Development of competences in Information Science and Information technologies among the Bachelors of Engineering sciences at classic University*

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Abstract. Formation and development of IT-competences among the future Bachelors of Engineering sciences on the "Quality management" course at classic University contribute to the creation of high-qualified specialists for the labor market. "The capability to work with basic software, applications, and information technologies within professional activity" is the foundation of IT-competences formed through the process of studying. The authors into several stages divide the process of IT-competences formation. The analysis of the basic knowledge level, diagnostics of the competences and skills essential for the future profession, and the assessment of the self-education readiness level. The article provides the analysis of proficiency level in mass-market software as well as in highly specialized applications. The assessment is based on school knowledge and skills in the field of information technology obtained after a computer science course at the university. The research reveals bottlenecks in the process of IT education for full-time and distance learning students. The authors cover aspects that help to increase the efficiency of IT-competences formation at the University.

Keywords: IT-competences, Bachelor, distance learning, groups of competencies, Information Science, Information Technologies.

1 Introduction

The "Digital Economy" project, initiated by the Government, determines basic directions of the education system development in Russia; it is aimed to provide the country with highly skilled and competent professionals prepared for digital future and economic breakthroughs. The implementation of this goal demands essential changes in classic University education, which concerns full-time students as well as distance education students. The theoretical part needs to be backed by practice because Russia critically needs highly qualified specialists capable to work effectively using

knowledge and skills from engineering sciences as well as from humanities. The economic problems cannot be solved without active, progressive, and competent engineers, interested in their profession, who would lead the country to technological progress. The Vilnius University scientists identify five basic skills of today's specialists: complex solutions of problems, critical thinking, cognitive flexibility, mathematical thinking, and active learning. (2018).

The University graduates must use their creativity not only for the good of science but also for constructive labor. In the 1990's Russian Academician P. Atutov marked the importance of students' familiarization with basic production aspects (1999). He considered polytechnic education as a part of the personality development process in conditions of technics application in every sphere of human life all over the world, fundamental for future professional training. Today's polytechnic education relevance could be seen even on the example of classic Universities which announce the opening of Engineering specialties; therefore, the introduction of the "Quality management" course for the Bachelors in Engineering Sciences in The Chelyabinsk State University is a brand new direction as for entrants, as for the labor market of South Ural. The modern vision of Bachelors's training within this course demands to shift focus from only using technologies, including the IT sector, to developing and managing them. Thus, fundamental professional education at the classic University is aimed to train competent specialists, capable to provide development, service, and assessment of the quality management systems; capable to analyze business processes and increase their technological, economic, and safety effectiveness. Besides, the quality management system (ISO 9001 - 2015) is focused on constant training of specialists and the development of new technologies (last accessed 2019/04/21).

The development of digital technologies gives opportunities to provide high-level education regardless of its form, which reflects on the constant popularity growth of distance education. The interactive area today is commonly used not only for basic education but also for additional education and professional development, to master professional skills and achieve any competences required. In this connection, scientists around the world develop and improve digital technologies as well as methods of their implementation in the education sphere.

2 Literature review

The article by Ordov K., Madiyarova A., Ermilov V., Tovma N., Murzagulova M. (2019) «New trends in education as the aspect of digital technologies» underlines that digitalization of the educational process is of particular importance since education can be considered the basis for the development of the economy and the achievement of the planned strategic goals [15].

Contreras-Mendieta J.A., Sarango-Lapo C.P., Jara-Roa D.I., Agila-Palacios M.V. (2019) proposed to integrate a remote laboratory (LR), as a support resource in an education system at distance, that encourage students to practice and experiment thus confronting theory with practice [4].

The Turkish model of distance learning was described by Turker Y.A., Baynal K., Turker T. (2019). Distance education has become an important educational model with the development of information and communication technologies in the world and performed by some special software called Learning Management System (LMS) [18].

Lebedev A. (2019) considers distance learning as an element of private technology to support the learning process, for the control and implementation of students' independent work system. In the work «Modernization of marketing conditions in the implementation of remote education programs» (2019), the author proposes to position the distance form of education on the market as a part of the information environment of the university, which focuses on practical results [12, 13].

Li H. (2019) in the research «Construction of distance teaching platform based on mobile communication technology» proves the expediency of mobile communication technology in distance education describes specially developed platforms for distance education [14].

Hong, B., Wei Z., Yang, Y. (2019) work on methods of elimination and forecasting on Massive Open Online Course (MOOC) using studying activity [8].

Bentaib M., Talbi M., Touri B. (2019) expressed the necessity to decide on the methodology of integrating transmission order size ergonomic, aesthetic, practical, time to achieve skills in the concrete discipline [2].

Kaysi F. (2018) in the research «An analysis of capstone courses given through distance education in Turkey» raised a problem that the experiment participants, knowing the time and space advantages of distance education but they do not use the system because they are not given sufficient information and they do not know how to use it [11].

3 The Issue

The process of competences development cannot be implemented without understanding the tasks of future alumni. The constituent parts of IT competences, such as “to know”, “to be capable”, and “to own” must be focused on practical activities of the future specialist. To become effective professionals in the future, the Bachelors of the course 270302, “Quality management”, during their studies need to master a large number of programs as well as principles on how to create and use automated systems [7]. Also, they must learn to find rational economic solutions and to analyze massive information arrays using special software.

First, students must explore CALS-technology [3]. This software helps to form united data space in the enterprise’s multi-functional system; it allows keeping all information in digital format, which increases the effectiveness of complex technologies during their usage. “CALS-method determines information space (IS) for the whole enterprise and accumulates all information about the production, which makes CALS-method the only data source (direct data exchange between the participants of the product’s life cycle is impossible), formed following international industrial standards.” (last accessed 2019/04/21). While studying ISO 9001-2015, students master the process approach, based on the chain “plan – do – check – act” [7]. Development of quality

management technologies is accompanied by the process quality analysis, used in modeling of business-projects. FMEA-analysis represents contemporary technology in process analyzing. It has standard result presentation forms and technology of conduction. This analysis is based on the expert evaluation, given by a group of highly qualified specialists. (Kaysi, 2018). The effectiveness of analysis depends on how well the students manage "the quality control instruments", which contain: control lists, Cause-and-Effect-Diagram, Pareto, dispersion, affinity diagram, mind map, dendrogram, matrix diagram, arrow diagram, process chart, priority matrix, etc. To form these charts the Bachelors in Engineering Sciences need to master contemporary Information Technologies [15– 17].

The students of Engineering Sciences in the Chelyabinsk State University, within the specified courses purposefully develop General Professional Competences during lections and practical classes. The courses include "Contemporary information systems and technologies", "Information technologies in quality management", "Database management systems", "Engineering Graphics", "Computer graphics", "Packages of application programs". General Professional Competencies include [1, 5, 9, 10, 17]:

- capability to use basic software and information technologies applied in professional activity; (GPC-4);
- capability to perform standard tasks of professional activity within information and bibliographical culture, applying information and communication technologies following major requirements of information security. (GPC-3) (last accessed 2019/04/21).

The competences considered above form basis for mastering the following professional disciplines, necessary for the specialists in quality control sphere; for example, "Quality and means of quality management", "Statistical methods in quality management", "Documentary providing for quality management systems", "Mathematical methods of modeling in economics", "Project management", etc. Process of studying these disciplines is directly connected with the necessity to use data processing technologies in various applications such as text editors, tabular processors, database management systems, mathematical editors, graphic editors, and other applications with necessary functions; for instance, management of the project, stock, and product's life cycle.

The authors into several stages divide the development of information competences. The first stage starts at school when fundamental knowledge, which is used and developed later at the University, is received. In this connection, the quality of school education influences the effectiveness of mastering information at the University. Taking into account the necessity of life-long education, the authors pay special attention to the motivation aspect of the studying process. The low productivity of students in the process of mastering disciplines mentioned above can be explained by a low level of motivation, insufficient basic Computer Science knowledge, discrepancies between educational programs and forms of education, and other reasons.

In this connection, the article is aimed to study the formation of IT-competences within all forms of education. To this end, the authors conduct pedagogical research, involving future Bachelors of Engineering Sciences with different forms of education. The survey includes surveillance and questioning; the participants are divided into two groups: the first group consists of 66 first-year students and represents distance education, while the second group includes 12 first-year students representing full-time education.

In the beginning, the research is oriented towards students' motivation level in the process of studying the following disciplines: "Contemporary information systems", and "Information technologies in quality management". The results of the monitoring show that extrinsic motivation prevails. The majority of students involved in research have full access to computer equipment that is why the number of hours spent at computers can be considered sufficient. The Internet is commonly used among students. More than 25% of students spend time on Internet playing games, almost 50% work in different applications and do homework. 90 % of research participants use the Internet to find information for studies and everyday information; 60% read news, magazines, books; 40% visit online stores.

The next stage of the research discovers that after school graduation, many students have no idea of how many useful programs and utilities for their studies exist. These applications work with all types of information processing and make studies much easier and more interesting. Students master some programs for studies in school (without taking into consideration MS Office), but only by initiative of their teacher and under teacher's surveillance they study programs' interface and functionality. However, the experience of such type cannot be considered as significant. It is demonstrated in Table 1, formed based on first-year students questioning.

According to Table 1, during the period of school education students master no extra software. Therefore, they have to do it during their studies at the University.

To form competences in IT disciplines (GPC-4, GPC-3), full-time students' educational plan includes lections, laboratory practice with step-by-step instructions and tutor's comments, self-education tasks, participation in conferences, writing works or essays on scientific issues. All the tasks are performed with the tutor's feedback. Students, taking correspondence courses or preferring distance education, generally study disciplines themselves, according to their educational plan. Modern technologies, for instance, real-time remote consultations (with the application of Tanberg system, used in the University); lections, recorded on digital media; e-mail exchange between students and professors (using e-mail services); knowledge check via studying management system (Moodle) are supposed to make Internet-based learning as effective as full-time education.

Table 1. Level of proficiency in software and utilities at school

Programs and utilities	Distance education		Full-time education	
	Quantity of respondents	%	Quantity of respondents	%
Systems of machine translation, and automated analysis of unstructured text in Russian or a foreign language	4	6%	1	8,3%
Social science training program	1	1,5%	0	0,%
Algebra and geometry training program	1	1,5%	1	8,3%
Software for mathematical diagrams	1	1,5%	0	0%
Foreign language simulator	2	3%	0	0%
Programs for Computer Science studying	1	1,5%	2	16,7%
MS Word	52	78,8%	7	58,3%
MS Excel	38	57,6%	5	41,7%
MS Power Point	31	47%	6	50%
On-line software for mathematical calculation	3	4,6%	0	0%
MS Access	1	1,5%	1	8,3%
Photomath – mobile application, "calculating camera" uses a smartphone's camera to recognize mathematical equations and demonstrate systematic solutions on the smartphone's display.	3	4,6%	2	16,7%
None	5	7,6%	0	0%

*The Table lists applied software and utilities from students' questionnaire

The development of IT-competences focused on mastering software and information technologies are performed within several disciplines. So, text, numeric, graphic data editing technologies, realized in software, such as MS Word, MS Excel, MS PowerPoint, COMPASS-3D, Mathcad, etc., are studied during laboratory practice within such disciplines as: "Contemporary information systems and technologies", "Information technologies in quality management", "Engineering Graphics", "Computer graphics", "Packages of application programs". Technologies of data storage and processing using relational databases, realized in DBMS MS Access, are studied within "Database management systems". Mastering other applications and utilities, that could be useful for studying or for future professional activity (AutoCAD, FreeCAD, MS InfoPath, MS Publisher, Scilab, Lightroom, ABBYY FineReader, SNOSKA.INFO, the virtual voice assistant for foreign language learning), is supposed to be done within self-education work. The results of software mastering are reflected in full-time students' reports presented during conferences, where they give examples of programs and utility application during their studies within other disciplines, and during their future professional activity. Distance learning students perform their tasks via standard MS Office programs; they are provided with methodological instructions and a list of research directions for independent study.

The results of questioning help to reveal actual proficiency levels in data processing applications, programs, and utilities among students (Table 2). A quality indicator is

not critical in this case; the fact itself of using applications and software during studies has much more meaning for the research.

Table 2. Students' proficiency level in software and utilities at the University

Programs and utilities	Distance education		Full-time education	
	Quantity of respondents	%	Quantity of re-spondents	%
MS Word	66	100	11	91,7
MS Excel	56	84,9	10	83,3
MS Power Point	60	90,9	10	83,3
MS Access	8	12	3	25
COMPASS-3D	0	0	1	8,3
Mathcad	0	0	1	8,3
Skilab	0	0	1	8,3
AutoCAD	5	7,6	3	25
MS InfoPath	1	1,5	0	0
MS Publisher	1	1,5	1	8,3
Lightroom	11	16,7	0	0
FreeCAD	8	12	1	8,3
PhotoMath (Android, IOS)	23	34,9	1	8,3
ABBYY FineReader	5	7,6	2	16,7
WinDjView	0	0	1	8,33
Multitran	6	9	0	0
SMath Studio	1	1,5	0	0
Virtual voice assistant for foreign language learning	9	13,6	2	16,7
SNOSKA.INFO	1	1,5	0	0
BPsimulator	0	0	0	0
None	6	9	0	0

As we see in Table 2, during studies at the University students generally master widespread software, for instance, MS Word, MS Excel, MS PowerPoint, and other useful assistants, for example, PhotoMath which helps in laboratory practice. It should be noted, that these programs also have the highest proficiency level indicator in the school period (Table 1).

Creative tasks, connected with mastering different software, are considered as difficult and do not cause much interest among students. It turns out that a new interface along with the necessity to translate manual written in English creates serious obstacles in the process of mastering the functionality of new software. During independent studies, full-time students regularly consult with professors. As for distance education students, for the majority such consultations are difficult to receive, because online lections are limited in time, and e-mail exchange cannot replace real communication and cover all the aspects of questions. We cannot disagree with distance education researcher F. Kyasi, who points out the importance of sufficient information in the process of distance courses realization, and interaction with tutors or lecturers (2018).

4 Results and recommendations

According to the authors, despite all the advantages of distance education (individual schedule, availability, mobility, social equality, etc.), this education form is restricted by at least three main factors:

1. Lack of motivation along with insufficient stimulus to study;
2. Low responsibility, the inability of students to organize their work properly;
3. Insufficient communication between tutors and students.

Studying the results of students questioning, we agree with K. Shapiro (2016). “Competences don’t form momentarily; it’s a lifelong process, which depends on student’s educational capabilities”. “Self-education can be productive only as a part of...the triad: collective education for everyone – education in groups – self-education”. In this connection, according to the authors, the most preferable form of education for Russian students would be a mixed one. It combines distance communication via the Internet with real-life communication between students and tutors, especially during the first years of education. In this case, on certain stage students and tutors have the opportunity to adapt to distance form of education demanding from student's capabilities to study. At the same time, tutors have time to prepare specific content for students using the interactive mobile area (tutor’s site or education management system Moodle), which contains training and methodical materials, links to digital resources, essential for studying disciplines, links to extra material (if necessary), tests, instruments to attach files with homework or creative tasks. The combined form of education has the potential to decrease the negative influence of the factors mentioned above. Tutors can form motives and find stimulus for students, teach them to organize studying activity, and establish feedback mechanisms with students. Besides, we recommend verifying competences proficiency level with system tests of actualizing binary models through the education management system (Moodle in our case). These tests are developed by one of the authors, A. Popova (2000). Tests are individual and contain the next features: equifinality, fixation of difficulties through the process of content mastering, determination of strategies to overcome the difficulties. Using the iterative process with feedback cycles, we observe positive dynamics in the process of IT-competences mastering with the application of this instrument.

References

1. Atutov P. (1999). Polytechnic education: encyclopedia of professional education: in 2 v., – V. 2. Russian joint-stock company: association "Professional education", Moscow. T. 2.8, p. 284
2. Bentaib M., Talbi M., Touri B. (2019). Integration of a computer device for learning and training situations: The case of Faculty of Sciences Ben M'sik (FBSM). International Journal of Emerging Technologies in Learning. 14(3), p. 243-249
3. CALS – technologies. Information and Education. Available at: http://info-tehnologii.ru/cals/index.html (Accessed 2019/04/21).

4. Contreras-Mendieta J.A., Sarango-Lapo C.P., Jara-Roa D.I., Agila-Palacios M.V. (2019). *Implementación de un laboratorio remoto (LR), como recurso de apoyo en un sistema de educación a distancia* [Implementation of a remote laboratory (LR), as a support resource in an education system at distance]. RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao (E17), p. 923-935
5. Encyclopedia of Economics. Available at: http://economy-ru.info/info/16276.pdf (Accessed 2019/04/19).
6. Federal state educational standard of higher education/training direction 27.03.02. Quality control. Available at: http://fgosvo.ru/270302.pdf (Accessed 2019/04/21).
7. GOST P ISO 9001-2015 (ISO 9001:2015), Quality management systems - Fundamentals and vocabulary. Available at: https://catalogue.normdocs.ru/?Type=searchresult&devs=com.normdocs.dict.developer.record.iso& actual=true& yclid=3158559795889055240.Pdf (Accessed 2019/04/21).
8. Hong B., Wei Z., Yang Y. (2019). A two-layer cascading method for dropout prediction in MOOC. Mechatronic Systems and Control 47(2), p. 91-97.
9. *Informatika v obrazovanii* [Computer Science in education]. (2018). Vol. 17, № 1, p. 21-44. Available at: http://infojournal.ru/journals/info/info_01-2018/ (Accessed 2019/04/20).
10. Internet-project *Korporativnyy menedzhment* [Corporate management] Available at: https://www.cfin.ru/management/iso9000/iso9000_tech.shtml, last accessed 2019/04/21. (Accessed 2019/04/20).
11. Kaysi F. (2018). An analysis of capstone courses given through distance education in Turkey. International Journal of Distance Education Technologies. 16(3), p. 1-17. DOI: 10.4018/ijdet.2018070101
12. Lebedev A.A. (2019). Distance education as a driver of the new technologies implementation. International Journal of Civil Engineering and Technology. 10(1), p. 1597-1611.
13. Lebedev A.A. (2019). Modernization of marketing conditions in the implementation of remote education programs. International Journal of Civil Engineering and Technology. 10(1), p. 1612-1630.
14. Li H. (2019). Construction of distance teaching platform based on mobile communication technology. International Journal of Civil Engineering and Technology 10(1), p. 1597-1611. DOI: 10.1504/IJNVO.2019.096612
15. Ordov K., Madiyarova A., Ermilov V., Tovma N., Murzagulova M. (2019). New trends in education as the aspect of digital technologies. International Journal of Mechanical Engineering and Technology. 10(2), p. 1319-1330.
16. Popova A.A. (2000). *Teoreticheskiye osnovy podgotovki uchitelya k diagnosticheskoy deyatel'nosti* [Fundamental theory for teacher's diagnostic activity]. Ph D. thesis: 13.00.01 p. 181.
17. Shapiro K.V. (2016). *Setevyye tekhnologii dlya organizatsii obrazovatel'nogo protsessa s ispol'zovaniyem distantsionnykh obrazovatel'nykh tekhnologiy* [Network technologies for educational process organization using distance education technologies]. *Molodoy uchenyy* - Young Scientist, pp. 42-45. Available at: https://moluch.ru/archive/123/32613/ (Accessed 2019/04/24).
18. Turker Y.A., Baynal K., Turker T. (2019). The evaluation of learning management systems by using Fuzzy AHP, fuzzy topsis and an integrated method: A case study. Turkish Online Journal of Distance Education. 20(2), p. 195-218. DOI:10.17718/tojde.557864