Methodology for evaluating the focus of educational programs in IT sphere

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Abstract. The growing IT market in Russia challenges the education system, requiring it to train highly qualified personnel who are ready to work in the IT industry after graduation. The article contains a research of educational programs in the IT areas of bachelor’s, master’s and specialist degree, purpose of identifying the focus on the development of professional competencies of an IT specialist. A methodology has been developed for evaluating the focus of educational programs in IT sphere to extend the professional skills of an IT specialist. It includes the research of the share of academic hours devoted to the development of professional competencies, which gives an understanding of the level of graduate's belonging to the IT industry. Results of approbation of method are presented on a basis of educational programs of universities of the Perm region. It's region where the growth of the IT sector market run ahead of the performance for the Russian Federation. The implementation of the methodology will allow comparing the educational programs of different universities, simplifying the assessment and selection process for job applicants and employers. In addition, the methodology can be used by university methodologists to modernization and maintain the relevance of curricula.

1. Introduction

According to the Federal State Statistics Service (Rosstat)¹ the number of organizations in the IT sector of the Russian Federation for the period from 2010 to 2016 increased by 20% and in 2016 amounted to 163 thousand units. The proportion of organizations using information technology in the total number of organizations in the Russian Federation for the period from 2014 to 2017 almost doubled. 6.04% is the share of organizations using information technology in the total number of organizations in the Russian Federation in 2017. These statistics testify to the growth of enterprises in the IT sector of the Russian economy, which in turn challenges the education system to train highly qualified specialists who are ready to start work after completion or while studying at a university [1-5].

Employers, students and researchers in the field of education faced with the problem of the discrepancy between the acquired knowledge and skills in higher education with the tasks that the labor market and the employer require from the graduate [6-9]. A number of researchers study the

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problems of the consequences of the mismatch of skills acquired during studies in terms of earnings, and highlight as one of the ways to solve this problem, the participation of employers in the educational process, which improves the development of professional competencies through education [10, 11]. Other scientists are considering the transition to a competency-based learning system that is optimal for medical education. [12, 13]. Some researchers are implementing their competency assessment systems, developed during training and applied in labor [14]. However, there are a number of scientists determining the development of general cultural competencies over professional [15-18].

One of the main constraints in choosing an educational program by job applicant, when analyzing the formed competencies of a candidate for a position, is the assessment of the education received, the mastered educational program [19, 20]. This problem mainly arises due to the difference in the regulation of educational program standards. Currently in Russia, higher education is regulated by the federal educational standard that prescribes professional, general professional and general cultural competencies developed by a specific educational program. In addition, a number of universities have their own educational standards that govern the developed competencies. Due to the discrepancy between university and federal educational standards for programs, distinction in competencies within the same standard for different educational programs, a universal methodology for evaluating educational programs is needed to determine the focus on the development of professional competencies.

Purpose of the article is to research on educational programs in the IT sphere of bachelor’s, master’s and specialist degree in order to identify a focus on the development of professional competencies of an IT specialist.

Reaching this objective is carried out through the implementation of the following tasks:
- development of a methodology for assessing the focus of educational programs on the skills development of professional competencies of an IT specialist;
- approving the methodology for assessing the focus of educational programs on the development of professional competencies of IT specialists at universities of the Perm region.

2. Methods

Research object was the educational programs of bachelor’s, master’s and specialist degree in IT areas in higher educational institutions (for example, the Perm region).

The methodology for evaluating the focus of the program on the development of professional competencies of an IT specialist contains the following steps:
1. Five groups of professional competencies developed by educational programs in IT areas are grouped into three expanded groups:
   - group 1: competencies of research (experimental) activities (GRC 1);
   - group 2: competencies of design and production and technological activities (GRC 2);
   - group 3: competencies of analytical and organizational and managerial activities (GRC 3).

2. In the curriculum of the educational program, the share of academic hours of disciplines developing the professional competencies of extended groups to the total number of academic hours of the program is determined (share of AH on PC).

3. In the curriculum of the educational program, the proportion of academic hours of disciplines developing the professional competencies of an expanded group is determined.

Research the share of academic hours devoted to the development of professional competencies provides an indication of understanding of the level of graduate belonging to the IT industry:

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2 Federal State Educational Standard for Higher Education (FSES HE 3++) under the direction of bachelor's. URL: http://fgosvo.ru/fgosvo/151/150/24 (reference date 16.09.2019)
3 Federal State Educational Standard for Higher Education (FSES HE 3++) under the direction of master's. URL: http://fgosvo.ru/fgosvo/152/150/25 (reference date 16.09.2019)
4 Federal State Educational Standard for Higher Education (FSES HE 3++) under the direction of specialist degree. URL: http://fgosvo.ru/fgosvo/153/150/26 (reference date 16.09.2019)
- if the share of academic hours for the development of professional competencies is more than 60% of the academic hours of the entire program, then the specialist is trained in the professional knowledge and skills of the IT industry and less attention is paid to the development of general professional and general cultural competencies;
- if the share of academic hours for the development of professional competencies is from 25% to 60% of the academic hours of the entire program, then the program graduates IT industry specialists with uniformly developed professional and general cultural competencies;
- if the share of academic hours for the development of professional competencies is less than 25% of the academic hours of the entire program, then the educational institution prepares specialists of too broad a profile who can work both in the IT industry and in any other.

Research on the share of class hours of an expanded group of professional competencies gives an understanding of the focus of training an IT specialist:
- if a large proportion of academic hours of disciplines developing professional competencies is allocated to the development of the competencies of research (experimental) activities, then the program focuses on training scientists and researchers in the IT industry;
- if a large proportion of class hours of disciplines developing professional competencies is devoted to the development of design and production-technological activity competencies, then the program focuses on training “field” specialists;
- if a large proportion of class hours of disciplines developing professional competencies is devoted to the development of competencies in analytical, organizational and managerial activities, the program is focused on training IT managers.

Restriction on the application of the methodology for assessing the focus of educational programs in IT sphere on the development of professional competencies of an IT specialist is the availability of open access curricula for educational programs and information on the distribution of competencies across disciplines.

3. Results and Discussion
Assessment of the focus of educational programs in IT areas on the development of professional competencies of IT specialists was assessed on the basis of higher educational institutions of the Perm region. This region is chosen as one of the regions with a rapidly growing IT market (from 2010 to 2017, the average number of employees of IT organizations in the Perm Region increased by 12% more than in the Russian Federation). The region also has its own scientific school for the training of IT specialists, that graduates, within the framework of their own enterprises, collaborate with universities and participate in the training of specialists (for example, the Perm Network IT University at the Perm National Research Polytechnic University).

The assessment methodology was carried out according to the educational programs for the recruitment of 2017 of the following universities of the Perm region:
- Perm National Research Polytechnic University (PNRPU),
- Perm State University (PSU),
- National Research University Higher School of Economics Perm (HSE Perm),
- Perm State Agro-Technological University (Perm SATU).

Three universities (PNRPU, PSU and HSE Perm) have their own educational standards, as they are national research universities.

In particular, information on the distribution of competencies by discipline in the curriculum of the Perm branch of the HSE Perm is not available in open sources, so the educational programs of this university were not studied in the framework of this research.

The research found examined educational programs in the following areas of bachelor’s, master’s and specialist degree related to the IT industry:

5 particle. 11 Federal Law “On Education in the Russian Federation”. URL: http://zakon-ob-obrazovani.ru/ (reference date 16.09.2019).
- 02.00.02. Fundamental computer science and information technology;
- 09.03.01. Information science and computer technology;
- 09.00.02. Information systems and technologies;
- 09.00.04. Software engineering;
- 10.00.01. Information Security;
- 10.00.03. Information security;
- 11.00.02. Information and communication technologies and communication systems;
- 38.00.05. Business informatics.

The application of the methodology for assessing the focus on the development of professional competencies of an IT specialist in educational programs of IT sphere of Perm region universities in bachelor degrees is set out in table 1.

Table 1. Assessment of the focus on the development of professional competencies of an IT specialist in educational programs of IT areas of bachelor's education in Perm region

| U               | The heading of educational program                                      | GRC 1, % | GRC 2, % | GRC 3, % | *share of AH on PC, % |
|-----------------|------------------------------------------------------------------------|----------|----------|----------|----------------------|
| PSU Open info systems | 02.03.02 Fundamental computer science and information technology         | 42       | 40       | 18       | 63,1                 |
| PNRPU Automated control and information processing systems | 09.03.01 Information science and computer technology               | 80       | 20       | 0        | 27,7                 |
|                | Computing machinery, complexes, systems and networks                  | 60       | 40       | 0        | 27,3                 |
| PNRPU Information Systems and Technologies | 09.03.02 Information systems and technologies | 38       | 42       | 20       | 38,1                 |
| PSU Information System Security | 09.03.04 Software engineering                                       | 27       | 43       | 30       | 64,9                 |
| Perm SATU Information Systems and Technologies | 10.03.01 Information security                                       | 41       | 59       | 0        | 94,4                 |
| PNRPU Software and information systems development | 11.03.02 Information and communication technologies and communication systems | 53       | 47       | 0        | 23,3                 |
| Perm SATU Software and information systems development |                                                         | 42       | 38       | 20       | 77                   |
| PNRPU Comprehensive security of informatization objects | 38.03.05 Business informatics                                       | 44       | 38       | 18       | 16,1                 |
| PNRPU Communication networks and switching systems |                                                        | 0        | 0        | 100      | 10                   |
| PSU Infocommunication technologies in communication services |                                                      | 26       | 54       | 20       | 63,5                 |

The application of the methodology for assessing the focus on the development of professional competencies of an IT specialist in educational programs for IT sphere of Perm region universities in master's program is set out in table 2.

Table 2. Assessment of the focus on the development of professional competencies of an IT specialist in educational programs of IT areas of master's programs at universities of the Perm region

| U               | The heading of educational program                                      | GRC 1, % | GRC 2, % | GRC 3, % | *share of AH on PC, % |
|-----------------|------------------------------------------------------------------------|----------|----------|----------|----------------------|
| PSU Open info systems | 02.04.02 Fundamental computer science and information technology         | 32       | 34       | 34       | 95,2                 |
The application of the methodology for evaluating the focus on the development of professional competencies of IT specialists in educational programs for IT areas of Perm region universities in areas of specialty is set out in table 3.

Table 3. Assessment of the focus on the development of professional competencies of an IT specialist in educational programs of IT areas of master's programs at universities of the Perm region

| U          | The heading of educational program | GRC 1, % | GRC 2, % | GRC 3, % | *share of AH on PC, % |
|-----------|-----------------------------------|---------|---------|---------|----------------------|
| PSU       | Secure Software Development       | 36      | 31      | 33      | 60,6                 |
| PNRPU     | Providing of information security in distributed information systems | 59      | 41      | 0       | 27,7                 |

* The proportion of hours of disciplines that develop students’ professional competencies to the total number of study hours of the program.

The research revealed that the largest number of educational programs in IT areas of Perm State University (PSU) and Perm State Agro-Technological University (Perm SATU) devotes more attention to the development of professional competencies in academic disciplines than general professional and general cultural ones. Perm National Research Polytechnic University (PNRPU) teaches in IT areas as part of educational programs that uniformly develop professional and general cultural competencies, as well as part of broad-based programs. Details of wide-profile programs relate to educational programs 09.00.01. Computer science and computer facilities, 09.00.02. Information science and computer technology; 09.00.04. Software engineering, 10.00.01. Information Security (table 4).

Table 4. Evaluation of educational programs of universities of the Perm region on the development of professional competencies of IT specialists

| Level of education | The heading of educational program | Evaluation of the programme |
|--------------------|-----------------------------------|-----------------------------|
Bachelor’s
02.03.02 Open information systems (PSU)
09.03.02 Information System Security (PSU)
09.03.02 Information Systems and Technologies (Perm SATU)
09.03.04 Software and information systems development (Perm SATU)
11.03.02 Infocommunication technologies in communication services (PSU)

Master’s
02.04.02 Open information systems (PSU)

Specialist degree
10.05.01 Secure Software Development (PSU)
10.05.03 Security of open information systems (PSU)

Bachelor’s
09.03.01 Automated control and information processing systems (PNRPU)
09.03.01 Computing machinery, complexes, systems and networks (PNRPU)
09.03.02 Information Systems and Technologies (PNRPU)
38.03.05 Business analytics (PSU)

Master’s
10.04.01 Information security complex systems (PNRPU)
11.04.02 Information and communication technologies of a modern city (PNRPU)
11.04.02 Information and communication technologies and city infrastructure networks (PNRPU)

Specialist degree
10.05.03 Providing of information security in distributed information systems (PNRPU)

Bachelor’s
09.03.04 Software and information systems development (PNRPU)
10.03.01 Comprehensive security of informatization objects (PNRPU)

Master’s
09.04.01 Distributed automated systems (PNRPU)
09.04.01 Intelligent systems (PNRPU)
09.04.01 Automation in business processes and financial management (PNRPU)
09.04.02 Information technology and systems engineering (PNRPU)
09.04.04 Software and information systems development (PNRPU)

An assessment of the focus on the development of professional competencies of educational programs, in which the share of academic hours on the development of professional competencies is more than 25%, revealed that there is no focus on the preparation of the IT industry. The highest number of educational programs is focused on the training of scientists in the field of IT and there are a number of programs whose focus is not determined due to the equal shares of academic hours of disciplines of different extended groups of professional competencies (table 5):

Table 5. Assessment of the focus on the development of professional competencies of an IT specialist in educational programs of IT areas of Perm region universities

| Level of education | The heading of educational program | Focus of the education programme |
|--------------------|-----------------------------------|----------------------------------|
| Bachelor’s         | 02.03.02 Open information systems (PSU) | Preparation of the scientists and researchers to the IT industry |
|                    | 09.03.01 Automated control and information processing systems (PNRPU) | |
|                    | 09.03.01 Computing machinery, complexes, systems and networks (PNRPU) | |
|                    | 09.03.02 Information Systems and Technologies (Perm SATU) | |
| Master’s           | 11.04.02 Information and communication technologies and city infrastructure networks (PNRPU) | |
| Specialist degree  | 10.05.01 Secure Software Development (PSU) | |
|                    | 10.05.03 Security of open information systems (PSU) | |
|                    | 10.05.03 Providing of information security in distributed information systems (PNRPU) | |
| Bachelor’s         | 09.03.02 Information Systems and Technologies (PNRPU) | Preparation of the field IT specialists |
|                    | 09.03.02 Information System Security (PSU) | |
|                    | 09.03.02 Information Systems and Technologies (Perm SATU) | |
|                    | 11.03.02 Infocommunication technologies in communication services (PSU) | |
|                    | 38.03.05 Business analytics (PSU) | |
| Master’s           | 10.04.01 Information security complex systems (PNRPU) | |
4. Conclusions
The article contains research of educational programs in the IT areas of bachelor’s, master’s and specialist degree programs in order to identify a focus on the development of professional competencies of an IT specialist. The following results are obtained:

1. Development of a methodology for assessing the focus of educational programs on the skills development of professional competencies of an IT specialist. The methodology includes the study of the share of training hours devoted to the development of professional competencies that allow an understanding of the level of a graduate's affiliation with the IT industry and the focus of IT specialist training.

2. Approving the methodology for assessing the focus of educational programs on the development of IT specialists professional competencies at universities of the Perm region. Educational programs of universities in the Perm region were assessed by the degree of professional competencies development and focus on training an IT specialist.

The implementation of the methodology makes it possible to evaluate the educational programs of various universities that have their own educational standards, making the content of the educational program more understandable for employers and applicants. In addition, the assessment methodology can be used by university methodologists to improve work programs, to increase their relevance, to attract partners to organize the practice of interested enterprises, to increase the demand for graduates in the labor market.

Using the methodology for assessing the focus of educational programs in IT areas on the development of professional competencies of an IT specialist will make the higher education system more understandable for the market, which, in turn, is going to establish communication between business and education and will qualitatively affect the development of the IT industry in Russia.

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