New tendencies in teaching measurement science in the higher education

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Abstract. This article dwells upon the organization of the educational process at ITMO University for specialization 27.04.01 Standardization and Metrology for masters according to the individual educational standard 3++ of ITMO University. The main professional standards and areas of activity for the implementation of this specialization and the process of creating competencies based on professional standards and areas of activity are described.

1. Introduction
In 2017, ITMO University as an advanced university of the Russian Federation developed and adopted new educational standards with the code 3++ (ES3++). Those standards allow educational program managers to create professional competencies (PC), which must be mastered by graduates, on the basis of professional standards, results of analysis of graduates' professional areas of activity, and requirements for professional competencies for graduates in the labor market, generalization of foreign experience and consultations with leading employers.

The previous educational standards with the code 3+ (ES3+) had clearly defined competencies, with all general cultural (GCC) and general professional competencies (GPC) being unified for all specializations. It offered a list of 28 professional competencies, divided by activities. In addition, organizations have the right to supplement the set of competencies of graduates, taking into account the focus of the master’s program on specific areas of knowledge and activities. ES3+ of ITMO University for the Standardization and Metrology specialization contains 28 PCs [1]. Partners of the base organization helped to the PCs implementation, as this educational program is implemented in network form with D.I. Mendeleyev Institute for Metrology (VNIIM), Saint-Petersburg, Russia.

At ITMO University only the masters program is implemented for the Standardization and Metrology specialization. Therefore, this article will be devoted exclusively to the development of new level educational documents, and in particular to the educational standard 3++ for masters programs, and the experience of practical solutions to emerging problems.

2. Educational standards 3++ development
In December 2017, ITMO University created individual ES3++ for all specializations, and in the autumn of 2018 ITMO University began to implement those specializations with a recruited contingent.
ITMO University has created its own graduate competency model, which contains key competencies (KC), Soft Skills competencies (SS), general professional and professional competencies [2]. The first three are unified for all specialties, since their development allows the graduate to be successful in any field of his activity.

Formation of competence involves the organization and implementation of certain activities of students. Each competence contains several indicators of the competence achievement, describing the actions of graduates in the framework of the activity being mastered. For each indicator, separate knowledge, skills and abilities are specified.

For the development of KC, SS and GPC ITMO University introduced university-wide disciplines that are held for all masters of the university. For example, for the competences of the SS block these are disciplines such as Emotional Intelligence, Business and Scientific Ethics, Organization of Scientific Research, Internationalization of Scientific Research, Effective Team Management, Personal Efficiency and Time Management, and some others. Students independently choose one of them upon admission and attend classes simultaneously with students from other areas of specializations. This allows them to get acquainted with a large number of students, and accordingly, faster and easier to adapt to the life of the university.

If KC, SS and GPC were registered in ES3++ along with indicators, the PC needed to be installed by the educational program developers themselves based on existing professional standards and the list of graduate fields of activity that were previously proposed in ES3++. This system gives some freedom of action, since now you can create competencies that would fully comply with the developers' idea of the ideal graduate of the educational program.

According to the recommendation of the ITMO University Guidelines in ES3++, there should be 7-8 PCs, which is approximately four times less than in the previous ES3+ for this specialization. Professional competencies based on professional standards were created according to the scheme indicated in table 1.

### Table 1. Algorithm of PC formation from generalized labor functions.

| Stage          | Level                  | Example                                                                 |
|----------------|------------------------|--------------------------------------------------------------------------|
| Stage 1        | Generalized labor function | Organization of work to improve the quality of products in the organization |
| Stage 2        | Professional competence | Able to organize work to improve the quality of products in the organization |
| Stage 3        | Indicators of professional competence | • Organizes work on the development and implementation of new methods and means of technical control;  
• Monitors compliance with regulatory deadlines for product updates and preparing it for validation and certification;  
• Manages the employees of the technical control service. |

To create PCs for the Standardization and Metrology specialization, the authors of the article used professional standards "Specialist in technical quality control of products" [3], "Metrology Specialist" [4], and "Product Certification Specialist" [5]. For the required level of qualification of the magistracy (level 7), generalized labor functions for creating competences were selected, labor functions for creating competence indicators. The results obtained are shown in table 2.
Table 2. Professional competencies based on professional standards.

| Competence name | Name of the indicator of competence achievement | Professional standard |
|-----------------|------------------------------------------------|-----------------------|
| PC-2            | Able to organize work to improve the quality of products in the organization | PC-2.1 Organizes work on the development and implementation of new methods and means of technical control |
|                 |                                                | PC-2.2 Monitors compliance with regulatory deadlines for product updates and preparing it for validation and certification |
|                 |                                                | PC-2.3 Manages the employees of the technical control service |
|                 |                                                | 40.010 Professional standard |
|                 |                                                | "Specialist in technical quality control of products" |
| PC-3            | Able to organize work on the metrological support of the organization | PC-3.1 Analyzes the state of metrological support in the organization |
|                 |                                                | PC-3.2 Manages employees of the organization engaged in metrological support |
|                 |                                                | PC-3.3 Plans the activities of the organization's metrology service |
|                 |                                                | PC-3.4 Organizes work on the accreditation of the organization in the field of ensuring the uniformity of measurements |
|                 |                                                | 40.012 Professional standard |
|                 |                                                | "Metrology Specialist" |
| PC-4            | Able to organize work to confirm the compliance of competitive products and services and quality management systems | PC-4.1 Carries out the organization to confirm the conformity of products and services in the organization |
|                 |                                                | PC-4.2 Implements the organization of confirmation of compliance with the organization's quality management system |
|                 |                                                | 40.060 Professional standard |
|                 |                                                | "Product Certification Specialist" |

For competencies on the basis of professional activities, it was necessary to independently consider the very wording of competencies and indicators. The results are shown in the table 3.

Table 3. Professional competencies based on professional activities.

| Competence name | Name of the indicator of competence achievement | Professional activities |
|-----------------|------------------------------------------------|-------------------------|
| PC-1            | Able to conduct modeling of thermophysical processes in nature, technology and experiment | PC-1.1 Understands and analyzes thermophysical processes in nature, technology and experiment |
|                 |                                                | PC-1.2 Identifies the relationship of thermophysical processes in nature, technology and experiment |
|                 |                                                | PC-1.3 Creates models of thermophysical processes in nature, technology and experiment |
|                 |                                                | The scope of numerical and full-scale modeling of thermophysical processes in nature, technology and experiment, the calculation and design of new heat engineering equipment |
Table 4. Variable-profile professional module (specialization).

| "Specialization 1" Metrological support of devices and systems in medicine and optical engineering | "Specialization 2" Metrological support in the energy sector |
|---|---|
| Reliability of devices and systems | 4 crd | Reliability of technical systems | 4 crd |
| Measuring systems and complexes | 4 crd | Methods to ensure the unity and traceability of measurements | 4 crd |
| Diagnostics of devices and systems | 4 crd | Design principles | 4 crd |
| Physico-chemical methods of analysis based on hybrid systems | 3 crd | Physico-chemical methods of energy analysis | 3 crd |

As can be seen from tables 3 and 4, the developers of the educational program tried to illuminate as much as possible all types of tasks and objects of graduates’ professional activity. On the basis of the obtained competencies a new curriculum was created.

At ITMO University educational program consists of several modules. PCs are formed only in the profile professional and variable-profile professional modules. Variable-profile professional module contains various specializations that a student may choose to master. This module takes at least 15
credits, each specialization must contain at least three disciplines. Table 4 shows the specializations that were developed by the authors for the direction of the specialization.

3. Conclusion
The educational program managers have created the new program with unique competence model in consequence of adaptation of the new educational standard. According to the results, the authors of the article can conclude that the new educational standard of ITMO University is more focused on students obtaining universal competencies as there are more than professional ones. These competencies will allow the graduate to better navigate general life situations, find their place in life and be successful in any situation. The number of PCs has been greatly reduced compared with the previous standard, however, now developers can create PCs and indicators for them themselves, thereby developing unique educational programs with authoring courses that would be updated according to professional standards and "foresight".

References
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