# Evaluation of market needs in Belarus for improvement of master-level education in the field of physical sciences

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***Abstract* – The article presents a case study of experience sharing between the EU universities and the EU neighborhood area – Belarus. The aim of this study is to facilitate the Bologna process joining by the Belarusian higher education system and, in particular, to consider challenges related to the labor market in the field of physics specialties due to upcoming changes in the qualification of university graduates. Before joining the Bologna process, the Ministry of Education has set the proportions of 5- and 6-year graduates specializing in physics as 90% and 10%. The enhancement of cooperation between HEI and labor market is essential to perform successful transfer to the Bologna-like 4-year higher education system. Of particular importance is the organization of master students internship and practice in order to meet the labor market needs.**

***Keywords –education, market needs evaluation, master – level education, Erasmus plus***

## I. Introduction

Striving to reform a higher system education in Belarus according to the Bologna process [1], the Ministry of Education of Belarus set the target for HEIs to reform their curricula. By the existing system “5 plus 1” the term of education is fixed as 5 years to get the basic “specialist” degree and 1 year to get the master’s degree. In the near future the system “4 plus 2” will be established in the area of physical sciences in the compliance with Bologna principles. Since the academic year 2014, HEIs have started the 4-year program for the first stage of higher education according to the Regulation No. 389 of the Ministry of Education issued in the year 2012.

Reduction of the training period from 5 to 4 years for students specializing in physics and engineering bears a certain risk and influences the labor market. First of all, it is a challenge for research institutions and enterprises because the qualification of new 4-year trained specialists will be different and probably weaker than of the earlier graduates. Previously, the proportion of specialists trained in physics 5 and 6 years has been set by the Ministry of Education as 90% and 10% and conformed to the labor market tendencies. As a rule, qualification of the specialists trained 5 years meets the industry requirements, but the specialists having the 6-year training cycle are requested mostly by universities and some research institutions. However, in EU countries the proportion of professional bachelors and professional masters significantly differs – in Baltic countries, for example, it is about 70% and 30% depending on the industry, and hence the labor market in EU countries is more focused on professional master graduates than in Belarus.

The Improvement of master-level education in the field of physical sciences in Belarusian universities [2], Acronym: "Physics" (http://wpweb-prod.rtu.lv/physics/) project addresses the mentioned problem in one of the regional and Belarusian national subject areas - physics. The project is focused on the development of a standardized program forming the basis of modernized curricula in the field of functional nanomaterials production and photonics for all the Belarusian higher educational institutions.

The Improvement of master-level education in the field of physical sciences in Belarusian universities is a collaborative European Project awarded under the “Cooperation for innovation and the exchange of good practices” Program of Erasmus plus. The research project forms a collaborative initiative among four Belarusian academic institutions – the Belarusian State University (BSU), Belarusian State Technological University (BSTU), Francisk Skorina Gomel State University (GSU), and Yanka Kupala State University of Grodno (GrSU) – and three European academic institutions – Riga Technical University, the University of Cyprus, and KU Leuven University – as well as the Ministry of Education of the Republic of Belarus and two industrial partners (the Belarusian Physical Society and the Republican Nanoindustry Association). The research project is aimed at a reform of the master-level educational system in Belarusian universities in the field of Applied Physics, and more precisely in the field of functional nanomaterials production and nanotechnology including photonics. Riga Technical University, the Institute of Industrial Electronics and Electrical Engineering, is the coordinator of the project started in October 2015 for a period of three years.

## II. Background

New high-tech industries associated with nanotechnology have appeared in the last few years. Progress in this sphere necessitates close cooperation with the leading universities and research centers of Europe both in the area of scientific research and education. Unfortunately, such cooperation in the field of specialist training is hindered due to incompatible educational systems in Europe and Belarus. The Belarusian system of education in the field of natural sciences, computer science, and advanced engineering should be reformed towards voluntary acceptance of the Bologna practices.

The quality of education of Belarusian first-stage specialists is mostly comparable to that of European bachelors. The need for improvement is most crucial for the second stage (master level) of higher education. Changes should be made in nomenclature of specializations as well as in didactic materials to support successful transfer to the Bologna process.

Specifically, in order to bring a system of higher education into line with the principles of the Bologna process, the Ministry of Education of Belarus has set the task for Belarusian universities to reform their curricula for the majority of specialties in connection with the transition from the existing training system "5 + 1" to the system "4 + 2". However, the reduced period of studies at the 1st stage of higher education (specialists), shortened from 5 to 4 years, in the field of physics and high-tech engineering can lead to certain risks associated with the competence of trained personnel for scientific research institutes (SRI), design engineering bureaus (DEB), high-tech enterprises (HTE), and also Universities. The following risks can arise:

• The graduates studying within 4-year educational programs will have lower qualification than those of the old 5-year programs. Potential employers should develop a policy to take this into account;

• Traditionally, in Belarus a share of master-level graduates in relation to all graduates is very low (approximately 10 %). It is very likely that this share is going to grow up, because some employers will need personnel with qualification at least not lower than that offered by the old 5-year specialist training. The key problem is that the universities should be aware of this.

At the present time, 5-year graduates mostly meet the industry and high school requirements, whereas graduates after the 6-year training cycle are employed by universities, SRIs, DEBs, and HTE.

Considering the experience gained in EU, the number of graduates having the 6-year training cycle of "4 + 2" system will be increased, so both Universities and other employers (HTE, DEB and SRI) must be prepared to this situation. Thus, it is essential to develop practice-oriented 2-year master-level studentships at the 2nd stage of higher education, especially in such areas as physics and engineering.

## III. COMPOSITION OF SURVEY

The first step in this project was the acquisition of interests and needs from the industry representatives related to the labor market situation that was implemented as a survey of the project stakeholders. The survey based on the 360-degree feedback approach has been implemented in January – March 2016. The methodology also known as a multisource feedback or multisource assessment [3] is a process utilized by organizations to solicit information from a variety of workplace sources on employee's work-related behavior and/or performance. Such a feedback can also include, when relevant, a feedback from external sources interacting with employees, such as customers and suppliers or other interested stakeholders. 360-degree feedback is so named because it solicits feedback regarding employee's behavior from a variety of viewpoints (subordinate, lateral, and supervisory).

The Erasmus plus project Physics involves different groups of stakeholders: teachers, students, student organizations, administration, Ministry of education, and industrial partners. The partners bring together the expertise and approach of the former Tempus Energy project [4], in particular the experience gained in cooperation, when improving education in the field of the energy efficiency [5], and best practice in voluntary education standardization within the scope of joint study programs [6].

Taking into account the specific of stakeholders, the risks of miscommunication, language barriers and culture divergence the survey was arranged in small groups “face-to-face”. The questioners contained the list of open questions giving an opportunity for broad responses and personal comments. Meetings with the university’s deans, the heads of the departments and a representative of the Ministry of Education have been arranged as personal interviews that helped to get deeper responses and to get a perception that a respondent understood correctly the purpose of the survey, as the particular questions in the questionnaire.

The novelty of presented study derives from the attempt to figure out specific challenges, which the labor market awaits because of upcoming transition from the system "5+1" to the "4+2" (the numbers mark years reserved for the first and the second stage of higher education). This study focuses not only on risks of employers and academia, but also provides a perception about employers' expectations related curricula content and competences of the graduates. In the frame of the reformation the training longitude for specialists (bachelors) and master students it is the first attempt to get a feedback from the industry, however, our research is restricted only by applied physics specialties in classic type universities and the Academy of Science of Belarus.

## IV. ACQUIRING OF STAKEHOLDERS INTEREST

To study the specific needs of the labor market in Belarus, a survey of professional associations, research institutes, and universities as employers of master graduates was organized. The provided survey was developed by recommendations of different guidelines, EU partners input and was slightly modified taking into account the educational and cultural traditions of Belarus. The purpose of this survey was to:

- Acquire ideas about the market needs of 2-year practice-oriented master-level education in Belarusian Universities.
- Find, how employers judge the qualification requirements for graduates from industry-oriented masterships.
- Identify the training requirements of practice-oriented masterships for the planned "4 + 2" system.

- Provide an input to new two-years master-level training programs “Photonics” and “Functional nanomaterials”.

This survey is planned to be used in the process of working-out the model curricula and study programs for two-year master-level education in the field of physics including such specialties as "Functional Nanomaterials" and "Photonics". The survey involved 8 teams from 4 universities (Belarusian State University, Grodno State University, Gomel State University, and Belarusian State Technical University), and also the Belarusian Physical Society (BPO), Research Institute for Nuclear Problems of BSU, and Republican Association of Nano-Industry (RANI). A half of the questioned respondents belong to the age group 40-50 years, 25 % were older than 50, 15% were aged 30-40; 65 % of the responding groups were represented by teaching stuff of Universities, 25 % - by employees of research institutions.

## V. ACQUIRING OF STAKEHOLDERS OPINION

The labor market segment related to specialists in physics is of medium size in comparison with the segments of other high tech specialties. Every year approximately 300 students graduate from Universities of Belarus with specialization in high technologies with fundamental training in physics and contemporary high-tech technologies. By now this quantity of specialists is in a relevant balance with the labor market needs. Moreover, the graduates of BSU usually get an employment in the first year of graduating [7].

Average 10-15 master students are trained annually at the Physics Faculty of BSU, while in GRSU and GSU they have about 5 master students in physics every year. In the academic year 2015 - 2016, RSIs of the National Academy of Sciences trained 14 master students specializing in physics. BSTU trains 3-4 master students per year for the advanced engineering. At the Research Institute for Nuclear Problems of BSU on average 3 master students undergo internship every year.

The survey is divided in three logical parts. The first part is related to the industry – academia secondments, the second is devoted to the adjustment of the educational tasks and the labor market needs in this sector, and the last one is dedicated to identification of missing skills and abilities.

Below one can find a brief analysis of the selected questions, specially prepared for this survey, from the filled questionnaires of the above mentioned groups of respondents:

1) Do the Mastership graduates undergo internships at your organization? How much is internship important for the development of a potential worker? Are any benefits provided?

2) What is the usual duration of this internship?

3) Should internship pass as one module or be divided into semesters? How complicated knowledge may be given during the internship?

4) How many master students are graduating from the polled universities and institutes per year?

5) What information is needed from employers for the universities to organize the most effective internship for master students?

6) What should be the ratio of lectures/problem solving for master students at the university?

7) Is practice assignment adjusted by the university (by the university’s practice supervisor)? Is this assignment agreed with HEI if it is given by SRI/enterprise?

8) Suggestions related educational disciplines that are especially needed for the successful completion of practice work and for further work of master graduates at the University/SRI/ a company.

9) What additional disciplines are required in the program of master-level training? What disciplines should be supplemented (increased in volume) or abridged? Justify your answer.

10) What skills and knowledge should be acquired by a trainee at the University before joining the practice work in SRI/company?

11) What kind of skills and knowledge should be acquired by master students during practice work (secondments at the SRI/enterprise)?

12) Do we need close cooperation between SRI/enterprise and universities, between the practice supervisors in SRI/enterprise and at the university?

13) Is it customary to organize visits of the university representatives to SRI/enterprise to get acquainted with a progress of a practice work and vice versa of the SRI/enterprise representatives to the university to discuss a progress in practice work?

14) The requirements to a training course, in your opinion, after which one a student is completely ready to independent work in SRI/company?

15) How many master-level graduates, on average, can be offered to stay after practice for a permanent job in SRI/company?

16) What is the average number of young specialists annually employed to work in SRIs/companies after graduation from university?

17) What kind of knowledge/skills graduates are lacking to perform full-value work in SRIs/companies?

18) What is the average time required for the "additional practical training" of young graduates before they are ready to full-value work at university/SRI/enterprise?

19) What do you think about improvements in the educational process of master-level students necessary to reduce the time of an "additional training" for young specialists?

According to the survey, graduate master students can undergo internships (working practice) at universities, research institutes, and enterprises. A place of a secondment usually is chosen individually for each student. It mainly depends on a choice of the planned job place and of the master thesis topic. Masterships are focused on the preparation of master's thesis. As noted by the respondents, the practice should enhance knowledge gained during the first stage of higher education.

For the system "5+1”, at the first stage of education the main practice work is organized only in the graduation year during the preparation of a diploma thesis. As regards the students involved in the old one-year master-level programs have internships during the second semester: 2 weeks for the specialty “Physics” and 3 weeks for the specialty “Photonics”. According to the opinions of university teams, it is reasonable to carry out practice works in one module during the last semester because internship is oriented to the research activity. A level of practice organization and its content (complexity) should ensure high scientific level of master's thesis that, in turn, should be a significant backlog for a PhD thesis. The duration of lecture courses and trainings in problem solving should be about 1/3 to 2/3. This is at variance with the old situation when all University hours were dedicated predominantly to lectures (see Fig. 1). In addition, it was advised to develop an electronic library (containing didactic materials) for teachers and a virtual laboratory for distance experimentations similar with [8] developed by colleagues of Ku Leuven university.

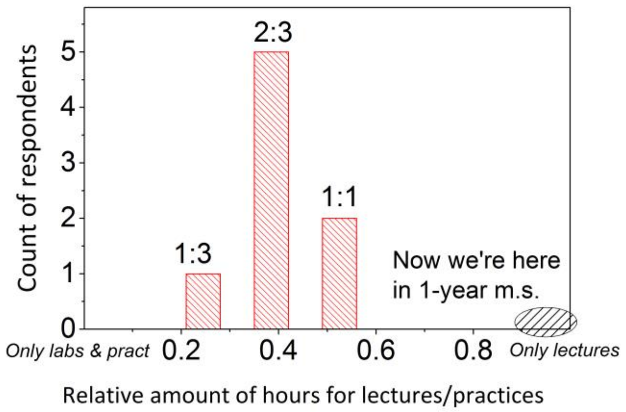


Fig. 1. The number of respondents *vs* relative amount of hours needed for lectures/seminars according to the opinion of the respondent groups.

## VI. SURVEY RESULTS

The second group of the survey questions is related to the adjustment of the educational tasks and the labor market needs in this sector. It is clear that the survey results are important for the master program standard. The assignment for practice work is given by the practice supervisor from the educational department (chair) in accordance with the program of practice. It is expedient to coordinate the technical matters of practice with the governing body of a practice place of employer (at an enterprise, research institute or university).

The survey results indicate, what educational disciplines are especially needed for successful completion of a practice work and for further work of master graduates at the University/SRI/company. Most of the respondents commonly marked disciplines associated with programming skill and specialization (75 % of respondents), as well as with theoretical physics (40 %). Among the additional disciplines required for the program of master-level training, most frequently mentioned by the respondents were “Physics of low-dimensional systems” (50 %), “Nanotechnology” (50 %), “Energy-efficient technologies and materials” (40 %), “Materials and technologies for nanoelectronics” (40 %). In addition, approximately 40 % of the respondents have noted the importance of the acquisition of skills in measurement and automation, microcontroller system programming, group symmetry theory, more extended quantum mechanics, statistical processing and fitting of the measured results.

As an additional recommendation, some respondents noted the need to establish stable interdisciplinary connections between the blocks of mathematical, physical, and special disciplines. Otherwise, the fundamental training may be reduced to a set of disparate information, therefore, the graduates could fail to acquire the adequate skills in solving of research problems or even can lose the ability to use their knowledge in practice.

About a half of the respondents expressed the expediency of reduction in time for “non-core” and social-humanitarian disciplines (for example, safety of human life, foreign languages, etc.). They believe that these disciplines, which are necessary for harmonious development of a personality, should be taught mainly at the secondary education level or at the 1st stage of higher education.

## VII. IDENTIFICATION OF MISSING SKILLS AND ABILITIES

Additionally, about 75 % of the respondents have noted such skills as theoretical calculations, construction of mathematical models for physical processes and phenomena, programming, automation of the experiment. Also, masters should attain general skills of working with control/measuring equipment; they should have knowledge in the field of general and theoretical physics, higher mathematics and mathematical physics, specialization disciplines (about 40 %).

It is important to work out the master-level programs enabling master students to acquire the adequate skills in production and technological activities, in the development of design and technological documentation, in the organization of scientific research. It is essential to provide knowledge of the system ESKD standards, ESTD, enterprise standards. Students must master operation of the particular experimental and technological equipment. All respondents have noted the need for cooperation between SRI/enterprise (employer) and university as well as between the practice supervisors from SRI/enterprises and the trainee-sending university. In Belarus such cooperation is organized within the framework of agreements between the SRI/enterprises and universities involved in traineeship. The regular secondments are negotiated during visits of the University representatives to SRI/enterprise to get acquainted with the progress in practice works and vice versa of the SRI/enterprise representatives to the University to discuss the progress in practice work.

Meetings of the representatives from enterprises and universities, as a rule, are organized during the contract preparation for practical training of master students or during the implementation of joint research projects. Regarding abilities of the students taking the training course, these students must be ready to full-value and independent work in SRI/company.

As a rule, the respondents noted that this is a case after complete mastering of the educational program at the 1st stage of higher education (during a five-year period of the study), in particular, after the practice for 16-18 weeks (usual period of practice at the first stage of higher education) at the place of future work. As regards the number of the master-level trainees whom SRI/company can offer to stay after the practice period for a permanent job, about 50-80 % of the master-level undergraduates, on average, can stay after their practice for a permanent job at the SRI/company, where they have prepared their thesis.

Among the distributable master-level graduates from the Belarusian universities, 100 % of the graduates (due to the practiced State Alumni distribution) have been offered their first job in 2015. It has been noted that the skills in teaching and industrial/technological activities; in the development of project, design, and technological documentation; in planning, organizing, and monitoring of the scientific research progress; contemporary knowledge in technological processes and practical electronics (such as controllers) are very essential and highly demanded at the labor market.

To reduce the "additional training" time, it is recommended to strengthen the fundamental training of master students in physical and mathematical disciplines, to improve their general technical skill, and to reduce time of studies for “non-core” and social-humanitarian disciplines.

The results obtained from the survey will be used for the development of the curricula content for 2-year master students in Belarusian Universities. Besides, recommendations relating the proportion of lectures and other-type activities will be given to the Ministry of Education to improve the correlation between the labor market needs and the tasks of HEIs.

Therefore, the project “Physics” provides two levels of the benefits for master students: at the local level all master students of BSU, BSTU, GSU, and GrSU benefit from the improvement of their curricula content (functional nanomaterials and photonics); at the national level the gain is possible due to taking into account of the recommendations associated with the labor market needs by all HEIs of Belarus, which offer training in the field of applied physics.

## VIII. Conclusions

In conclusion, it is advisable to reduce the time for studies of the “non-core” and social-humanitarian disciplines, since the training time at the undergraduate level will be reduced from 5 to 4 years. The respondents recognized, the basic knowledge in these subjects may be obtained mainly at a level of secondary schools.

The proportion of theoretical and practical training for master level students is recommended from 1/3 to 2/3 – the number of hours for laboratory/practical training must exceed the number of lectures at least by 30 %.

It is advisable to strengthen the training of master students in the field of programming skills and some specialized disciplines. Besides, it is recommended to introduce new disciplines related to physics of low-dimensional systems, nanotechnology, and biotechnology.

The majority of respondents noted the importance of capability to operate modern laboratory equipment and of mastering the computer science-related techniques.

All the above measures will require systematic changes in the approach to the teaching process of master students. It is required to go from the “mere lectures” way of training to a more balanced approach involving both practical and theoretical training of master students.

Although offered research is restricted only by applied physics specialties in classic type universities and the institutes of Academy of Science of Belarus, the research team expects that its outcomes will reduce the risks of employers and academia, and provides a perception about employers' expectations related curricula content and competences of the graduates during the transition period of higher education reform in Belarus.

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