Secondary vocational education for IT-industry personnel training: achievements and prospects

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Abstract. The article explores the problem of personnel training for the IT-industry in the secondary vocational education system based on both the statistics analysis and national experience; determines the main trends and the reform outcomes; identifies the best practices for training and potential strategies as well. The conclusion emerges that the secondary vocational education is becoming increasingly important as a part of the lifelong learning strategy. Personnel training for the IT-industry under the incredibly accelerated technological changes requires the same rapid adaptation, combinations of high cost-effectiveness and training flexibility, traditional and advanced training aids, extensive use of the most sophisticated information and communicative resources, formation of not only professional competences but spiritual and personal qualities of the future specialists, creation of conditions for self-development and self-improvement. In this context, the need for the use of the best national and global training practices adapted to the Russian environment has been emphasized in the paper. The current experience analysis has shown that the extensive interaction between business and educational institutions would ensure the formation of staff capacities for high-tech companies.

1. Introduction
The skilled staff training system, capable of adjusting to both rapidly changing realities and employers’ needs-demands is becoming crucial in technology race. 63 % of Russian enterprises embarked upon digital transformation programs in 2017-2018. However, in early 2019 human resource gaps in Russia’s technological area was estimated at 1 million people [1].

Achievement of expectations in the framework of Digital Economy Development Strategy depends largely on the expertise level of personnel in the IT-field. According to the Internet Initiative Development Fund (IIDF) estimates, another 2 million specialists will be required in the coming decade [2]. Moreover, companies in all economy sectors are now seeking after IT-professionals. The demand has increased not only for programmers. Nowadays employers need employees having the skills to implement and operate digital technologies successfully. To ensure high quality of training to graduates in the respective majors within the secondary vocational education (SVE), as well as exploring the progress, revealing issues and problems emerged are topical.

2. Materials and methods
The personality and activity theory, general theory of lifelong learning presented in the writings of S Batyshiev, B Gershunsky, G Ibragimov, A Novikov, N Chapaev, et al. have served as a theoretical and methodological background to the present research. Furthermore, such foreign scholars as R Dave (India) [3], D Kidd (Canada) [4], etc. contributed significantly to the development of the lifelong
learning theory. Of great importance were also ideas on theoretical background for the lifelong learning computerization, operation of educational and information technologies set out by P Galperin, N Astafjev, V Razumovsky, M Chvanova, A Denisova, V Slastenin and others.

L Anischeva, O Arefjev, V Gusev, L Elagina, O Nazarova, V Suvorov et al. explored various aspects of building up crucial professional competences when learning within SVE system. However, primary trends and search of new forms in the course of optimization of skilled personnel training for IT-industry have not become the subject of the special investigation.

The choice of the research methods is determined by its goal and objectives. We have used both theoretical (analysis and synthesis, comparison, generalization, simulation, comprehensive approach) and empirical (studying pedagogical experience, pedagogical experiment, Delphi method) ones together with the Statistical indicator technique, methods of absolute, relative, average values as well as the information visualization.

3. Results

According to the statistics as of 1st of October, 2019, there were 3 119 688 students in the RF system of secondary vocational education. 222 051 persons were trained on Informatics and Computer Science and Information Security majors, which was 7.1 per cent of the total number of students in the secondary vocational education institutions. 76 063 people were enrolled in the first-year to be trained under these majors with the number of graduates being 38 855 (see the tables below) [5].

**Table 1.** Distribution of students admitted to educational institutions performing education activities under secondary vocational education curricula by enlarged groups of specialties/professions (as of October, 1 2019) (Regardless of organizations under the supervision of the Federal Penitentiary Service of Russia).

| Indicator name | Total    | By full-time training | By training programs for skilled manual and office workers | By training programs for mid-level specialists |
|----------------|----------|-----------------------|----------------------------------------------------------|---------------------------------------------|
| Total          | 1 042 137| 910 623               | 209 711                                                  | 832 426                                     |
| Informatics and Computer Science | 70 682   | 67 854                | 7 950                                                    | 62 732                                      |
| Information Security | 5 381   | 5340                  | 0                                                        | 5 381                                       |

**Table 2.** Distribution of student enrollment of educational institutions pursuing education activities under secondary vocational education curricula by enlarged groups of specialties/professions (as of October, 1 2019) (Regardless of organizations under the supervision of the Federal Penitentiary Service of Russia).

| Indicator name | Total    | By full-time training | By training programs for skilled manual and office workers | By training programs for mid-level specialists |
|----------------|----------|-----------------------|----------------------------------------------------------|---------------------------------------------|
| Total          | 3 119 688| 2 674 145             | 543 445                                                  | 2 576 243                                   |
| Informatics and Computer Science | 206 956 | 197 726               | 18 851                                                    | 188 105                                     |
| Information Security | 15 095  | 14 959                | 0                                                        | 15 095                                      |
Table 3. Distribution of graduates of educational institutions performing education activities under secondary vocational education curricula by enlarged groups of specialties/professions (as of October, 1 2019) (Regardless of organizations under the supervision of the Federal Penitentiary Service of Russia).

| Indicator name               | Total   | By full-time training | By training programs for skilled manual and office workers | By training programs for mid-level specialists |
|------------------------------|---------|-----------------------|----------------------------------------------------------|-------------------------------------------------|
| TOTAL                        | 705 293 | 599 449               | 165 466                                                   | 539 827                                          |
| Informatics and Computer Science | 36 810  | 35 130                | 6 519                                                    | 30 291                                           |
| Information Security         | 2 045   | 2 030                 | 0                                                        | 2 045                                            |

Thus, the above data illustrate that IT-professions and specialties acquired within the SVE system are reckoned as the most popular among SVE institutions’ applicants. In this regard the spectacular dynamics of students number to be trained under the Informatics and Computer Science programs over 2015 – 2018 period is rather indicative (see figure 1) [6].

![Figure 1](image URL)  
*Figure 1. Number of students in state SVE institutions under various Informatics and Computer Science training programs (thousands of people).*

The determinants of such extensive growth are: an increased government order for training IT specialists, entry into adulthood of the so-called Generation Z not familiar with the life “before the Internet”. Besides, in the labor market a significant interest is drawn to such IT specialties as Information Systems (by fields) obtained within SVE system (graduates occupy positions of computer operators and production equipment engineers and having gained certain expertise and skills can work as IT systems administrators). Specialists in Information Security of Telecommunication Systems and Information Security of Automated Systems are involved in the assessment of draft technical specifications, plans and work schedules on technical information protection, etc.; “Information security
organization and technology” technicians can work in production enterprises, scientific institutions and finance as well. We cannot but mention that the demand for IT security experts is increasing each year. Computer Networks is one of most-in-demand specialties in Russia. Graduates who have mastered it can work as computer networks service engineers providing for due operation of LAN’s hardware and software in offices and enterprises. Computer Systems and Complexes, Computer Systems Programming specialties are also much sought after. A software technician with sufficient qualifications and working experience, after taking up related professions or after re-training (systems analyst, IT systems administrator, web designer) is highly sought after [7].

According to statistics the most numerous student enrollment in SVE under the training programs for skilled manual and office workers falls on Master in Digital Information Processing curricula (13.9 thousand people or 75.3 % of the total number of students in these programs). By training programs for mid-level specialists under Programming in Computer Systems curricula this number includes 50.9 thousand people or 30.3 % of the number of students in programs for mid-level specialists) [6].

Specifying the recent trends in the field of training specialists for IT-industry and the results of its restructuring makes it possible to state that the Russian Federation has taken considerable efforts in order to ensure conformity of educational programs to the requirements of the digital economy.

So, new educational standards have been approved for most in-demand IT-proфессии on the labor market. Their key points are commitment to cutting-edge technologies and professional standards, prominent practice-oriented training process, updating of requirements for training aids and facilities, implementation of a demo exam. At present, it does not seem feasible to ensure high-quality education without ongoing re-training and improving teaching staff competence. Over the last 3 years, 27.5 thousand teachers have upgraded their skills under training programs in the ICT field that accounts for 17.4 % of the total number of academic staff in SVE institutions. Moreover, the recent years’ trend represents the growing interest in this type of educational programs.

Key priority in enhancing skilled IT specialists training is provision of the learning process with the up-to-date physical infrastructure. In this field, positive developments have been also identified. Compared to 2016, the number of PCs in colleges and technical schools, including those used for the educational purposes, has increased by 11.5%. In 2018, there were 187 PCs per 1000 people, while in 2016 – 177, with 76 % of these having the Internet access [6].

Active interaction between educational institutions of vocational training and special organizations and enterprises is of crucial significance for ensuring the quality of personnel training for the IT-industry. The RF President V. Putin specified this factor as essential for further SVE reform strategy: “Together with the enterprises, a significant step forward has been taken in the development of dual education, where both training and practice are closely integrated. It is becoming more and more common for businesses to provide patronage to vocational colleges and technical schools and actively participate in organizing labor occupations competitions under the World Skills standard. It is important to use the accumulated experience and methods to make sure that our entire training system meets, or better yet, sets high international standards taking into account the global technological changes” [8].

Meanwhile, in May 2019, the participants of the business program in the final of the national championship "Young professionals" noted that nowadays technologies are developing very quickly and more and more competencies related to digitalization are emerging. Therefore, colleges’ equipment and technical facilities require annual upgrading. A. Doskanova, Deputy Director General of “WorldSkills Russia”, also highlighted the need for annual updating of standards. Currently, WorldSkills experts define the future in-demand professions followed by competence determination. Then the relevant skills are specified and tested at the championship competition in order to master it. This format of this kind allows presenting the best practices for their further replication.

Studying the main trends, we would also like to outline that educational institutions do not tailor enough to the employers’ demands, 90% of which continue to claim that young people lack both practical skills and work experience [9]. A more effective approach nowadays for the companies is to be directly involved in the training process that is in determining not only the list of disciplines and the required competencies formation, but also send practitioners to colleges and technical schools to provide
on-the-job training for selecting personnel already in training process. Experience has shown that only continuous and extensive interaction between business and educational institutions will ensure the formation of the human resource capacities for high-tech companies.

The modern system of vocational education should be flexible, provide for various forms and terms of training, carry out not only training of school leavers, but also be engaged in re-training professionals. Meanwhile, educational institutions’ early century certain lagging behind the business needs has resulted in creation of its own education systems. Therefore companies are currently using either their own corporate training or re-training systems still being in their infancy in our country, or third-party organizations to form the required competencies. As early as 2015, the US companies spent about $ 70 billion on corporate education. In the Russian Federation today this figure varies from 40 to 70 billion rubles, according to various sources. Experts’ assessment of the results of such training is mixed. A method combining these approaches is more common. The Seversky Pipe Plant and Polevskiy multidisciplinary vocational college named after V. I. Nazarov can serve as examples of such dual training. Built as part of the target development program, the training site allows students to acquire practical skills in industrial automation field and program logic controllers [1]. In addition, college teachers have the possibility to intern in the employer's organizations, and employees of the company are given the chance to improve their skills at the educational institution. Kaluga Technical College is also an example of interaction between business and education system. In 2014, this educational institution signed an agreement with “Kaluga Astral”, a company specializing in personal data protection, e-document management and so on, as a part of the Federal project "Optimization in the System of Training Skilled Workers and Mid-level Specialists by Introducing Dual Training Elements into the Educational Process". Practitioners serving as teachers, without any doubt, strengthen the practical aspect of the educational process. Colleges add modules of elective disciplines to curricula, in response to the employers' wishes. There are certain topics, which students can master enterprise-based. “Kaluga Astral” supplies each college student with high-tech equipment. The fact that students have the opportunity to work in the company for the entire period of study, receiving 50-70% of the average employee salary deserves special attention. They become full-time employees being 3rd year students. The employers are also involved in the final examination of graduates, which is carried out in the form of individual project presentations. The College also provides intense cooperation with the Kaluga company "Kamin", which specializes in the development, implementation and maintenance of projects in the field of production companies automation based on the system "1C: Production Enterprise Management" [9].

One of the latest trends is that companies choose to invest more and more efforts and money not in the traditional system of education, but in modern training methods: the use of various visualization methods, simulators based on VR and AR technologies, distant training, etc. The most effective formats include a mentoring system and the use of game-based approaches. The participatory approach allows not only transferring certain information, but also paying more attention to the industry specialization as well as developing soft skills: time management, communication skills, which are now in high demand among employers.

Targeted recruitment for training is one way to implement this approach. However, monitoring data reveal extreme lack of interaction between employers and educational institutions. In 2018, the percentage of students learning under targeted contracts was 1.8 % of the total number of mid-level specialists-graduates trained in "Computer Science and Engineering" field of study. Similar trend is alarming, as it could lead to a decline in training quality. It is educational institutions, which have experience and concepts in the field of data mining, machine learning and artificial intelligence related to education, are able to provide not only professional, but also socio-liberal and natural science training. One of the problems having been monitored deals with a relatively low level of employment among graduates trained under the Computer Science and Engineering field of study, compared to the graduates of other professions representing slightly more than 60% in 2018. However, it is primarily due to the desire of almost every fourth graduate in this professional group to continue their studies at university [6].
4. Discussion

The analysis of scientific literature on the topic of the research has shown that in recent years the authors took a considerable interest in the problems of IT specialists training at tertiary levels of education [10], modernization of the system of vocational training in general [11, 12]. At the same time, the research of the problem proves that continuous, comprehensive, multi-level and multi-disciplinary personnel training increases greatly the importance of secondary vocational training as a part of the system of educating specialists for the IT-industry. However, only a few Moscow colleges of information technologies, the Ufa College of Statistics, Informatics and Computer Science as well as the Rostov-on-Don College of Communications and Informatics have earned high expert appreciation [13]. We believe that special research related to the improvement of the quality of personnel training for the IT-industry is required as well as positive experience dissemination over the regions. In particular, launching the training program "Applied Informatics" makes it possible to meet the labor market needs for specialists in information systems operation, their implementation and maintenance. The experience of MIREA - Russian Technological University that has the college in its structure and whose leavers are the "Golden Fund" for training highly qualified specialists, is worth studying and adopting by Russian universities.

Experts in the field of IT technologies rightly believe that there is a good reason in taking a gap in the continuous process of professional training, as it allows the learners to not only acquire practical skills, but also to evaluate future industry development and choose their own professional development trajectory. Such training involves first developing programming skills. After getting employed and gaining 2-5-year hands-on experience in programming, which involves participation in projects, trainings courses and so on, a programmer has the opportunity to continue their education and become a project manager. The effect of rapid obsolescence of the knowledge obtained requires fractional training cycle, which means that encoders and testers (who are on-fire) receive training in colleges within universities for not more than 2-year period, studying the same disciplines as bachelors, but on a smaller scale.

5. Conclusion

Thus, secondary vocational education is becoming increasingly important as a part of the lifelong learning. Training specialists for the IT-industry in SVE in the environment of incredibly accelerated technology changes requires an equally rapid adaptation to them, a combination of high economic efficiency and flexibility of the education process as well as traditional and newest methods of education, greater use of the advanced information and communication resources. Besides, focusing on professional competences, spiritual and personal values training for future specialists and creation of opportunities for their personal development and self-improvement are of importance too. In this context, we need to use the best national and global training practices while adapting to the Russian environment.

The problem research allowed us to identify a number of the most significant factors that determine the current situation on the IT labor market:

- Rapid expansion of ICT use
- Regular updating of training content, aimed at acquiring creativity, necessary skills for solving interdisciplinary tasks and problem situations;
- Developing the willingness of self-realization and lifelong learning, as well as the desire to enhance knowledge in the field of advanced technologies, master foreign languages and so on.

The entire learning cycle correlation with the rapid changes in IT-industry is quite the challenge to be met quickly, because IT is the field where new technologies and approaches emerge every 10 months. The way from a concept to mass production takes an average of three years and every 5 years hardware platforms and operating systems change.

Analysis of the experience available has shown that only extensive interaction between business and educational institutions would provide the formation of human resources pool for high-tech companies.
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