S.I. Gerasimov

T.E. Lubovskaya

S.B. Mogilnitsky

Yu.P. Pokholkov

UDC 378.14

Nanotechnology Education Programmes: Experience in Accreditation

Siberian Transport University
National Research Tomsk Polytechnic University
Association for Engineering Education of Russia
S.I. Gerasimov
Fund for Infrastructure and Educational Programs (RUSNANO)
T.E. Lubovskaya
Russian State Agrarian University – Moscow Timiryazev Agricultural Academy
N.L. Yablonskene
National Research Tomsk Polytechnic University
Association for Engineering Education of Russia
S.B. Mogilnitsky, Yu.P. Pokholkov, A.I. Chuchalin, E.Yu. Yatkina

The paper presents the results of pilot accreditation of nanotechnology education programmes. The analysis performed allowed revealing a number of challenges in engineering education of Russia and suggesting solutions ensuring its future development and competitive growth of Russian economy in general and professionals, in particular.

Key words: professional and social accountability accreditation, education programme, criteria.

Introduction

Against the backdrop of the sixth wave of innovations and when the national economy growth is associated with implementation of breakthrough technologies, there is an urgent need in professionals possessing new type of competencies. Lack of qualified personnel is one of the major challenges for the development of national priority industries significantly invested over the past ten years. **Nano systems** are one of the priority areas the RF is currently focused at [1].

One of the factors which facilitates the development of nanotechnologies in the RF is improvements in staff training since it is the personnel who develop and operate nanotechnologies and whose high qualification is attributed to the successful development of the national engineering education system. High quality of education is secured by professional and social accountability accreditation (PSAA) of education programmes (EP) implemented by higher education institutions (HEI). Professional and social accountability accreditation is an approve of quality and level of education provided by higher education institution in compliance with the programme accredited; PSAA confirms that the education provided meets all professional standards in effect and labour market requirements to professionals, workers, and officials [2].

PSAA experts are representatives of the industry (employers), universities, and scientific centres. PSAA is a tool to secure the interests of all parties (stakeholders): applicants and their parents, students, employers, government, and the society in general can be sure that the HEI and the provided education meet their expectations and requirements.

In 2014, Association of Engineering Education of Russia (AEER) and the Fund for Infrastructure and Educational Programmes

(RUSNANO Group) signed a contract aimed t**o develop methodological and organizational basis, put together a team of experts, and accredit higher education programmes provided in the sphere of nanotechnology.**

In the course of the project (2014-2015), PSAA methodology was developed, which prescribes the procedure and criteria of accreditation, includes a set of documents describing the programme and provides a guideline for education programme estimation. Based on this methodology, a pilot accreditation has been conducted. Within the project, 20 education programmes in metrology and nanoelectronics provided at 9 HEIs and 15 education programmes in nanophotonics and nanomaterials provided at 8 HEIs of Russia have been accredited. The experts participating in the accreditation were trained in the course of the project implementation.

Criteria for professional and social accountability accreditation

To estimate education programme quality and relevance to nanotechnology sector, a system of global and local criteria was developed. The global criteria, which reflect the requirements of FIEP RUSNANO, are focused on real economy demands, reveal whether the graduates will be in demand, and elicits if the programme content and education outcomes meet the professional standards in effect. As for the local criteria, they allow giving integrated consideration to the educational prossess and specifying if the programme meets the international standards of Washington Accord (WA) [3] and European Network for Accreditation of Engineering Education (ENAEE) [4]. Conformance to the standards of WA and ENAEE means that the education degree obtained in the accredited programme is equivalent to that in the signatories (the USA, Canada, the Great Britain, Japan, etc. – 17 countries in total) and that the programme can be marked by EUR-ACE® Label, certifying conformance to EUR-ACE® Framework Standards and Guidelines (EAFSG) [5].

The global and local criteria developed and used for accreditation within the project by FIEP RUSNANO and AEER are as follows:

Global (integral) criteria:

- **Criterion 1.** Education programme objectives and outcomes. Programme content.
- **Criterion 2.** Resources.
- **Criterion 3.** Programme efficiency in terms of labour market demand and graduates' relevance, graduate positioning and promotion.

Each global criterion comprises a number of local criteria (see Tab. 1).

Table 1. Global and Local Criteria

Global criteria (FIEP RUSNANO)	Local criteria (AEER)
Criterion 1. Education programme objectives and outcomes. Programme content	1.1. Programme objectives 1.2. Programme content and outcomes 1.3. Professional training
Criterion 2. Resources	2.1. Students and educational process 2.2. Academic staff 2.3. Programme resources
Criterion 3. Programme efficiency in terms of labour market demand and graduates' relevance, graduate positioning and promotion	3.1. Graduates

A.I. Chuchalin

N.L. Yablonskene

E.Yu. Yatkina

PSAA procedure is held in the established standard form and includes: submission and pendency of application, execution of contract with an accrediting organization (AO), internal audit, analysis of internal audit results, establishment of expert commission, audit, Accreditation Council (AC) Session for audit results analysis, confirmation of AC decision by the AEER Administrative Board and/ or the Accreditation Council of Russian Nanoindustry Association (RNA) [6].

The analysis of global and local criteria [5, 7-9] showed that they are interrelated. Moreover, the suggested system of criteria, if there is an agreement signed by both parties, makes it possible for the education programme that have been through PSAA process to be awarded with three certificates: certificate awarded by Russian Nanoindustry Association, national and international certificates by AEER (EUR-ACE label/ certificate of significant conformity to WA standards).

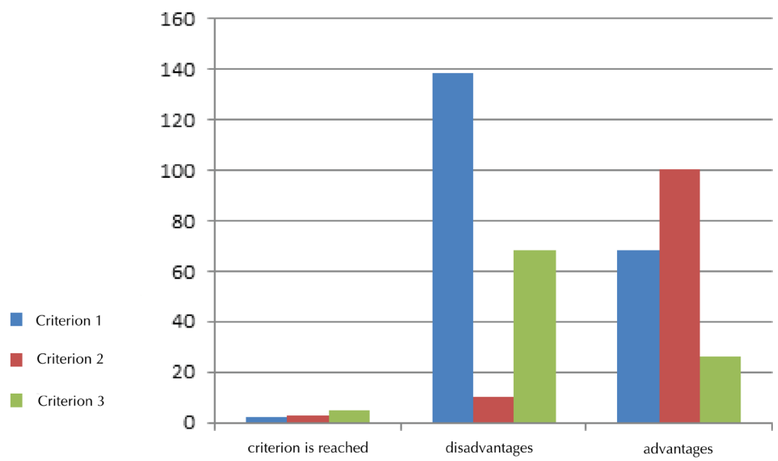
Pilot accreditation of nanotechnology education programmes

This paragraph describes the result obtained via application of the developed methodology and criteria. Within the scope of the project, 35 Master's degree programmes were accredited, including 16 programmes in Electronics and Nanoelectronics (11.04.02, 11.014.04, 12.04.01, 28.04.01), 4 programmes in Standardization and Metrology (27.04.01), 9 programmes in Nanomaterials (22.04.01, 22.04.02, 03.04.02, 150100.68, 270800.68), and 6 programmes in Nanophotonics (12.04.03, 200400.68). The programmes are implemented in 17 leading national universities, including one federal and six national research ones. As mentioned above, the programme was estimated in terms of three criteria, and each criterion was analyzed relating to three categories: programme advantages, criterion is reached (no comments), programme disadvantages. Estimation results are given in fig. 1 – 3.

As seen in the graph, all criteria are estimated in terms of three categories: there were 410 estimates with comments and 10 estimates without ("criterion is reached").

In the course of accreditation, 216 advantages and 194 disadvantages were identified. Most disadvantages are generated within criterion 1 "Education programme objectives and outcomes. Programme content" and advantage – within criterion 2 "Resources" (fig. 2).

Fig. 1. Criteria estimated in terms of three categories



The estimates indicate modern resource base and highly-qualified academic staff at leading national universities, which is attributed to universities' participation in national priority and international projects. Low estimate of criterion 1 indicates that academic departments lack knowledge in developing education programmes: firstly, there should be correlation between programme objectives and outcomes, and secondly, programme content should meet employer's requirements and conform to professional standards in the sphere of nanotechnology.

However, it is difficult enough to answer the question whether this or that disadvantage is attributed to a particular programme or a particular university in general. This is due to the fact that within the pilot project there was only one programme accredited at 9 universities (50% of experiment participants), i.e. about 25% of the accredited programmes. Therefore, we identified advantages and disadvantages, which characterize a particular programme or a particular university (Fig.3).

The disadvantages are low rate of academic mobility of both students and staff, poorly developed system of graduate's employment and career support. To some extent, these disadvantages result from intrinsic reasons, such as development of a new social and economic pattern, economic crisis, higher education reforms, etc. However, the experience of national leading universities (National University of Science and Technology MISIS; Higher School of Economics, National Research University; ITMO University (Saint-Petersburg National Research University of Information Technologies, Mechanics and Optics); TPU (National Research Tomsk Polytechnic University) and other participants of Global Universities Association) shows that these challenges can be overcome.

Conclusion

Based on the accreditation results, the suggested methodology proved to be efficient for education programs in nanotechnology and this conclusion is supported by the representatives of companies operating within technology-intensive industry. PSAA appeared to be

Fig. 2. Criteria estimation

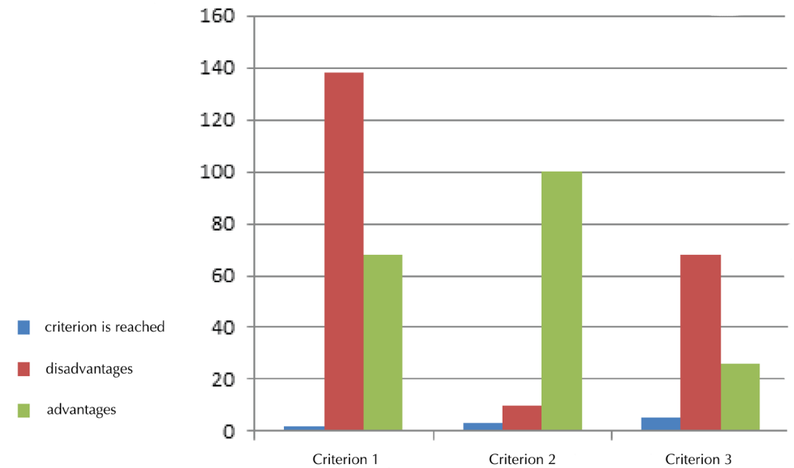
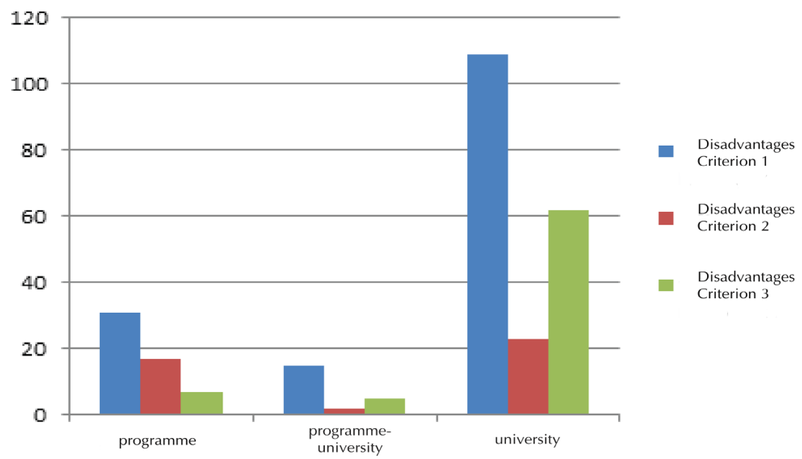


Fig. 3 Criteria estimated regarding university or programme



an important issue for real economy and the experience can be disseminated within the cluster including RUSNANO, JSC Academician M.F. Reshetnev Information Satellite Systems and other high-tech companies of the RF, as well as higher education institutions training professionals for the companies.

The analysis performed allowed revealing a number of challenges in engineering education of Russia and suggesting solutions ensuring its future development and competitive growth of Russian economy in general and professionals, in particular.

EDUCATION PROGRAMMES

ENGINEERING EDUCATION
19'2016

REFERENCES

1. Ukaz Prezidenta Rossiiskoi Federatsii «Ob utverzhdenii prioritetnykh napravlenii razvitiya nauki, tekhnologii i tekhniki v Rossiiskoi Federatsii i perechnya kriticheskikh tekhnologii Rossiiskoi Federatsii» ot 7 iyulya 2011 g. № 899 [The order of the President of the RF "Statement of priorities in science and technology development and approvement of the list of urgent technologies in the Russian Federation" dated July 07, 2011, № 899]. Moscow, 4 p.
2. Federal'nyi zakon ot 29 dekabrya 2012 g. N 273-FZ «Ob obrazovanii v Rossiiskoi Federatsii» [Federal law "Education in the Russian Federation" dated December 29, 2012, № 273-FZ]. Moscow, 105 p.
3. Washington accord: official website [Electronic resource]. URL: http://www.washingtonaccord.org.
4. European Network for Accreditation of Engineering Education [Electronic resource]. URL: http://www.enaee.eu (Accessed 20.05.2016).
5. Standards and Guidelines for Quality Assurance in the European Higher Education Area: ENQA official website [Electronic resource]. URL: http://www.enqa.eu/wp-content/uploads/2013/06/ESG_3edition-2.pdf (Accessed 01.04.2014).
6. Gerasimov S.I., Tomilin A.K., Tsoi G.A., Shamritskaya P.S., Yatkina E.Yu., ed. Chuchalin A.I. Kriterii i protsedura professional'no-obshchestvennoi akkreditatsii obrazovatel'nykh programm po tekhnicheskim napravleniyam i spetsial'nostyam: informatsionnoe izdanie [Professional and social accountability accreditation of technical education programs: riteria and procedure (information edition). Tomsk: Tomsk Polytechnic University Publ., 2014. 56 p. URL: http://www.ac-raee.ru/files/criteria/2014_criteria.pdf.
7. Gerasimov S.I., Mogil'nitskii S.B., Chuchalin A.I., Shamritskaya P.S., Shaposhnikov S.O. Aprobatsiya novykh kriteriev professional'no-obshchestvennoi akkreditatsii Assotsiatsii inzhenernogo obrazovaniya Rossii [Piloting a New Set of the AEER Accreditation Criteria]. Vysshee obrazovanie v Rossii [Higher Education in Russia], 2016, no. 3, pp. 5–16.
8. Rukovodstvo po otsenke obrazovatel'nykh programm v oblasti tekhniki i tekhnologii. Ch.1 (Eticheskii kodeks eksperta na 3 str.) [Assessment of education program in technology: guidelines. Part 1 (Expert's code of ethics on 3 pages)] [Electronic resource]. URL: http://www.ac-raee.ru/files/criteria/rukovodstvo-2011_Part_1.pdf.
9. Rukovodstvo po otsenke obrazovatel'nykh programm v oblasti tekhniki i tekhnologii. Ch.2. Instruktsii po zapolneniyu form (tol'ko dlya ekspertov, zashchishcheno parolem [Assessment of education program in technology: guidelines. Part 2. Instructions for filling forms] [Electronic resource]. URL: http://www.ac-raee.ru/files/criteria/rukovodstvo-2011_Part_2.pdf.