Actual problems of modern software engineering

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Abstract. The article discusses some pressing issues of training specialists in the field of software engineering. The characteristic problems of this scientific field are presented. The main standards, methodologies and training programs for software engineering specialists are briefly described. Based on the statistical data for 2019, the place of the programs 09.03.00 and 09.04.00 in the educational structure of the Russian Federation and the Krasnoyarsk Territory is shown. The problem of reducing the gap between the formation of software engineering and the requirements of the IT industry is considered.

1. Introduction
For modern Russia, one of the priority areas is the transition to an intensive, advancing development path. One of these tasks is the task of training qualified personnel in various fields of production.

The solution to this problem should be the reform of the education system. The education system must promptly respond to the demands of the labor market and provide training for highly qualified specialists in demand.

Progress in software engineering over the last 50 years has been astonishing. More than fifty years have passed since the introduction of the concept of software engineering. Today we do not think our societies without using software for various fields of human activity. The Internet, any area of production and social services are not complete without the use of software.

Software engineering provides processes for the development, maintenance and liquidation of software. The outcome of software engineering is an efficient and reliable software product.

Software engineering is characterized by activities based on the following principles [1]:

- development of only effective solutions that meet specified requirements;
- creation of practical solutions to customer requirements;
- creating solutions based on knowledge and techniques of modern fundamental technologies;
- development of projects based on accumulated experience;
- mandatory maintenance and decommissioning of software products.

Thus, software engineering specialists span the entire software life cycle.

A feature of this profession is that software developed according to the requirements is subject to modification or complete processing when new technologies appear.

And this is one of the main problems of software specialists.
2. Formalization of software engineering
The software industry is growing rapidly. Standards, methodologies, standard training programs have been developed. The most famous documents in this area are:

- the key knowledge requirements for systems engineering (SEBOK). This is a constantly updated product. It also provides examples of successful large-scale projects;
- the body of knowledge is presented in the form of the standard ISO / IEC TR 19759: 2005 SWEBOK (Software Engineering Body of Knowledge). It is a guide to the body of knowledge in software engineering, which defines and describes the areas of knowledge required by a software engineer;
- the methodology for describing the life cycle of a software product by domestic standards of different generations (ISO/IEC 12207:2008, ISO/IEC/IEEE 29148-2011);
- requirements for an automated system in accordance with GOST 34.602 and requirements for project management in accordance with GOSTR 54869-2011;
- a set of rules and procedures designed to build a functional model of an object of any subject area (SADT Methodology);
- recommendations for performing systematic literature reviews on software engineering in the form of SLR (Systematic Literature Review) or SMS (Systematic Mapping Study);
- typical curriculum (Curriculum) for various levels of training of software engineers (SE 2004, GSwE).

In particular, the paper [2] describes the experience of introducing a undergraduate in software engineering at the Stevens Institute of Technology, based mainly on the latest recommendations of ACM and IEEE-CS.

A joint project of nine universities and four industries (IT SPIRAL) was developed to create a common curriculum for training in software development [3].

In [4], the results of a study on software engineering based on scientific English-language library publications (IEEE Xplore, ACM Digital Library, SpringerLink, and ScienceDirect) are presented. It was revealed that the main attention of researchers is paid to innovative teaching methods, the curriculum and the formation of competencies.

Despite some successes achieved by software engineering at the present stage of development, the specialist training in higher education institutions often does not meet the requirements of customers.

Should higher education be tied to the profession?

In [5], it was noted that in conditions of free employment and when choosing a future profession, higher education of a narrow professional orientation can lead to unemployment. The very idea of the interdisciplinarity of higher education educational programs denies the concept of narrow-profile departments and contains the danger of substituting higher education for teaching a particular profession.

The level of education is determined not only by specific knowledge, but also by the ability of the graduate to self-development, retraining, development and acquisition of new skills.

As rightly noted in [6], in a market economy, a graduate should be considered more realistic as a "semi-finished product, not a product." In this case, the difference between the competencies of a professional and a graduate is perceived as inevitable [7]. Therefore, the problem of the adequacy of the quality of university training must be moved to the field of search for new organizational forms, educational technologies.

3. The place of undergraduate programs on 09.03.00 and master's programs on 09.04.00 in the Russian education system
Based on the developments of the Federal state statistics service and the Institute for statistical research and knowledge Economics Of the national research University Higher school of Economics, we will
consider statistical data on students programs training. These data refer to students studying in state and municipal higher education institutions of the Russian Federation on a full-time basis.

By the number of budget places for 283 undergraduate and specialty programs in 2019, the software engineering program was in 18th place (figure 1). In terms of the number of applications submitted for this area of preparation, the competition as a whole in the Russian Federation amounted to more than 6 people per place.

![Figure 1](image1.png)

**Figure 1.** Distribution of undergraduate and specialist training programs depending on budget places in the Russian Federation in 2019.

For comparison, the rating on the number of budget places in the Russian Federation in the field of software engineering is increasing: in 2018 it amounted to 20th place, in 2017 - 29th place, in 2016 - 50th place.

For the Krasnoyarsk Territory in the direction of preparation 09.03.00 for 2019 (figure 2 a) it follows that in the direction of 09.03.04 the smallest number of budget places is allocated. The same trend is typical for the Russian Federation as a whole (figure 2 b).

![Figure 2](image2.png)

**Figure 2.** Data on the number of budget places for the enlarged group on 09.03.00 Krasnoyarsk Territory (a) and Russian Federation (b) in 2019.
For the direction of the master's programs, it should also be noted that software engineering is a fairly demanded specialty (figure 3).

![Figure 3. Distribution of master's programs by the number of accepted applicants (thousands of people) in the Russian Federation in 2019.](image)

It is also characteristic of master's training programs that the leading direction is 09.04.01 computer science and computer engineering (figure 4).

![Figure 4. The distribution of admission (thousands of people) in the areas of preparation of master's programs on 09.04.00 in the Russian Federation.](image)

The structure of specialists in software development and analytics by group of classes and skill levels in 2018 (as a percentage of the number of employees in the corresponding group of classes), according to [8], indicates the demand for specialists in software engineering (figure 5).

![Figure 5. Software and application developers and analysts.](image)
4. Conclusions
Specialists in the field of software engineering are in demand in the labor market. Over the past few years, a significant breakthrough has been made in the field of standardization, unification and formalization, methodological aspects of this field of knowledge. Today, there is a gap between the software engineering education system and the requirements of the IT industry. This gap exists due to high demands from industry and practical experience, confidence of graduates.

As recommendations in the preparation of curricula and organizational work for the direction of training in software engineering, the following points should be considered.

It is necessary to determine the main competencies that would cover the requirements of the standards of SWEBOK, SEBOK, etc., be guided by the needs of the regional labor market, employment data.

Classical lectures should be replaced or expanded to develop or discuss software projects. New forms are needed: rethinking the practical component of the educational process and shifting this emphasis to real production. It is necessary to create specialized platforms, graduate certification centers, the introduction of professional accreditation of educational programs.

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