the project that is now being realized using the DC in Kherson State University as a case study. The next phase of our research is the investigation of the efficiency of using the described model and its influence on qualitative characteristics of science.

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