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Professional Objectives of Future STEM Specialists

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***Abstract*—The results of the research of professional objectives of future STEM specialists are presented. The initial stage of professional identification of students mastering STEM programs is considered. Factors of choice of STEM profession, strategy of increase of competitiveness, features of professional motivation and ideas of the future career are shown. We used questionnaire "STEM education and career survey", the technique of "Satisfaction with the profession" (V. A. Yadov, in modification N.V. Kuzmina, A.A. Rean). The sample consisted of 372 students mastering STEM programs, students of universities of Ivanovo, Voronezh, Kursk, Orenburg, Bryansk regions. A survey on the Internet was used to collect data. The research results have shown that the STEM job satisfaction ratio was 0.14. The problem of insufficient readiness of future STEM-personnel to implement the received qualifications in the specialty is revealed. The necessity of professional support programs in building STEM career, development and implementation of practice-oriented programs, the use of opportunities of specialized organizations, large campaigns and holdings interested in STEM personnel.**

Keywords—STEM, professional objectives, future specialists.

I. INTRODUCTION

The updating of engineering education is currently the focus of attention of state bodies and scientific community. Russian Prime Minister D.A. Medvedev declared that the country has set course for rebuilding the engineering education under the National Technological Initiative, which implies motivation of youth for joining technological departments of higher schools and pursuing of science.

A package of scientific and technological subjects, defined as STEM, includes a number of disciplines like natural science, technology, engineering and mathematics. Actually, this is a system of subjects that serves as a basis for training high technology specialists. Introduction of the STEM education is determined by the new world economy that implies involving youth in knowledge-intensive branches of science such as neuroelectronics, robotics, bioelectric medicine, neurobiology, mathematics, engineering, etc. The solution of this problem will improve qualitative performance of human capital and its efficiency [1, 3, 4, 9].

The STEM professions become instrumental in introduction of modern technologies and resources. The STEM education is a modern educational factor taken seriously and with understanding by the students who are aware of importance of subjects related to science, technology, engineering and mathematics. The mastering of STEM disciplines by the students, the acquisition by them of social and professional skills, including through improvement of conceptive thinking techniques, initiates the use of humanities, to wit psychology as a booster of STEM education. At a summit of the American Psychological Association (APA) in May 2009, 150 experts in psychology, economics, medicine, business and politics pointed out the growing role of applied psychology for STEM disciplines [2].

Given that the STEM education is directly linked to the new type of economy where professional skills and expertise are the driving force of progress, it is extremely important that the future STEM specialists should start, as early as possible, to outline their professional objectives [7, 11].

The professional objectives of a student, as an attitude to his chosen job or profession, act as an ultimate goal of education. A student's professional self-determination is impossible without solving the problem of self-determination associated with a choice of a value system and aims [10].

It is appropriate to consider the STEM students' professional objectives through motivation in choosing a profession, satisfaction with it as well as in the light of its competitiveness and updating strategy.

STEM professions are believed to not be typically females'. However, despite the resisting gender-related stereotypes, they are undergoing a transformation [5, 6]. In this connection it has become imperative to analyze gender-related specifics of professional objectives of future STEM specialists.

Our study primarily focused on STEM students' professional objectives. We also sought an answer to the question if young men and women are equally aware of their belonging to a professional group of STEM specialists involved in the economy, how satisfied are they with their chosen job and do they expect to improve their efficiency and professional skills?

II. METHOD

The study materials were results of the "STEM education and career survey" carried out from November 2017 to February 2018. Used in the research were the following methods: "STEM education and career" questionnaire which was aimed at the study of strategies for improving competitiveness, description of professional demand, and bolstering of the desire to work in the chosen profession. The research also presents the methods of measuring the ratio of students' satisfaction with

their future profession (V.A. Yadov, in modifications of N.V. Kuzmina and A.A. Rean).

372 students, involved in the STEM program, took part in the research, 223 (59.9%) of whom were girls and 149 (40.1%) boys aged 17 to 23-24 years, from higher schools of Ivanovo, Voronezh, Kursk, Orenburg, and Bryansk regions. Pointed out as educational disciplines were engineering subjects (23.4%), medicine (23%), ecology and nature management (17.1%), software development and information technologies (13.0%), biology (10.9%), chemistry and chemical technologies (8.5%), industrial safety (6.0%), physics (5.1%) and others.

III. Results and Discussion

The research results have shown that the STEM job satisfaction ratio was 0.13 for young men and 0.15 for women. Figure 1 shows perception of the STEM profession and its appraisal.

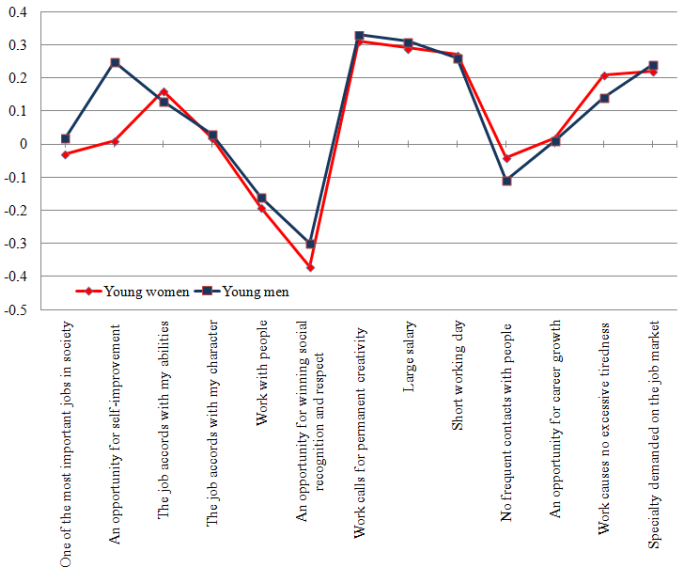

Fig. 1. Perception of the STEM profession and its appraisal.

Based on results obtained with the aid of a method of assessing the job satisfaction, factors were calculated that determine the students' attitude to the STEM profession. The factor analysis was made using the SPSS Statistica 17.0 software package, via chief components technique by varimax rotation with Keiser normalization.

Table 1 shows the most significant factors in choosing a STEM job by young men and women.

In the course of the research it was established that the chief factor in choosing a profession by students majoring in STEM subjects is its assessment as one of the most important in society (37.2% for young women and 40.3% for men). Satisfaction with a chosen profession depends on its objective recognition and subjective understanding by students of its importance. Both of these factors contribute to professional predilection.

Young men (40.9%) pointed out, as the chief attraction, a demand on the job market while only 24.7% of young women pointed to this factor. For females it is of lesser importance to be assured of a future position in the STEM profession.

TABLE I. Leading Factors that Determine Young Men and Women's Attitude to STEM Profession

Chosen group	Factors and their significance			
	I	II	III	IV
Young women	Social significance of profession	Salary	Work accords with abilities and character	Negative factor: Work causes excessive tiredness
Young men	Social significance of profession	Work accords with abilities and character	Salary	No frequent contacts with people

Another important factor relates to opportunities provided by the STEM work. 32.7% of young females and 37.9% of young males see in it an opportunity for self improvement. With 33.6% of girls and 36.2% of boys their profession tallies with their capabilities. 34.5% of girls and 32.9% of boys believe that their profession accords with their character. Respondents' opinions significantly differ regarding evaluation of the professional demand on the job market. So 40.9% of boys answered this question in the affirmative while only a quarter of girls did so.

The analysis results have shown that the payment factor is among priorities. However, it should be noted that the number of respondents who pointed to a high salary in the STEM job as an attraction (17.4% of boys and 9.4% of girls) is much lower than the number of those who, when asked, pointed out the low salary factor as unattractive (47.0% of boys and 46.0% of girls). Therefore, the salary factor content is important for most boys and girls though they do not consider salary in STEM work as high.

The research has shown that 16.2% of boys and 34.0% of girls involved in the study stated that the principal means of enhancing their attractiveness in the eyes of employers is their desire to study well. Such an answer can be regarded as a formal justification of a lack of any other extra activities.

At the same time, globalization of the STEM market continues to transform the process of education so that the study of English, taking online courses in various universities, and attendance of paid special courses are becoming a fairly normal practice for Russian students. 45.6% of boys and 31.4% of girls declare an in-depth study of dedicated STEM subjects. 18.1% of boys and 10.3% of girls additionally study English. Each sixth boy (15.4%) does an odd job in his profession. The research has revealed an interest in additional education and research studies. So 14.1% of the surveyed boys and 9% of girls noted that they were taking extra-mural courses, while 19.7% of boys and 19.3% of girls participate in projects and scientific conferences.

If all actions of the surveyed participants seeking to enhance their competitiveness are divided in active and passive, the following distribution pattern will be obtained: 32.3% of girls "float downstream", choosing only such versions as "I study conscientiously", I study in depth certain subjects", "I study English on my own", i.e. "processional" implying the

student's clinging to the conventional pattern. With boys this figure is 44.8%. Around 70% of girls and 55% of boys "perform actively," i.e. they step away from the routine studies, for instance, by taking online courses, participating in conferences, supporting volunteer movement, etc.

Most participants of the study expressed their intention, on graduating from higher school, to find a job in STEM profession they are receiving (52.3% of boys and 46.6% of girls). However, some plan to change their specialty, remaining nonetheless in the STEM sector (12.1% of boys and 36.3% of girls). Quite significant is the number of those who intend to quit the STEM profession (35.6% of boys and 36.3% of girls).

The demand for their profession on the STEM market job can be illustrated by students' popular opinion that they may have difficulties in finding work for themselves. Girls (48.0%) are more prone to envision employment-related problems than boys (37.6%). At the same time, for 24.8% of boys and 19.7% of girls the search of work will not be very hard. During their training at higher school girls receive job proposals far less often than boys (5.8% versus 15.4%). Girls tend to draw less optimistic pictures of their career growth than boys. They note that they either doubt their ability to find a job in their chosen profession (respectively 15.4% and 17.9%) or altogether do not plan to work in it (6.7% and 9.0%). This is probably linked to the girls' more emotional attitude to the profession, and their keener perception of social and psychological impacts of other factors on their aspirations and ambitions, including in professional pursuits.

The desire to work the STEM job is not a determining factor for most students in choosing a career. Those remaining true to their profession account for 22.9% of the surveyed girls and 22.1% of boys. Most of them regard choosing a profession in terms of maxim profits. Every other of those surveyed, even desirous of making use of the knowledge acquired at a higher school, would rather opt for a higher salary (should the market offer such opportunity), while each fourth does not altogether care for his specialty.

The share of those desiring a job in a chosen profession but prepared to work not necessarily in this line is twice that of respondents for whom work in the profession is absolutely essential, among both men and women. The study has shown that a quarter of those surveyed are inclined to believe that a profession (specialty) is a factor of secondary importance in choosing a job.

One of the stages in processing the research results was correlation analysis. Used as correlation objects were job satisfaction, desire to work, employment opportunities, importance of specialty and professional development. Both in boys' and girls' groups common correlative links were detected between job satisfaction and such factors as a desire to work ($p \leq 0.05$), adequate estimation of employment opportunities ($p \leq 0.05$), and professional development ($p \leq 0.01$). The increasing desire to work a STEM job significantly influences boy's and girls' employment opportunities ($p \leq 0.01$), and enhances the importance of specialty for the society ($p \leq 0.01$). The growing employment opportunities also contribute to importance of the STEM profession ($p \leq 0.01$). Boys showed a genuine correlative link between their desire to work and professional development ($p \leq 0.05$).

IV. Conclusion

Thus, the study has shown a low level of students' preparedness to be engaged in the STEM area. This is evident from their insufficient job satisfaction. Often, while desiring to build a STEM career, the students are not averse to changing the STEM or even giving up the profession altogether. This trend is particularly pronounced with girls.

Today, the leading countries have developed education strategies offering ways and means of rectifying the deficiencies in STEM education and including various specialized higher education programs, among them those aimed at involving women in the STEM. Such countries as Australia, England, Scotland, and the USA have published national reports containing recommendations for implementing STEM education reforms. Australia, China, England, Korea, Taiwan, the USA develop special training programs. Much attention in them is given to making the students realize how the STEM training will influence their professional career.

Thus, the Russian higher education system faces the problem of developing and implementing practically orientated programs [8]. It is necessary to apply more widely the requirements of higher education standards, especially in training specialists of dedicated organizations and the so-called "scientific volunteer movement." Large companies and holdings seeking personnel for industry and economy are already implementing programs of adaptation, support, and tutorship in employing boys and girls in order to help higher school leavers understand how the STEM training may influence their professional career. Further cooperation between professional training, science and technology sector, and network professional education community will develop towards a closer combination of theoretical education and practical work, practice at organizations using advanced job models, creating technologies and resources, and mastering relevant qualifications.

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