Professional and Teaching Training of Masters in Engineering: Challenges and Solutions

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The paper focuses on some aspects of organizing the training of Master of Engineering for future professional and teaching activity. We carry out a brief overview of the genesis of master's education in Russia to provide higher education with educators. We discuss the challenges of the higher education system to (1) prepare teaching staff and (2) increase their qualification mobility. The paper analyzes (1) the expediency of including the teaching component in the education programs for masters of engineering, (2) the demand for masters of education in technical universities, and (3) the motivation of masters of education for professional and teaching activity. We obtained the presented empirical material during the research conducted in the 2017–2018 academic year and the 2018-2019 academic year at the Institute of Mechanics and Energy of the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy. The study involved 109 students getting a master's degree and passing the teaching practice at the university.

Keywords: professional education, professional and teaching training of master students, motivation of professional and pedagogical activity, teaching practice, competencies, competency-based objectives

INTRODUCTION

The European model of two-level education has been gradually implemented in Russian higher education for more than two decades. During this time, scientific paradigms and models of undergraduate and graduate training in various areas of professional activity have repeatedly changed; different approaches to goal-setting, structuring and selection of educational content, and the use of educational technology in universities have been introduced (Kubrushko, Kozlenkova, Mikhailenko & Nazarova, 2018). Postgraduate studies were relegated from the scientific level of education to the third level of professional education. Nowadays, in Russia, as well as in the other countries, highly educated and professionally motivated specialists with fundamental knowledge, high level of practical training, creative abilities, and ability and readiness to solve standard and non-standard tasks in changing economic conditions, promptly improve

their professional level, and train their subordinates are in demand (Zeer, Tretyakova, Bukovey & Scherbina, 2019). This level of requirements for a graduate can be fully realized at the level of master's training.

MATERIALS AND METHODS

The research aims to (1) study the motives of choosing a professional and teaching activity in a university among students of engineering profile getting master's degree and (2) develop directions for improving the professional and pedagogical education of masters in technical universities.

The research methods include (1) the analysis of legislative and educational-normative documentation, scientific and pedagogical literature, and statistical data on the problems of providing universities with professional educators; (2) observation, (3) questioning, (4) analysis, and (5) generalization of the results of educational and cognitive activities of students, expert assessment.

The study was conducted in the Institute of Mechanics and Energy of the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, which trains masters in engineering. The research involved 109 students getting master's degrees in different areas ("Agroengineering," "Heat Power and Heat Engineering," "Electric Power and Electrical Engineering"), studying the discipline "Fundamentals of teaching activity," and passing educational practice at the university.

RESULTS

The humanization and humanitarianization of education are considered by most academic educators and researchers of the axiological aspects of higher education to be the leading idea in the development of Russian higher education. These aspects are enshrined in all documents on the modernization of domestic higher education. In the context of such an idea, in the 2000s, the problem of developing the composition and content of the graduate's competencies was actualized in the targeting of training of masters in engineering based on the competency-based approach. Over the past period, significant changes occurred in the types and list of competencies of master's training in different areas, the types and content of professional activities, and professional tasks. In our opinion, an important component in the structure of the master's competencies is the readiness (motivational, gnostic, practical, etc.) for teaching in a professional school. The pedagogical component in the structure of the activity of any highly qualified specialist, including the engineer, is highlighted in labor psychology, industrial and engineering pedagogy. If we consider the etymology of the term *master*, its key attributes are a superior, a mentor, and a teacher. It was the masters who were prepared for scientific and pedagogical activities as mentors and teachers at different stages of the development of higher education.

Let us briefly review the history of training of masters to comprehend the applied pedagogical aspect of the master's training, its social, professional, and teaching status, and the orientation of the master's education. There are several stages in the development of a master's education:

- Creation of master's education. The first master's degree, "Master of Philosophy," was given in 1753 at the Academy of Sciences on M. V. Lomonosov's initiative. In 1755, the Imperial Moscow University began training masters, and in 1758 several leading university professors were awarded the title of "master." The preparation of masters at that stage was carried out on the model of German universities. The content of the preparation of the masters suggested that the future teacher must pass an oral exam, read trial lectures, and write and defend a thesis ("scientific composition");
- Improvement and development of master's training. In 1803, the "Preliminary Rules of Public Education" established the title of "master" in universities. In 1819, a decree of Emperor Alexander I adopted the "Regulations on the Production of Academic Degrees" (Krivoruchenko, 2012), which gave Russian universities the right to train and award master's degrees according to unified requirements. This system operated in Russia for almost a hundred years. According to the Ministry of Public Education (since 1884, the procedure for awarding

a master's degree was controlled by this body), about two thousand people received a master's degree at Russian universities from 1803 to 1917 (Krivoruchenko, 2012). Subsequently, the masters could be appointed to the post of extraordinary professor (which is more status than the current position of an assistant);

- Termination of master's education. The training of masters was canceled by the decree of the Council of People's Commissars of the RSFSR dated October 1, 1918 (Council of People's Commissars of the RSFSR, 1918). In 1934, the Resolution of the Council of People's Commissars (Council of People's Commissars of the USSR, 1934) introduced two academic degrees-candidate and doctor of sciences, which still exist, including for university educators;
- Revival and development of master's education in the post-Soviet period. In 1996, the Russian higher education system introduced a "master" qualification as a step to upgrade the qualifications of bachelors and specialists. This was connected with the orientation of Russian higher education towards the European model of two-level higher education and the idea of nostrification of Russian diplomas in the global educational space. Master's education in the 1990s was based on the "Provision on Master's Training (Master's Degree) in the System of Multilevel Higher Education of the Russian Federation (State Committee of the Russian Federation for Higher Education, 1993). The document determined that master's education should prepare graduates to carry out research, scientific, and teaching activities. Since December 2007, the Federal Law "On Higher and Postgraduate Professional Education" (Russian Federation, 1996) established that master's training in Russian universities is the second level (not mandatory for all graduates of a bachelor's degree) of higher education.

The preparation of masters in various fields of study is based on the Federal State Educational Standard (FSES) 3++, which requires graduates to master universal, general professional, and special professional competencies.

In the context of our study of professional and pedagogical training of Master of Engineering, let us quote the results of the study conducted by D. I. Lapshina (Herzen State Pedagogical University, St. Petersburg). She analyzed the FSES of Higher Education (121 standards) for the training of students of a no-teaching profile to identify the teaching component in the structure of the competencies of graduates. The author stated that 79% of the content of the masters' competencies prepare for teaching activities, and 25% – for scientific and teaching activities (Lapshina, 2016). Unfortunately, the researcher does not name the criteria for distinguishing the teaching component in the structure of normative competencies. However, the above figures can be of interest and use in the creation of "Programs of training university educators in industry disciplines."

The authors of this research analyzed the normative and curriculum documents (FSES of Higher Education, basic educational programs, curricula, and working programs of disciplines and professional modules) implemented at the Institute of Mechanics and Energy named after V. P. Goryachkin. The analysis showed that graduates with a master's degree, in their professional activities, should be able to solve technological, design, research, organizational, managerial, and pedagogical problems. In other words, the range of professional tasks of a Master of Engineering has significantly expanded compared with the 1990s (Chistova, 2018). It is assumed that, while forming a sufficiently high level of fundamental knowledge in special (industry) disciplines, students of non-teaching profiles should have the opportunity to share this knowledge and achievements with students of universities and colleges in their technological, design, research, organizational, and managerial activities in the engineering field. Moreover, students should carry out professional and teaching activities.

For this purpose, one or several psychological and pedagogical disciplines are included in the variable part of the educational programs for the preparation of Master of Engineering and technical profiles in different directions. For example, the psychological and pedagogical training of aviation engineers at the Ufa State Aviation Technical University is impressive. Since 1973, the university has a department of engineering pedagogy and psychology, where students study "Education and Psychology," "Management Psychology," "Engineering Psychology," and "Transport Psychology." The curriculum of masters in all areas includes the discipline "Education and psychology of higher education" (72 hours) and teaching

practice. The university has a program for selecting and training young teachers at all levels of education: undergraduate, graduate, and postgraduate (Sharipov, 2014).

However, researchers, heads, and teachers of universities, who have passed all the classical stages of professional and teaching formation (the scientific and teaching career of a university educator from assistant to a professor, as a rule, is counted in decades), understand that attracting masters to teaching activities in professional school is a somewhat forced step in solving the problem of filling the higher school with young teaching staff. Based on the analysis of theoretical assumptions and our empirical research, we will try to identify the "challenges" of the Russian higher education at the present stage and possible ways of preparing professional and pedagogical staff through master's education. Let us consider one of the leading "challenges" of higher technical education and outline the priority measures to solve the problem.

Over the past thirty years, the law of dialectical development has been repeatedly violated in the development of Russian higher education as a complex biosocial system. As known from the laws of dialectics, the source of development lies inside the developing system. The reform and modernization of higher education ignored this law for three decades. All these years, modernization of the education system (globalization, accession to the European educational space, a change in the paradigm of educational outcomes, an almost complete change in the structure of professional education to the European model, etc.) was based on declarative and often contradictory orders, instructions, methodologies, and other instructions from the Ministry of Education, the Ministry of General and Professional Education, the Ministry of Higher Education and Science, etc. Without going into the content of the education reforms, we note only one of the negative results of their implementation – the outflow of teaching staff from universities. This includes professional migration, "brain drain" to foreign universities, dramatic changes in the activities of teachers due to low wages, destruction of the system of higher education, loss of the high social status of the teaching profession, etc. As a result, over the years, the mechanism of self-reproduction in higher education was almost destroyed. This fact leads to faculty aging and a significant decrease in the professional and teaching motivation of students and graduates of universities (Kozlova & Atamanova, 2013).

The compliance with the law of transition of quantitative changes to the qualitative level is an essential condition for the effective dialectical development of the education system. Over thirty years of permanent reform in higher education, there have been some positive results. These results are as follows:

- The widespread introduction of innovative learning technologies (Kubrushko & Nazarova, 2013);
- Development of the information and communication base (Kucirkova, Alipichev, Vasbieva & Kalugina, 2017; Vezirov, Guseynov, Sultanov, Abdulgalimov & Sorokopud, 2014);
- Nostrification of Russian Diplomas of Higher Education;
- Standardization of the training of bachelors, masters, and specialists, guaranteeing a single level of training in all educational institutions regardless of geography and university cluster.

During this period, the number and nature of requirements for teachers and changes in normative and curriculum documentation in universities have exponentially grown. This turned the methodological work, traditional and interesting for teachers, into a routine of endless (often pointless) correction of work programs, textbooks, and assessment materials. This law is also violated concerning the scientific and teaching activities of teachers. Currently, the success of this activity is excessively formalized by the established standards (publications, citations, Hirsch indices, and other indicators). The process of filling out all the reports takes a considerable amount of time and effort from the teacher. Moreover, such paperwork creates a negative "clerical" image of scientific and teaching work in the university among young educators.

The tendency of aging of teaching staff is preserved in higher education for more than a decade. In the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, the average age of teaching scholars is 53 years, and 41.3% of teachers are people of retirement age. The smallest part of the teaching staff (24.4%) is under 40 years old. Only 20.5% of teachers are of the most working age (41–50 years). Having analyzed the obtained data on the age of the teachers of the leading Russian agricultural

university, we compared them with the average statistical data of Russian universities in different historical periods. For this purpose, we focused on certain results of a sociological survey conducted by V. F. Pugach, who studied the age groups of university teachers in the USSR and Russia in different years. The researcher points out that in 1988, of the total number of teachers in the Soviet universities (the total number of university educators was 528.7 thousand people), the smallest was the age groups under 30 years old (9.6%) and over 60 years old (7.2%). Most of the teachers were 30–39 (32.1%) and 40–49 years old (33%). From 1998 to 2008, there was a persistent tendency towards the reduction of young personnel in universities. For example, in 1998, 18.1% of teachers employed in Russian universities were aged 30–39, 26.6% of teachers – 40–49 years, and 17.7% of teachers – over 60 years old. Since 2008, the situation with attracting young teachers to universities has somewhat improved. In 2008, teachers aged 30–39 accounted for 21.3%. From 2010 to the present, this figure has been relatively stable at 23%–25%. This cannot be said about the category of "golden age" teachers, who usually already have degrees, titles, significant experience, and great potential in the implementation of scientific and teaching activities. These are teachers aged 40–49. Since 1998, there has been a clear annual outflow of such personnel from universities. In 2010, only 17.6% of "golden-age" faculty worked in higher education. This figure slightly increased by 2014 (18.9%) and a little more (19.8%) by 2018. At the same time, there were 27.7% of employees over 60 years old in the composition of the teaching staff of universities in 2014 (Pugach, 2017).

From 2016 to 2018, the internal structure of universities was reorganized. The departments were merged due to the introduction of modular didactic units in the content of bachelor training and the reduction of the class load in disciplines and professional modules. Therefore, the teaching staff was reduced by an average of 30%. This figure included young faculty members who had not yet defended their Ph.D. dissertations.

These statistical data give a reason to actualize the problem of reproducing pedagogical staff in the system of higher engineering education, using various forms of their training: postgraduate, master's degree in educational and non-educational directions, and additional professional and pedagogical education.

The results of the survey conducted among students getting a master's degree in engineering before studying the discipline "Fundamentals of pedagogical activity" allowed us to conclude that their ideas about the essence of pedagogical activities of teachers in higher education are formed only based on the visual observation of these activities during their undergraduate and graduate studies. The survey showed the following:

- 43% of the respondents rated this activity as challenging and interesting, but unacceptable to them;
- 32% of undergraduates noted that the work of a teacher is monotonous (the same disciplines are read every year, the same tutorials are written, etc.) and poorly paid;
- 17% of students consider the activity of a teacher to be unpromising due to the active introduction of information technology and distance learning in universities;
- 8% of respondents confirmed their readiness for such activities, identifying the teaching profession as one of the interesting and necessary for society.

Considering the professional teaching status of the discipline "Fundamentals of Pedagogical Activity," its practice orientation, lectures, practical classes, and teaching practice were conducted according to the author's methods. The basis of these methods is the methods and means of contextual, active, project, problem, and informational learning technologies, including partially exploratory methods, case-method, lecture-visualization, business games, the performance of the group and individual competence-oriented tasks, solution of competence-oriented issues, and independent work with the educational portal and Internet resources (Tolsteneva, Vinnik, Voronkova, Lagunova & Zhilina, 2020; Zhukova & Shingareva, 2011).

When studying the discipline and passing the pedagogical practice, students getting a master's degree were questioned. Moreover, we assessed the quality of the fulfillment of competence-oriented tasks and issues, as well as the quasi-professional activities of students as an intern-teacher. We also used expert assessments of the methodology of conducting open classes for undergraduates at the branch departments

of the university. A set of evaluation methods allowed (1) to consider subjective and objective factors influencing the efficiency of students learning the discipline. Moreover, it allowed us to (2) identify the level of mastering the basics of teaching activities in teaching major disciplines and the changes in students' motivation for professional and teaching activity in the universities. According to the research results, 76% of the university professors noted a sufficient level of preparation of students for teaching practice (average – 57%, high – 26%, low – 17%). Nevertheless, the experts noted the weak preparedness of students in the methodology of teaching communication. More than half of the trainees had difficulty in communicating with students in the classroom, could not organize the discipline and attention of students, did not have a good command of speech culture, etc. However, after studying the subject and completing teaching practice, there was a positive dynamic of increased interest in teaching (57%) and a conscious desire to work as a university teacher (24%). Additionally, 73% of undergraduates positively evaluated the methodology of the subject. This group emphasized the practical importance of competence-oriented tasks and tasks to develop methodological skills in the analysis of normative and curriculum documentation. They also positively assessed the development of thematic plans, didactic design of classes, and observation and analysis of the activities of university teachers. The students getting the master degree indicated the following:

- 38% of the students rated their level of design skills as high (they can formulate the goals of the lesson, correctly determine the type of lesson, select educational material on the topic from various sources, choose effective methods and means of teaching in accordance with the purpose, content, and contingent of students);
- 42% of the respondents rated their level of design skills as average,
- 11% considered their level of design skills low;
- 9% could not assess the level of their skills.

DISCUSSION

The idea of training masters of engineering for professional and pedagogical activities at a university is relevant for solving the problem of rejuvenation and self-reproduction of the educators. However, the introduction of several disciplines of teaching or methodological orientation, coupled with pedagogical practice, will not fully solve the problem of providing technical universities with highly qualified personnel. The analysis of the main professional educational program of higher education, the FSES, and the curriculum of the bachelor's degree program for the abovementioned fields ("Agroengineering," "Heat Power Engineering and Heat Engineering," and "Electric Power Engineering and Electrical Engineering") showed that only one subject – Psychology – allows familiarizing students with the basics of mental processes and the psychology of personality, activity, and team. In 1993, the subject "Psychology and Teaching" was introduced into the curricula of all technical universities. The objectives of this subject included the motivation of students to professional and teaching activities.

This provides the basis for a more in-depth study of legislative, regulatory, theoretical, applied (organizational and methodological) issues to create different models of training teaching staff based on the master's programs. Masters, as potential teachers of technical universities, should have a basic engineering education and master's training in this area. Moreover, they should be motivated to perform teaching and scientific activities in their universities.

CONCLUSION

Currently, the scientific and teaching community is to successfully and methodologically solve the problem of preparing teaching staff for technical universities through master's education. Therefore, it is necessary to take the following steps:

1. Conduct basic research on the theory and methodology of this level of education.

2. Study and generalize the historical experience of master's education in Russia for its adaptation to the current system of training teachers for professional schools;
3. Develop theoretical and applied issues of the structure of the content of the master's education to improve the effectiveness of educational programs, including the pedagogical component;
4. Identify and implement diverse and practical forms, models, flexible (adaptive) training programs for the professional and teaching activities of masters and their further professional development;
5. Create a targeted corporate program for the phased selection and training of young educators from among undergraduate, graduate, and postgraduate students. This step will allow building individual trajectories of training young educators for research and teaching activities. The determinants of this program should be the following organizational and teaching conditions:
    - Involvement of undergraduate students (starting from the first year of study) and master students in research work;
    - Inclusion of the psychological and teaching component in the content of the bachelor and master training;
    - Creation of comfortable organizational and teaching conditions and incentives for students to obtain professional and teaching training through the system of additional education in the university.

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