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MODERN APPROACHES TO TEACHING COMPUTER PROGRAMMING TO IT STUDENTS

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Abstract

This paper studies current issues in the development of IT specialists training in the context of the global digitalization of economy. Since Russian universities apply new updated Federal State Educational Standards of Higher Education (FSES HE) that have a framework nature and are based on the occupational standards (OS), it becomes reasonable to implement international standards into Russian training of IT professionals with due regard to the particular nature of a given university. The paper also studies modern IT job market and forecasts demand for various professional competencies of IT graduates among their employers. It is indicated that the selection of a certain occupational standard determines the high quality of a degree program and success in building graduates' career paths. The paper demonstrates current approaches to teaching computer programming in educational institutions offering degree programs in IT. It analyzes the employers' requirements for IT graduates majoring in computer programming and topics of continuing professional education and retraining programs. Moreover, the paper examines PhD papers on teaching computer programming to IT students in the context of a methodical teaching system approach. The analysis shows that modern methodological research pays insufficient attention to the modernization of computer programming teaching in educational institutions of professional education. The study proves that the most relevant for a regional university approach to teaching computer programming to future IT specialists should be based on the advanced training in modern programming technologies, specifically web development.

Keywords: Information technology, computer programming, web development, educational standard, occupational standard, international standards.

1. Introduction

Digitalization of all aspects of human activities is one of the major impetus of the development of modern society and economy.

For Russian economy to maintain its competitiveness in the world, Russian government (2018) has designed and now implements its Digital Economy of the Russian Federation national program (Passport of the national program Digital economy of the Russian, 2018). However, modern labor market lacks programmers and IT specialists necessary to boost and successfully develop digital economy (Russian government, 2018).

For this reason, one of the key components of this national program is Human Resources for Digital Economy federal project designed to train highly competent IT specialists by increasing admission target numbers for IT degree programs in Russian universities.

The development of high-quality IT programs for various economic sectors is a top-priority not only for Russia (Truică & Barnoschi, 2015).

World digital market seeks sound software development and maintenance as well (Stepanova, 2019). Furthermore, researchers say that having professional competencies only is not enough for an IT graduate: employers often complain that young professionals lack communicative skills (Titthasiri, 2017).

More than that, internationalization of higher education – and IT in particular – has become a global trend. Many countries have certain degree programs where not only national language but also English is used as a medium of instruction, whereas insufficient English proficiency has a negative impact on the quality of education (Bradford & Brown, 2018).

IT jobs are ranked among the highest paying ones; and the development and use of information technology is considered to be one of the most stable career paths. The joint research on IT market carried out by Yandex and HeadHunter (Yandex.Practicum and Analytical service HeadHunter, 2019) similarly indicates demand growth for IT professionalse.

2. Problem Statement

Russian and foreign universities face an immediate task of training competent competitive IT professionals. Data provided by websites of major recruitment agencies (HeadHunter, 2020; SuperJob, 2020) prove the pressing demand for web developers.

International labor market demonstrates strong demand for this comptuning occupation as well. This can be illustrated by Information Technology Curricula 2017 (ITC-2017) (Information Technology Curricula 2017, 2017) that shows employment growth and demand for comptuning occupations in IT (See Figure 01).
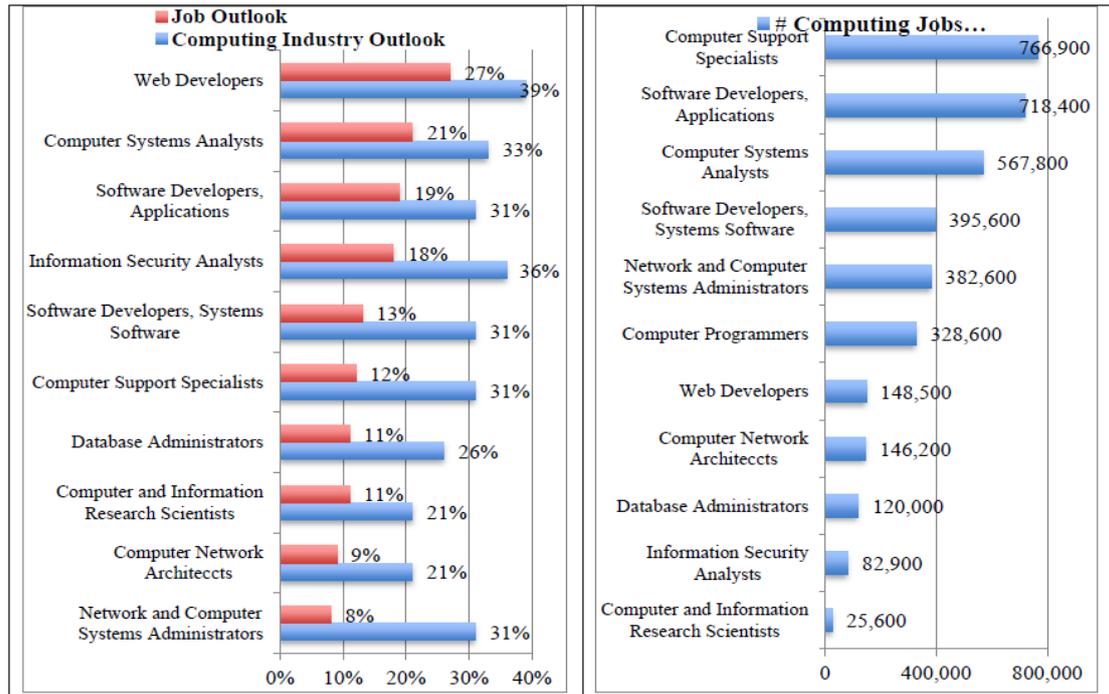
Figure 01. Rating of in-demand IT jobs

The left column of Figure 01 shows computing occupations projected growth for 2014-2024 across all sectors (job outlook), while its right column indicates the number of open positions per each comptuning job as of 2014. Web developer occupation has the most significant change in its rating position and is projected to take the first place in it by 2024 (Information Technology Curricula, 2017).

Modern labor market with its link to global digitalization of economy and social life determines the necessity to change the approach to teaching computer programming and curricula for its degree programs.

Those responsible for the development of IT degree programs should take into consideration the requirements for their quality of all stakeholders. In Russia, curricula for Bachelors' professional training in IT is designed under FSES HE educational standard, occupational standards, the needs of employers, and international requirements for IT degrees.

Updated educational standards for Bachelor's degree programs in Russia have a framework nature and do not describe professional competencies that under the section 3.4 of FSES HE should be developed by the educational institution itself and "is based on the occupational standards (OS), ..., the analysis of Russian and foreign experience, and after consulting with major employers ... in the field" (Portal of Federal state educational standards of higher education, 2020). In Russia, the professional requirements for web developers' training are summarized in the Web and Media App Developer occupational standard (On the approval of the professional standard Developer Web and multimedia applications, 2017). Foreign countries have international occupational standards in IT that include some guidelines for curricular planning, their syllabus, and theoretical and applied aspects of training. Researchers believe that standardization of IT curricula on the international level would enable educators to design high-quality programs that prepare graduates able to compete on the labour market (Karakozov et al., 2019; Sukhomlin & Zubareva, 2016).

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ITC-2017 (Information Technology Curricula 2017, 2017), in the context of the development of labor market in IT, emphasizes the importance of acquiring professional competencies in web development. Yet, in Russia, there is insufficient research on computer programming training in universities, in general, and web development teaching methods, in particular.

Although there exist numerous continuing professional development programs in programming technologies, the authors believe that to prepare competent IT professional, career broadening programs should be based on basic knowledge and skills in the domain of IT, specifically web development.

Ultimately, it is necessary to find an efficient approach to teaching computer programming to future IT specialists in regional universities that should be based on the advanced training in modern programming technologies, web development in particular.

3. Research Questions

The paper analyzes current approaches to teaching computer programming in educational institutions offering degree programs in IT. To identify the most relevant for a regional university approach, the paper studies PhD papers, employers' requirements, students' interviews, and international standards and their guidelines.

4. Purpose of the Study

The overall goal of this study is to identify the most relevant for a regional university approach to teaching computer programming to IT students receiving professional education. More than that, the degree program of a Russian university should be designed in a way to correspond to FSES HE educational standard, occupational standards, the requirements of regional employers, and with due regard to foreign experience of teaching in the same field.

5. Research Methods

The study analyzes the labor market requirements for professional competencies of IT specialists, subjects of continuing professional education and retraining programs being popular in the context of supplementary vocational education as well as different approaches to teaching computer programming that are described in PhD research.

Even though web developers are highly demanded, the Web and Media App Developer occupational standard (On the approval of the professional standard Developer Web and multimedia applications, 2017) is not included in the list of occupational standards necessary to perform professional activities by undergraduates obtaining Computer Science and Computer Engineering degree (an extended group of various majors) (Portal of Federal state educational standards of higher education, 2020).

The occupational standards mentioned in Annexes to Russian federal educational standard for four majors within this extended group include Programmer, IT System Technician, Senior Project Manager in IT, and Systems Analyst occupational standards. At the same time, modern IT labor market makes universities take into consideration the Web and Media App Developer occupational standard (On the approval of the professional standard Developer Web and multimedia applications, 2017).

In fact, professional competencies of students should be based on general job functions and functions stipulated in the corresponding occupational standard. If a degree program is made without regard to the certain occupational standard, graduates will lack necessary professional competencies, meaning that a young professional has to acquire required knowledge and skills by attending some programs and courses in the context of supplementary vocational education.

In light of increasing demand for web developers, major Russian universities (Center for continuing professional education of Saint Petersburg national research University, 2020; Specialist training Center at the Bauman Moscow state University, 2020) and IT companies offer some new services and design continuing professional education and retraining programs, including online courses. More than that, online education is becoming increasingly popular worldwide. Referring to the views of Pekker (2016), Russian e-learning market has a great potential for its vast territory and large population. Yet, the question of whether online courses are similarly effective as in-person classes has caused much debate (Donald, 2016). Researchers try to evaluate the quality of massive open online courses MOOCs (Stracke, 2015) and discover why e-learning might fail (Onah, Sinclair, & Boyartt, 2014).

Russian online recruitment company HeadHunter (Analysis of the Russian market of online learning, 2018) studied Russian e-learning market and found out that one of the most popular online course topics included IT and was chosen by 23% of interviewees.

The data gathered by EdTech (Online learning market research 2020, 2020) showed that most interviewees when asked about their learning goal mention that "they want to learn some practical skills," i.e. the emphasis was on practice and soft skills.

In the context of the digitalization of modern society, many universities, retraining centers, and large companies develop and run online courses in computer programming for both IT novices and those with the degree in it, with web programming being one of the most popular ones. For instance, online courses in this topic are offered by Mail.ru Group, GeekBrains, Yandex (Yandex.Praktikum), Netology-grooup, SkillBox, etc.

As mentioned above, within the guidelines stipulated in international standards, web development is one of the most significant areas of modern programming technologies. ITC-2017 (Information Technology Curricula 2017, 2017) suggests IT domains to be included in IT curricula and emphasizes the importance of Web and Mobile Systems domain that should be both essential and supplemental. The results of ITC-2017 (Information Technology Curricula 2017, 2017) study demonstrate that leading IT companies and faculties consider Cybersecurity, Cloud Computing, and Web Systems domains to be the most significant ones. Employers suggest that web development skills are top skills in demand (see Figure 02.).

Technical Skills	Needed at Company
Security	40%
Database/Information management	38%
PC support	36%
Storage/Backup	33%
Networks	31%
Cloud architecture	29%
Telecommunications	27%
Web development	27%
Server/Datacenter management	27%
Mobile device support	24%
Application development	23%
Big Data tools/analytics	23%
Virtualization	21%

Figure 02. Rating of in-demand IT skills

For this study, a questionnaire survey was conducted to collect students' opinions – who are the educational service consumers – on the significance of professional competencies in web development in 2020. Respondents included 209 senior students from three regional universities offering degree programs in IT: Nizhnevartovsk State University (144 students), Chechen State Pedagogical University (46 students), and Liepaja University (21 students). In average, 70% of respondents answered that they planned to pursue their careers in web development. However, 57% of respondents felt the need to improve their knowledge and skills in this area and believed that it should be included in their curricula, while 8% of students suggested that supplementary vocational education might allow someone to become a successful web developer. To summarize, students expressed interest in developing web programming skills.

Further, let us consider various approaches to teaching programming illustrated in PhD papers on theories and principles of IT teaching published by Russian scholars.

The development of programming skills is essential for IT professionals' training, while high quality development of necessary skills in the context of professional education is related to a number of issues having been studied for many years. To clarify, let us briefly describe recent PhD papers in this field, with the components of Pyshkalo's methodical teaching system approach (Pyshkalo, 1975) being at the forefront.

Kugel (2015) in his research highlights that current teaching methods are not effective enough and graduates lack competencies to formulate and perform professional tasks independently and with due regard to their customers' requirements. To eliminate the problem, the scholar suggests using system-algorithmic approach.

Kalitina (2015) in her research accentuates the absence of science-based methods of computer programming teaching that should develop cognitive abilities of students following their core curriculum.

In response to the issue, the scholar suggests developing students' "software-algorithmic competence", an integrated concept defined by the author herself.

Shkarban (2018) discovers that methods of visual learning environment usage in teaching object-oriented programming (OOP) are not established enough. To increase the effectiveness of training, the scholar suggests considering object-oriented programming to be essential in bachelor's core curriculum.

Yet, current PhD papers on computer programming training mostly focus on algorithm development and object-oriented programming teaching, while the web development one is practically ignored.

The analysis reveals that researchers mainly suggest changing the components of methodical teaching system approach, namely methods and techniques of teaching, whereas the curriculum of a degree program is rarely discussed.

6. Findings

For having less resources, regional universities find it more difficult to respond to the fresh challenges that modern system of education faces. In order to train competent demanded professionals who have the skills required for modern IT field, it is necessary to use some approaches based on the advanced training in the fastest growing IT services. This study suggests using the approach centered around the advanced training in web development.

The advanced training means teaching modern programming technologies – specifically web development – in a way that corresponds to the requirements of modern labor market, international IT curricula standards and their guidelines as well as the current theories and research in computer programming teaching. Furthermore, it is provided on every stage of a degree program: from the curriculum development to the assessment of student competencies. Purpose statement and syllabus design in web programming is at the forefront of this approach. The development and implementation of the approach and its stages are described below.

The stage of design of a principal professional educational program: the enumeration of professional competencies of a graduate, curriculum drawing, the distribution of credits/hours per subject, and scope and sequence documents drafting. To design a curriculum and state purposes of web programming teaching, it is necessary to analyze the requirements of Federal State Educational Standards of Higher Education, occupational standards, regional employers, and international IT curricula standards; to conduct questionnaire surveys and interviews with employers; to study statistics and jobs and vacancies posted by leading recruitment agencies; to evaluate programs offered by retraining centers, including massive open online courses; to examine approaches to teaching computer programming described in scientific research; to study the experience of teaching web programming in Russian and foreign universities; and so on. At this stage, it is possible to increase the number of hours/credits per course required to acquire web development competencies and to add some elective courses that might improve students' knowledge and skills in new technologies (specifically web development). Practical training should also be updated, with tasks on web technologies implementation being added.

The stage of implementation of an educational program: modern approaches and methods of teaching web programming, including e-learning, are used. The representatives of regional employers competent in web development are invited to teach.

The stage of assessment of student competencies in web programming: students are asked to defend their projects to regional employers who carry out independent objective assessment of the professional competencies being acquired.

7. Conclusion

By analyzing the job market, employers' requirements for necessary professional competencies, international curriculum guidelines for baccalaureate degree programs in IT, and scientific research in computer programming teaching, the authors indicate that the most relevant for a regional university approach to teaching computer programming to IT students should be based on the advanced training in modern programming, specifically web programming. In addition, the paper describes the development and implementation of the approach and its stages and introduces the concept of "advanced training in web programming". The intent of this approach is to improve degree programs in IT and to have students develop competencies, so they can achieve professional success in their future careers. Finally, this approach will also prove effective if it is implemented in the context of secondary vocational education.

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