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Implementation of Practice-Oriented Training at Northern (Arctic) Federal University. IT Professional Standards as a Factor Influencing the Syllabus of IT Training Courses

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The paper covers education program development according to Russian and international professional standard requirements, development of IT specialist competency model, choice of training paths and learning outcomes with regard to international recommendations.

Key words: training of IT-professionals, engineering education, professional standards, international professional standards, learning outcomes.

Informational technology is the most intensively developing industry both in Russia and in the world. This is the industry that always faces the lack of qualified human resources. Besides, IT is instrumental in implementing any interdisciplinary research projects. Nowadays, the Russian education setting is confronted by the necessity to train highly qualified and highly demanded engineers including IT-specialists. Russian IT companies were among the first companies that elaborated the professional standards that should be taken into account while developing a competency model for graduates. Taking into account the global informational society expansion, special attention should also be paid to international IT professional requirements.

According to international IT training standards Computing Curricula 2005 (CC2005) there are 5 disciplines that are basic for the corresponding professional activities [1]:

- Computer Science;
- Computer Engineering;
- Software Engineering;
- Information Systems;
- Information Technology.

The combination of professional standards requirements and FSES ensures multidisciplinary professional training in the frame of a one degree program.

Education program development for a degree program according to FSES makes it possible to preserve the fundamental basis of the academic education aiming to achieve long-term educational objectives on the one hand; on the other hand, a variative program component provides freedom for the Universities to meet the current demand of a regional labor market. So, it is more important to analyze professional competences that ensure successful training of graduates [2].

Let us study IT-specialist training, a degree program "Applied mathematics and informatics" being taken as an example. IT professional standards developed by the Information & Computer Technologies Industry Association (APKIT) can help to define professional competencies for this degree program. These standards identify job responsibilities, professional competencies, educational level, work experience and certification according to qualification levels [3].

Education standards take into account

Table 1. Correlation of professional training according to Russian Federal State Educational Standards (FSES) with CC2005 degree programs

CC2005 degree programs	Russian degree programs
Computer Science	02.03.01/ 02.04.01Mathematics and computer science 02.03.02/ 02.04.02/ Fundamental informatics and informational technologies 01.03.02/01.04.02 Applied mathematics and informatics
Computer Engineering	09.03.01/ 09.04.01 Informatics and computer engineering
Software Engineering	02.03.03/02.04.03 Mathematical support and information system control 09.03.04/09.04.04 Software Engineering
Information Systems	09.03.02/09.04.02 Information systems and technologies 09.03.03/09.04.03 Applied informatics 11.03.02/11.04.02 Infocommunication technologies and communication systems 38.03.05/38.04.05 Business-informatics
Information Technology	09.03.01/09.04.01 Informatics and computer engineering 09.03.02/09.04.02 Information systems and technologies 10.03.01/10.04.01 IT security 11.03.02/11.04.02 Infocommunication technologies and communication systems 10.05.01 Computer security 10.05.02 Information security of communication systems 10.05.03 Information security of automated systems 10.05.04 Information-analytical security systems 10.05.05 IT security in law enforcement

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both general education and fundamental training requirements. In these conditions, several professional standards can correspond to one FSES. For example, such professional standards as "programmer", "system architect" and "information security specialist" correspond to the education standard for the degree program "Applied mathematics and informatics".

Professional standards reflect current labor market demands and ensure successful performance of job responsibilities implied by a particular qualification level. Thus, the professional standard model (Fig. 1) is simpler than that of an education standard (Fig.2).

Each qualification level (from 1 to 8) is specified by professional activities described by FSES and such requirements as work experience, certification, grade level, training and the list of positions as well.

For example, the requirements for the professional standard "programmer" are specified according to four qualification levels with regard to educational attainment

Fig. 1. Professional standard model

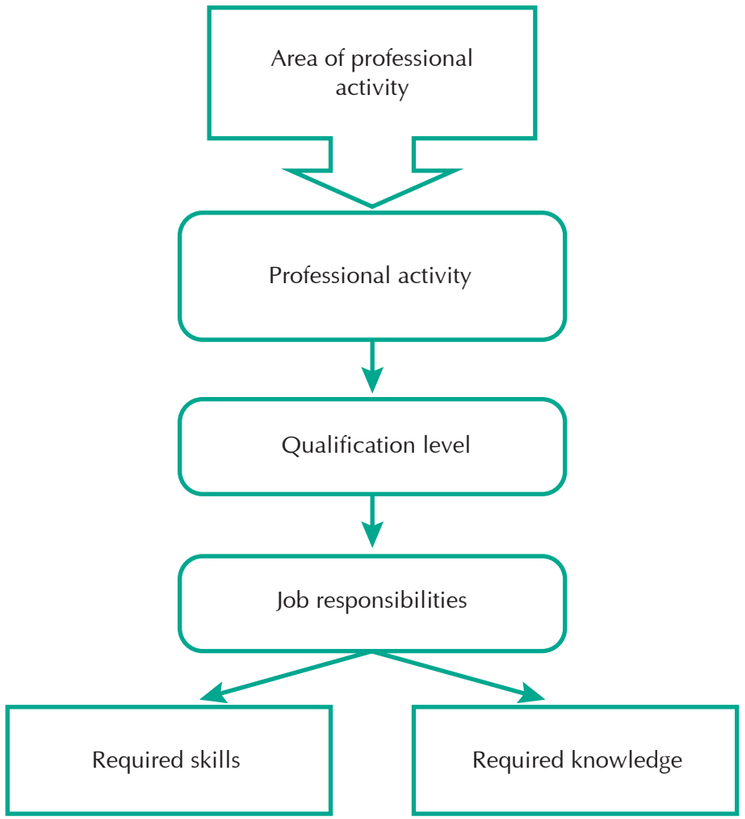

Fig.1. Federal State Standard model

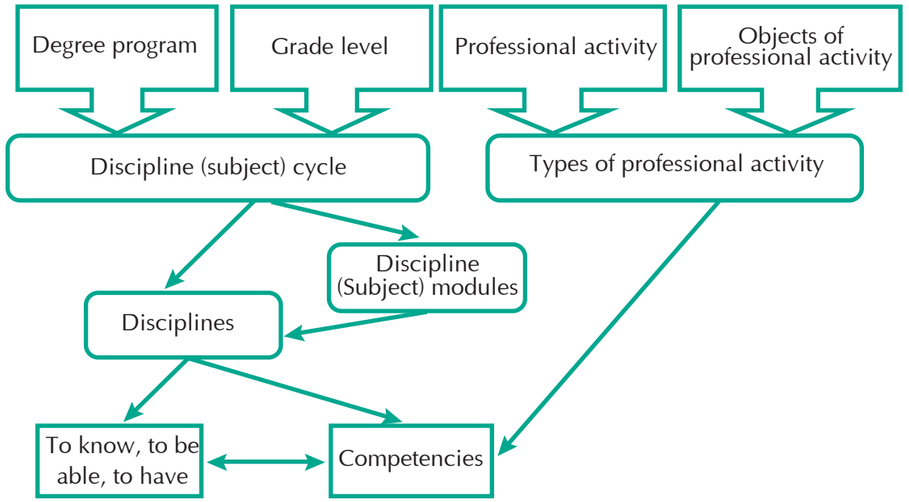

Table 2.

Grade level	Positions	Qualification level
Bachelor's degree «Certified specialist»	Programmer Development engineer Engineer	2nd level
Master's degree «Certified specialist»	Engineer Senior development engineer Senior programmer	3rd level
Master's degree «Certified specialist»	Senior engineer Senior specialist Chief programmer	4th level

and estimated positions (Table 2).

Each qualification level determines a set of particular job responsibilities. Each job responsibility implies a set of particular skills and knowledge. While comparing professional and educational standards, it is possible to present job responsibilities as specified objectives and competences of educational standards (Table 3 as an example). At the same time, the required skills and knowledge of the professional standards can be correlated with the disciplines of the educational standards.

This is the first experience for Russian IT business in developing recommendations for the educational community, whereas the international IT business headed by the Association for Computing Machinery (ACM) has been actively involved in this activity for many years [4].

Currently, the recommendations available at www.acm.org/education/curricula-recommendations cover the following disciplines: computer engineering, computer science, information systems, information technology, software engineering, with the update period no longer than five years.

The recommendations include a list of topics, like in Russian FSES for the disciplines of the basic part, as well as student learning objectives achieved by studying these topics.

For example, the learning objectives for the subject "Object Oriented Programming", knowledge area "Programming languages", discipline "Computer science" are recommended to be as follows: to introduce the philosophy of object oriented programming, to define such notions as encapsulation, abstraction, inheritance and polymorphism; to study the issues of program design, implementation, testing and adjusting by using the languages of object oriented programming [4].

Russian higher education internationalization is a relevant issue nowadays. Development of integrated education programs is one of the forms of the process. In this respect, while designing

Table 3.

Professional competencies of degree program "Applied mathematics and informatics" introduced at NArFU	**Job responsibilities of a programmer defined by IT professional standards**
Ability to draw up regulatory and technical documentation as well as reports on a project	to collect and analyze requirements and to create scenarios of product application; to develop different types of software program requirements; to reconstruct requirements with a code during re-engineering; to develop detailed specifications based on high-level specifications according to the obtained requirements; to formalize and control the correctness of the requirements and/or specifications expressed by informal language
Ability to work with multiprocessor computing systems (clusters)	to develop and adjust concentrated, distributed and multithreaded applications
Ability to apply parallel programming by using MPI	
Ability to assess computational complexity and efficiency of parallel solutions	
Ability to test and review code and project documentation to control the project outputs such as quality and functionality	to analyze and optimize code by using tools to enhance product quality and operation performance; to plan testing and to develop testing sets and procedures; to develop and adjust test automation tools for a project; to elaborate and record project and technical documentation in accordance with the assigned task; to review technical documentation
Ability to use basic methods and techniques of software development process	to develop a code of software product basing on given specifications; to adjust the code at module level, inter-module level and the level of interaction with external environment
Ability to use project management tools	to measure software product parameters; to analyze project tools efficiency
Ability to interact with customer representatives or experts in specific subjects	to train and consult the staff
Ability to specify stages and methods of software product development quality management during the entire life cycle of the production	to integrate software components; to test software

the education program of specialty "Applied mathematics and informatics" in the Institute of Mathematics, Information and Space Technologies, NArFU, the following international recommendations (Table 4) were taken into consideration.

Having more intensive interaction with educational institutions, professional communities give their recommendations to the learning outcomes through professional standards, which makes educational programs more open for external evaluation and increases University's responsibility for training quality.

Table 4.

Knowledge areas of ACM	**Curriculum subjects of specialty "Applied mathematics and informatics"**
Discrete Structures (DS)	Discrete mathematics Theory of graphs Finite fields and polynomials Theory of Probability and Mathematical Statistics
Programming Fundamentals (PF)	Informatics fundamentals Programming languages and translation methods Computer Practicum
Algorithms and Complexity (AL)	Algorithms and data structures Basics of cryptography Error control codes Modern crypto-algorithms
Architecture and Organization (AR)	Computer architecture
Operating Systems (OS)	Operating systems Application support in operating systems Systems programming and information security of OS
Net Centric Computing (NC)	Computer network Computer network and network security Parallel programming Parallel programming and information security of distributed information systems
Programming Languages (PL)	Object oriented programming Office programming
Graphics and Visual Computing (GV)	Computer geometry Computer graphics Elements of abstract and computer algebra
Information Management (IM)	Database design and management Databases and their security
Social and Professional Issues (SP)	Business communication Business planning Law Basics of management Business ethics and psychology Psychology of successful career Risk theory
Software Engineering (SE)	Software development technology Software quality management, certification and standardization Project practicum Model and program verification Software testing System and applied software
Computational Science (CN)	Theory of parallel processes Computer modeling Optimization and mathematical methods of decision-taking Linear, discrete and network programming Game theory

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REFERENCES

1. Computing Curricula 2005 [Electronic resource] (CC2005): The Overview Report covering undergraduate degree programs in Computer Engineering… / Assoc. for Computing Machinery (ACM), Assoc. for Inf. Systems (AIS), and Computer Soc. of IEEE (IEEE-CS). – [s. l.], 2005. – 30 Sept. – 56 p. – (Computing Curricula Series). – URL: http://se.hse.ru/data/791/313/1234/CC2005-March06Final.pdf, free. – Tit. from the screen (reference date: 16.10.2014).
2. Federal State Educational Standard Higher Professional Education (FSES HPE) specialty 0104000 "Applied mathematics and informatics (Bachelor's degree)" [Electronic resource] approved by Ministry of education and science of the Russian Federation the 20th of May 2010, № 538 // Russian education: federal education portal – Moscow, 2002–2012. – URL: http://www.edu.ru/db-mon/mo/Data/d_10/prm538-1.pdf, free. – Title from the screen (reference date: 16.10.2014).
3. IT professional standards [Electronic resource] // APKIT: Information & Computer Technologies Industry Association [site]. – Moscow., 2008. – URL: http://apkit.ru/committees/education/meetings/standarts.php, free. – Title from the screen (reference date: 16.10.2014).
4. Computer Science Curriculum 2008 [Electronic resource]: An Interim Revision of CS 2001: Report from the Interim Rev. Task Force includes update of the CS2001 body of knowledge plus commentary / Assoc. for Computing Machinery, and IEEE Computer Soc. – [s. l.], Dec., 2008. – 108 p. URL: http://www.acm.org//education/curricula/ComputerScience2008.pdf, free. – Tit. from the screen (reference date: 16.10.2014).