Training of teachers for engineering education in Russian schools

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Abstract. For the scientific and technological development of the Russian Federation, it is necessary to train personnel since school days. With this approach to engineering education, the training of highly qualified teachers becomes especially relevant. These “technology teachers of the XXI century” should not only be motivated to work with students, but also demonstrate modern digital, engineering and technological competencies. The following research methods were used: analysis of scientific papers on the problems of engineering education in schools; the concept of teaching the subject area "Technology" in Russian schools that implement the main general education programs, the latest educational and methodological complexes for technology; analysis of the legal framework and systematization of the leading normative documents determining changes in the professional and pedagogical education of technology teachers; analysis and generalization of the author's experience in the development of basic professional educational programs; pedagogical experience in training future technology and informatics teachers, as well as experience in teaching technology to schoolchildren; analysis of the impact of digitalization of education and professional activity on the transformation of the ways of their implementation, as well as the processes of interpersonal interaction and professional identification; diagnostics according to L.B. Schneider "Professional Identity", questionnaires and descriptive statistics; generalization and interpretation of research results. A detailed analysis of psychological and pedagogical research, regulatory documentation in the field of technology education allowed the authors to identify the main conditions for the training of technology teachers for the implementation of engineering education in secondary schools in Russia.

1. Introduction
Scientific and technological progress requires trained creative engineering personnel. For the effective selection of such personnel, training must begin at school. At the same time, the terms of job orientation for schoolchildren are significantly shifted. It is important not only to give a vivid description of the importance of the engineering profession, providing illustrative examples of the fact that most of the things that surround people today and have qualitatively changed the life of human civilization (buildings, transport, communications, gadgets, etc.) were created thanks to engineering and technical developments but it is essential to involve learners in real design and technological activities, to implement engineering education in schools on the basis of a system-activity and practice-oriented approaches. Only by doing project work, learners will be able to consciously choose engineering specialties for their professional future. At the same time, engineering education in schools should be
certainly carried out using the most modern equipment, digital devices, information technologies, robotics, etc. Therefore, one of the pressing issues in this regard is: “How to reform the existing technological education in schools so that it becomes really engineering?” Indeed, the education system has always been distinguished by some inertia. All the changes taking place in society, only after some time were reflected here in the form of various reforms. However, the changes taking place today associated with digitalization are so revolutionary and rapid that one cannot wait with the transformation of technological education; otherwise our country will remain at the sidelines of global technological advances. Peculiarity of the school subjects “Technology”, which distinguishes it from the disciplines of the humanities cycle, is that it is not enough only to modernize the teaching methodology and familiarize future teachers with it. The whole difficulty lies in the need for a versatile technical training of teaching staff. A technology teacher of the XXI century is not just a teacher who knows how to teach technology, but is, first of all, a specialist with digital and engineering competencies, who is able to organize the project activities of engineering students on a base of modern equipment (3D modeling, 3D printing, robotic devices etc.). At the same time, the academic subject “Technology”, in its existing “outdated” form, is perceived by the teaching community, schoolchildren and their parents as insignificant. This, in turn, leads to the fact that the prestige of the profession of a teacher of technology is decreasing, and in recent years there has been practically no competition for this profile in pedagogical universities. It turns out to be a vicious circle. Consequently, the training of teaching staff for engineering education in general education schools is today a very pressing problem.

2. Materials and methods

The theoretical and methodological basis of the research is the system-activity, competence-based and practice-oriented approaches; the concept of changing information revolutions and technological structures, provoking comprehensive socio-economic, social and cultural changes affecting the life of each individual. Modern society is characterized by going through the information revolution, called digitalization, as well as the transition to a new technological order associated with the global transformation of the labor market, the content of the professional activity itself, the nature and conditions of work, the achievements of science and technology and the changes following them in production technologies [1].

In the course of the study, the authors used such methods of theoretical and empirical research as analysis of the scientific papers of national and foreign scientists and teachers on the problems of engineering and technological education; analysis of the existing state of the technological education system in the Russian Federation, the concept of teaching the subject area “Technology” in educational institutions of the Russian Federation, implementing the main general education programs, educational and methodological complexes in the subject field "Technology" from the standpoint of digital transformation of education (authors S. A. Beshenkov, V.M. Kazakevich, D.G. Koposov, G.V. Pichugina, G.Yu. Semyonova), analysis of the legal framework and systematization of leading normative documents determining changes in vocational and professional education in our country as a whole and in the subject training of technology teachers, in particular Presidential Decree "On national goals and strategic objectives of the development of the Russian Federation for the period up to 2024", national projects "Education", "Digital Economy", Federal State Educational Standard of Higher Education majoring in 44.03.05, 44.03.01, 44.04.01 "Pedagogical education"; analysis and generalization of the author's experience in the development of basic professional educational programs for the directions of training bachelors (profiles "Technology. Informatics"), master’s degree students; pedagogical experience in training future technology and informatics teachers, as well as experience in teaching technology to schoolchildren; analysis of the impact of digitalization in education and professional activity on the transformation of the ways of their implementation (distance educational technologies, remote work, replacement of workers with robots), as well as the processes of interpersonal interaction and professional identification; diagnostics according to L.B. Schneider "Professional Identity", questionnaires and descriptive statistics; generalization and interpretation of research results.
3. Results and discussion
The authors believe that the problem with a shortage of young qualified teachers of technology in modern schools arises, among other things, due to their lack of a formed professional identity [2]. Many modern researchers of the problem of the teacher's professional development note that the teachers understand their role through the subject area they teach [3]. It is noticed that teachers with different pedagogical experience and different subject orientation have noticeable differences in the structure and types of professional identity [4]. Many studies emphasize that an important part of the teacher's professional identity is precisely the awareness of the status of their subject area in the structure of school education [5]. For example, Beijaard argues that the professional identity of a teacher is made up of factors such as the subject they teach, relationships with students and awareness of their teaching role [6]. Therefore, the authors consider it reasonable and relevant to identify the formation of professional identity separately for teachers who implement engineering education.

To organize experimental work during the 2019/2020 academic year, the methodology of L.B. Schneider "Professional identity" [7] was applied, which is aimed at identifying its type in the subject. The results are shown in Table 1.

| Types of professional identity (by L. B. Schneider) | Bachelors | Master’s degree students | Technology teachers |
|--------------------------------------------------|-----------|--------------------------|-------------------|
| Pseudo-positive identity                          | 28        | 35                       | 38                |
| Achieved (positive) identity                      | 17        | 21                       | 29                |
| Diffuse (blurred) identity                        | 36        | 31                       | 24                |
| Moratorium                                        | 19        | 13                       | 9                 |

The main part of the respondents were full-time and part-time students of Ulyanovsk State Pedagogical University named after I. N. Ulyanov (32 of them - bachelors majoring in “Pedagogical education” in the field “Technology. Informatics”, “Technology”; 54 of them – master’s degree students in the field “Scientific and methodological support for technological education”, “Quality management of education”). Moreover, 42 practicing technology teachers from Ulyanovsk, Ulyanovsk Oblast, Republic of Tatarstan took part in the survey. The sample consisted of 128 people.

Reference should be made to the interpretation of the empirical data obtained. The table shows that “pseudo-identity” and “achieved (positive) identity” prevail among the sample of technology teachers who clearly recognize, and sometimes publicly emphasize their own professional uniqueness, manifest a set of professional goals and values that determine the teacher's awareness of the meaning of pedagogical activity, opportunities for career growth. “Diffuse identity” and “moratorium”, on the contrary, prevail among bachelors. Such results are quite natural due to the uncertainty of the professional future, the lack of a clear life plan. Master’s degree students, in turn, occupy an intermediate position between bachelors and technology teachers, since the sample presented includes both yesterday's bachelor graduates and practicing technology teachers.

The analysis of the data obtained shows that in the process of educating technology teachers, it is important to pay attention to the formation of professional identity [7-9]. Many researchers point out directly that “... the professional development of a teacher actually begins with studying at the faculty, when future teachers begin to form their professional identity, which occurs through the definition and recognition of various roles” [4].

An important factor in professional identity is the context of training, which determines the image of future professional activity. Consequently, the features of the subject training of teachers implementing engineering education should consist not only of mastering pedagogical competencies, but also of comprehensive engineering training, familiarization with innovative industrial enterprises of their region, and close interaction with the engineering community.

In the formation of a positive professional identity of a teacher, one can use such information and communication technologies (ICT) as including professionals to the Internet communities in order to
exchange experience and mentoring (the positive effects of mentoring have been proven in studies [10]), presenting own methodological developments, experience of digital technologies, etc.

To identify the actual level of formation of digital skills in the subjects, a questionnaire created by authors was used. The responses of the respondents have been thoroughly and comprehensively analyzed. This is followed by an interpretation of some of them.

When answering the question “What ICT do you use in learning process / in your professional activity?” it was revealed that the vast majority of respondents actively and systematically use Internet resources; special programs for processing information, photos, etc.

Table 2 shows the generalized results of responses to the question of the questionnaire “Assess your digital skills”, reflecting the opinions of respondents about the degree of their ICT proficiency.

| Good skills | Bachelors | Master’s degree students | Technology teachers |
|-------------|-----------|--------------------------|---------------------|
|             | 46        | 38                       | 21                  |
| Rather good than bad | 41        | 43                       | 48                  |
| Rather bad than good | 13        | 17                       | 22                  |
| Bad | -         | 2                        | 9                   |

When studying the answers to the question “In what areas for implementing the educational process do you use ICT?” (Table 3) a certain number of respondents should be singled out from among teachers of technology and master’s degree students who indicated in the column “Your option” that they use ICT to manage the research and project activities of students.

| Completing educational assignments | Bachelors | Master’s degree students | Technology teachers |
|------------------------------------|-----------|--------------------------|---------------------|
| Writing term papers / theses       | 79        | 88                       | -                   |
| Organization of lesson and extracurricular activities | 100       | 100                      | 17                  |
| Using an electronic journal, performing administrative tasks, etc. | 12        | 35                       | 100                 |
| Cooperation between school and parents | -         | 23                       | 47                  |
| Your option | -         | 5                        | 11                  |

Analysis of answers to the question “What modern promising directions for the development of the content of the subject area “Technology” related to digitalization, do you know?” makes it possible to record the awareness of the respondents of all groups of the implementation of such areas as robotics, virtual laboratory, prototyping, graphic and other designs, as well as of the emergence of quantoriums, "Growth Point" projects, etc.

To the most frequent answers to the question “What digital educational resources do you create yourself?” among the respondents of all groups the following were classified: multimedia presentations, video fragment / video tutorial, computer testing, own web-page.

Within the framework of the current study, it is of undoubted interest to generalize the opinions of the respondents of the “technology teacher” sample to the question asked “In your opinion, do the material and technical conditions in your educational institution allow you to fully ensure the digitalization of education?” Only a small part of teachers (16%) declared good material and technical conditions, namely, that there are freely available computers, multimedia equipment, a stable and high-speed Internet connection, personal robotic constructors, 3-D printers, CNC machines, etc. The answer “Rather good than bad” was noted by 47%, “Rather bad than good” - by 29%, and 8% of respondents had “Bad” conditions (insufficient number of computers and multimedia equipment, unstable Internet connection).
Content analysis of the respondents’ statements to the question “What options for advanced training in the field of digitalization of education do you consider optimal for yourself?” demonstrated the presence in the answers of both traditional options (courses, master classes, open lessons) and more modern (mastering digital educational platforms, exchange of experience and on-line training, participation in webinars, network conferences, etc.) (table 4).

**Table 4. Options for advanced training in the field of digitalization, %.

| Options for advanced training in the field of digitalization | Bachelors | Master’s degree students | Technology teachers |
|-------------------------------------------------------------|-----------|--------------------------|---------------------|
| Retraining courses, including with the involvement of engineering personnel | 43        | 66                       | 89                  |
| Master classes, demo lessons, etc. | 67        | 72                       | 93                  |
| Mastering digital educational platforms (Google Class, Moodle, Zoom, Discord, etc.) | 72        | 61                       | 58                  |
| On-line training courses, webinars | 59        | 61                       | 47                  |
| Participation in teaching communities | 37        | 54                       | 83                  |

Special attention was paid to the interpretation of answers to the question “How did the digitalization of education during the pandemic in the spring of 2020 affect your organization of the educational process?” All respondents are unanimous that the current situation has made significant adjustments to the educational process and forced many of them to quickly use a variety of digital educational resources. However, in addition to the indicated positive moment, negative consequences were also named. Thus, most of the bachelors were not able to fully “immerse themselves” in the real educational process at school, since the production pedagogical and educational practices were held in a distance format. For master’s degree students, the situation did not in the best way affect the awareness of oneself as a teacher, in other words, the process of formation of professional identity slowed down. For practicing technology teachers, the very process of mastering digital resources, restructuring the method of teaching the subject turned out to be difficult.

**4. Conclusion**

The current research attempted to answer the question: “What conditions are necessary in the preparation of technology teachers for the engineering education of schoolchildren?” They are formulated further:

- assistance in the formation of the professional identity of a young teacher, which ultimately affects the effectiveness of career strategy planning;
- the formation of ICT competence and information culture in conjunction with the strengthening of modern subject training (equipped with knowledge about promising technologies, mastering design and digital competencies, etc.);
- inclusion in both the pedagogical and the engineering community of professionals from their region and country;
- socio-economic factors (increasing the prestige of the profession of a technology teacher, including with an emphasis on their active participation in additional engineering education of schoolchildren, an increase in the level of wages and material incentives for young and enterprising personnel, etc.);
- improvement of the material and technical base of technological education, along with careful training of personnel for the use of this base, since today it can be argued that professional training of specialists lags behind the level of material and technical equipment.
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