AKKORK

Agency for Quality Assurance in Higher Education and Career Development

**Approved**

Chairman of the Advisory Council

_____ V.D. Shadrikov

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# REPORT
# on the Results of External Assessment of the Programme "Applied Physics and Mathematics" (Master's Degree)
# Saint Petersburg State University


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# SUMMARY OF THE PROGRAMME

The programme "*Applied Physics and Mathematics*" (Master's degree) is implemented within the field "Applied Mathematics and Physics" under the SPBU Educational Standard and results in Master's degree. The programme is managed by Head of the Chair of Computative Physics Sergei Yakovlev.

AKKORK experts visited the university in person within the external programme assessment procedure from the 6th to the 7th of March, 2018.

***Strong points of the programme under analysis***

The quality of learning outcomes in graduates of the programme "Applied Physics and Mathematics" (Master's degree) implemented at the SPBU was estimated as high, while quality assurance of education provided by the educational institution in programme implementation was found to be sufficient. Strong points of the programme include the following.

- Saint Petersburg State University, where the programme is implemented, is the oldest and one of the most influential Russian universities. It enjoys a special status along with Lomonosov Moscow State University. An SPBU diploma is a guarantee of competitive advantage that graduates in this programme have in the regional, national, and global labor markets.
- The content of the programme and the competency-oriented graduate model are in accordance with a series of professional standards: 06.001 "Programmer", 40.008 "Expert in the Organization and Management of Research and Developement", and 40.0411 "Expert in Research and Development".
- The subjects in computer simulation that the programme includes are highly topical and offer quality education. This is especially important in the context of international research.
- The programme was developed and is implemented in tight cooperation with leading research institutions and companies in the respective field both in Saint Petersburg and across Russia: The A. Ioffe Physical Technical Institute of the Russian Academy of Sciences, B. Konstantinov St. Petersburg Nuclear Physics Institute, National Research Center "Kurchatov Institute", GK Tavrida Electrik JSC, and more (a total of over 50 institutions and companies).
- Employers are involved in each stage of programme implementation, which includes: membership in the Teaching Commission and Programme Council to determine the purposes and content of the programme, participating in the State Final Examination, teaching specialized courses, agreeing graduate qualification work subjects, hosting student practice and internship, etc. The effort to align training with the needs of specific organizations commands sincere respect. SPBU is among world's top 20 higher education establishments by interaction with employers.
- Students' research work is largely practice-oriented and related to their occupation.

- The educational process within the programme is ensured by a highly-skilled teaching staff. About 45% of the teaching staff are Doctors of Science and about the same percentage PhDs. All the teachers are active researchers, producing a total of 295 articles in RSCI, Web of Science, and Scopus-indexed journals over the past 2 years. About 10% of teachers in the programmes have carried out research and teaching work abroad int he recent years. The subjects of graduate qualification works are determined by teachers and employers whose scientific interests and research areas lie within the field of Applied Mathematics and Physics.
- 9 SPBU chairs are responsible for implementing the learning process within the programme. The set of subjects ensures fundamental basic training in Physics and Mathematics while extending students' scientific scope to include from biophysics to atmospheric physics as branches of physics, from numerical computation of partial differential equations to object-oriented programming as specific areas of applied mathematics and computer science.
- The university offers excellent scientific and computing equipment, in particular for physical research. Modern software is purchased. The instrumentation of practical training in Physics inspires respect. The SPBU Research Park consisting of 26 resource centers offers state-of-the-art equipment. Essential facilities for the programme include the laboratories, the Computing Center, and the resource centers located in V. Fock Physical Research Institute near the main teaching building for Applied Physics and Mathematics. Teachers and students of the programme "Applied Physics and Mathematics" have regular access to scientific equipment, materials, and computing tools that enable cutting-edge research in science and technology. Laboratory and practical classes enable students to acquire experience of working in scientific laboratories and become contractors under research grants, which is extremely important to their further employment in the field.
- The equipment is modern and used for global-scale research.
- SPBU possesses one of the best university libraries across Russia. The Gorky Library offers over 7 million items as well as subscription to all influential physical journals and electronic abstract databases. It provides teachers and students of the programme with up-to-date professional literature in a quick and efficient manner.
- Of great importance to further interaction with the global academic community, in particular through academic articles and conferences, is the fact that certain subjects are taught in English.
- The University's management encourages student research by organizing international youth conferences and sponsoring outstanding students' trips abroad to report at conferences as well as international internships, which commands respect.
- Living conditions are obviously important to student performance in the programme. Numerous measures have been taken by the University's management in this respect. All non-resident students are offered dormitory accommodation.

Those residing in Saint Petersburg have the option as well because the research facilities and some of the teaching buildings are located outside of the city. It should be noted that students from Petersburg get dormitory accommodation on a second-priority basis, which the experts reported as the programme's weak point in the respective section.

- It is noteworthy that the SPBU management encourages physical training and sports as part of students' education, offering broad opportunities through the University's sport resources. The purpose is not only to maintain and improve student health and increase their interest in studying but to foster team work and teach students to use their internal resources in order to attain their goals.

***Weak points of the programme under analysis***

The experts found a number of shortcomings and areas of potential improvement for the Master's programme "Applied Physics and Mathematics".

- Some employer and student representatives reported the time that students are offered for research work to be insufficient. This is due to a tight curriculum, restricted academic hours, and a large number of subjects to be covered.
- Some graduates referred to their work experience in expressing the opinion that related subjects such as Chemistry should be covered in more detail. A student survey on the content of Master's graduate qualification works revealed this problem as well. Since the number of academic hours is limited, a focus on extracurricular classes is recommended as well as measures to develop in students the skills necessary to work with professional literature independently, in particular in related branches of science. The concept of university education and today's scientific situation with the borders between disciplines continuously blurring make the effort absolutely necessary. This is especially important for academic-oriented graduates. Besides, the high rate of economic development where old professions cease to exist and new one emerge require graduates who seek industrial employment to have a wider range of knowledge as well.
- A narrow, highly formalized approach to physics as a major showed in the course of direct assessment of competencies. Students often failed to relate their knowledge to simple physical phenomena, which indicated poor analytical skills and inability to use the existing knowledge. This problem is largely due to students' inability to use information from related branches of science to get a broader picture of the objects or phenomena described in their research works.
- A number of lecturers of the programme admitted the university to have advanced scientific equipment but reported its efficient use within the learning process to be prevented at times. Students cannot use certain equipment of their own because it is too complex and expensive, so they have to watch experts carry out the experiments. The University has a lack of high-quality modern *training* equipment. The risk of expensive equipment breaking up further complicates the situation since to raise enough funds for repair is difficult. Unfortunately, teachers

reported the grants received to purchase specific devices not to cover their repair and maintenance.

- Even though the SPBU administration has taken a number of measures to ensure student feedback (the Student Council, On-Line Reception, etc.), the experts' meeting with students showed student awareness and use of the tools to be poor. Student surveys to assess the quality of educational courses appear to be occasional and not a regular work practice. Students have to display initiative if they want programme managers or the University's administration to know their opinion on the content of the programme, form of instruction, social and household problems (accommodation, transport, meals, etc.). The scope seems to be too large for yesterday's schoolchildren.
- Students reported the following social and household problems to prevent full-fledged programme implementations.

1) Students residing in Saint Petersburg can only get dormitory accommodation in Petergof a month after non-resident students have been provided with accommodation. The shortage of dormitory beds is aggravated by long-running renovation. The way from the main part of the city to the main academic building takes up to ninety minutes.

2) Some classes within the programme take place in the city center. This causes a similar conveyance problem for students who live in dormitories, especially if they have to arrive for the first class.

3) None of campus student canteens work on Sundays.

4) Some classrooms are unacceptably cold during the cold season.

Experts found certain rooms in the main academic building to need renovation (e.g. floor and wall renovation in the Physical Practicum corridor).

***Key expert recommendations on the programme***

- Managers of the programme should improve the curriculum so that senior students have more time for independent work, primarily research, and work experience internship. This should probably include introducing additional elective courses to the curriculum. This will enable students who are more or less certain that they want a scientific career to carry out more research and those who prefer industrial employment to take further work experience internship.
- The status of a university includes not just a broad range of occupations offered but all-round education for each graduate enabling them to develop on their own and fill any knowledge gaps. This requires them to analyze the objects that they study and employ their previous knowledge. This ability is critical not only for research-oriented students but for highly skilled experts who seek industrial employment. Today's rapidly developing world is characterized by constant blurring of interdisciplinary borders and the emergence of new branches of science as well as new professions and practical problems in industry. It is important for any expert to be aware of the processes and develop a broad scope of knowledge. This is a problem that many higher education establishments are faced with at

present. It is brought around primarily by today's secondary education, which mainly covers just the small range of subjects for the Unified National Exam. The university should help students acquire knowledge in related disciplines, which can be done through further courses.

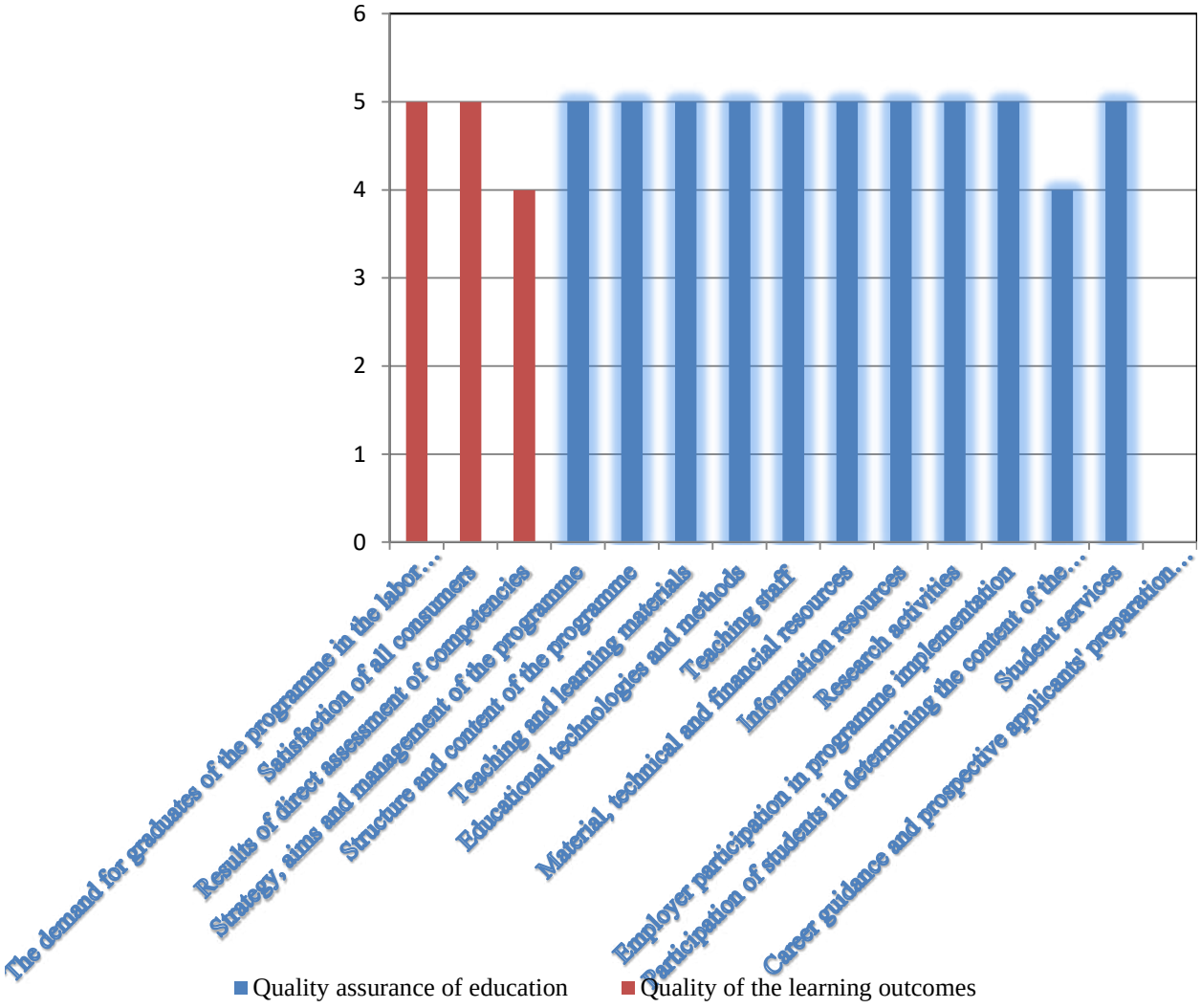
- More attention should be paid to developing analytical skills in students. This will enhance the effect of the education offered as well as the extent to which it is mastered, i.e. increase its efficiency. Students should be enabled to study physics not as a dead science that is down to formulas and relations but a set of instruments to study specific problems by finding the physical meaning of certain processes and phenomena, which involves their entire knowledge. Besides, the analytical approach would motivate students to find any necessary information in literature, in particular in related disciplines that are not included in the core programme.
- The SPBU administration should pay special attention to training devices and equipment in training laboratories for Applied Mathematics and Physics. Funds should be allocated to purchase any necessary equipment as well as to ensure its regular repair, maintenance and upgrading. Quality training equipment is absolutely necessary as a bridge to lead students to the high-grade modern equipment offered by the SPBU Research Park.
- The University's administration as well as the programme management should improve the student feedback scheme. Students view the initiative to file a suggestion or complaint on any issue related to programme implementation as having the potential to cause a conflict and thus tend to avoid is. It is thus essential that student surveys, both anonymous written or electronic ones and joint meetings of students and programme managers should be a regular work practice normally initialized by programme managers.
- The University's administration should pay due regard to the above students' suggestions regarding the studying conditions of the programme and campus life. First and foremost, effort should be made to provide dormitory accommodation to all students in the programme as the campus is located far from the main part of the city. Inspections should be carried out to make sure that sanitary requirements (room temperature) are met in all classrooms of the main academic building. Any repairs or improvements necessary should be done.

***Assessment profile of the learning outcomes and quality assurance of education***

| No. | Critetion | | Assess ment |
|---|---|---|---|
| *I* | *Quality of the learning outcomes* | | |
| | 1. | The demand for graduates of the programme in the labor market | *5* |
| | 2. | Satisfaction of all consumers | *5* |

| | | | |
|---|---|---|---|
| | 3. | Results of direct assessment of competencies | *4* |
| *II* | *Quality assurance of education:* | | |
| | 1. | Strategy, aims and management of the programme | *5* |
| | 2. | Structure and content of the programme | *5* |
| | 3. | Teaching and learning materials | *5* |
| | 4. | Educational technologies and methods | *5* |
| | 5. | Teaching staff | *5* |
| | 6. | Material, technical and financial resources | *5* |
| | 7. | Information resources | *5* |
| | 8. | Research activities | *5* |
| | 9. | Employer participation in programme implementation | *5* |
| | 10. | Participation of students in determining the content of the programme | *4* |
| | 11. | Student services | *5* |
| | 12. | Career guidance and prospective applicants' preparation (Bachelor's programme) | |

## Assessment profile of the learning outcomes and quality assurance of education



# QUALITY OF THE LEARNING OUTCOMES

## *1. Demand for the graduates of the programme on the federal and regional labor market*

***Criterion assessment: excellent***

***Analysis of the role and place of the programme***

The programme "Applied Physics and Mathematics" characteristically combines fundamental basic training in physics and mathematics with extensive training in modern information technology. The content of the programme thus corresponds to the current trends in the labor market since computer simulation of technical processes as well as natural phenomena, using computers to calculate various devices and structures, and software development is an essential, or even primary part of a modern researcher's or engineer's work.

The city of Saint Petersburg has always been one of Russia's biggest centers concentrating research and educational institutions as well as represenatives of knowledge-intensive industries. The Saint Petersburg Employment Office reports the demand for experts who are knowledgeable in physics and mathematics to grow continuously, while that for software engineers has more than doubled over the past 3 years. The Labor Committee of Saint Petersburg and Leningrad Region reports the demand for design engineers to have doubled from 2015 and 2017 and expects more jobs in this and similar fields in the nearest future. Even though the above reports to not specify the share of jobs that applied mathematics and physics account for, the assumption appears sound that the demand for graduates in the programme grows along with the total figures. According to the Saint Petersburg Statistics Agency, the number of employees in the industries targeted by the programme has increased by about 6.5 thousand over the past year, which is more than the total graduate count of all educational institutions in Saint Petersburg that offer training in Applied Mathematics and Physics. This and other data that the educational institution has included in the self-evaluation report as well as the information that the experts found out during their visit to SPBU suggest that nearly all graduates in the programme find employment in the labor market of Saint Petersburg and Leningrad Oblast.

Saint Petersburg universities that offer Master's programmes in Applied Mathematics and Physics apart from SPBU are Peter the Great St. Petersburg Polytechnic University and the St Petersburg National Research Academic University of the Russian Academy of Sciences. SPBU accounts for over 40% of the total graduates in the field. As the labor market grows continuously, SPBU graduates seldom have to compete directly from graduates of other higher education establishments. Another factor is that the Master's programme field "Applied Mathematics and Physics" includes a wide range of specializations, some of which are unique. Such specializations at SPBU are Computational Physics, Electronic and Ionic Processes in Gases and Liquids, Magnetic Resonance and Tomography, Nanobiophysics, Optics of Semiconductor Nanostructures and

Nanotechnlogy, Laser Physics and Quantum Optics, Oceanic and Atmospheric Physics, and Physical Principles of Functional Material Diagnosis; at the Polytechnic University, those include Fluid and Gas Dynamics and Thermal Physics, and at the RAS Academic University, Theoretical Computer Science, Software Development, Algorithmic Bioinformatics, and Nanobiophysics. SPBU cooperates with a number of companies to ensure further employment guarantees for its graduates. Those include the industrial group Tavrida Elektrik, a producer of electrical equipment with offices in Petersburg, Moscow, and Sevastopol.

***Analysis of information indicators submitted by the higher education institution (conclusions)***

- *The percentage of students combining study at the higher education institution with work in their specialization field: 30%*
- *The percentage of graduates who found employment within one year after the graduation from the educational institution in the field of training (specialization) within the programme: the educational institution did not provide any data for the recent year; 64% over the past 3 years*
- *The percentage of graduates employed on request of corporate employers: n/a; the share of graduates who were employed following internship: 10 to 20%*
- *The percentage of students trained on request of employers, for example, under tripartite (target) agreements: 17%*
- *The percentage of graduates working in their specialization fields within the region: 32%*
- *The percentage of graduates working in their specialization fields outside of the region: 32%*
- *Number of complaints about graduates: 0*
- *Number of positive feedbacks on graduates from organizations: 8*
- *The percentage of students in the programme admitted for Master's programmes who have completed training under Bachelor's programmes: about 100%*
- *The percentage of graduates of the educational institution in the programme as related to that of graduates of all other regional higher education institutions in the programme: 40%*

## *2. Satisfaction of consumers with the learning outcomes*

***Criterion assessment: excellent***

- *The percentage of employers who believe that the competencies of graduates of the programme:*

• *fully comply with the requirements to modern experts in the industry: 42%*

• *essentially comply with the present-day requirements to experts in the industry with minor reservations: 58%*

• *there are few graduates whose competencies comply with the present-day requirements to experts in the industry: 0%*

• *do not comply with the present-day requirements to experts in the industry: 0%*

•*The percentage of graduates satisfied with the learning outcomes: 80%*

### *3. Direct expert assessment of competencies*

***Criterion assessment: good***

During the visit, a direct assessment of the competencies of graduate students was conducted. 7 students of the 2nd year of the Master's programme took part in the direct evaluation, which is 30% of the graduate course.

Students were offered to prepare a short presentation on their future graduate qualification work and answer a series of questions asked by the experts within the direct assessment.

To analyze the formation of competencies, an experts selected the following:

- Assessment of competencies characterizing the individual's personal qualities as an integral part of their professional competence:

  OKM-4 Prepared to acquire new knowledge and skills using information technology, in particular in new spheres, and use them in practical activities.

- Assessment of competencies aimed at the development, maintenance and improvement of communications:

  PK-6 the ability to present the plans and outcomes of their activities in a professional manner in Russian and English using state-of-the-art technology.

- Assessment of professional competencies ("competence core"), including the competencies reflecting the need (requirements) of the regional and/or federal labor market, depending on the main consumers of the graduates of the programme:

  PK-1 the ability to use profound knowledge in the respective field of study in professional activities;

  PK-2 the ability to set problems for theoretical and/or experimental research and solve them using physical and mathematical methods, modern equipment, and information technology.

Experts asked students the following questions during the direct assessment of competencies:

1) Please describe the area of your research and the specific issue that your graduate qualification work deals with.

2) Please describe the research methods you use, in particular any experiments carried out for your graduate qualification work, the mathematical

tools used to model the phenomena studied, analytical and numerical simulation methods.

3) Please describe your key findings at present.

4) Please outline your further research and share your future work/study plans after you complete the Master's programme.

5) A number of clarifying questions were asked, e.g. to name the types of equations used, explain the physical and mathematical meaning of their parameters, explain any symbols and abbreviations, etc. Students used laptops to present their work. Paper or the blackboard was used for writing where necessary.

The direct assessment of competencies revealed the vast majority of students to have a mastered the competencies sufficiently. See the table below for the quantitative data.

| Level / Percentage of students | Sufficient level (students coped with 80 % of the proposed tasks) | Acceptable level (percentage of tasks solved: 50 to 79 % of the tasks were completed) | Low level (percentage of tasks solved: less than or equal to 49 %) |
|---|---|---|---|
| Results of direct assessment of competencies characterizing the individual's personal qualities as an integral part of their professional competence | | | |
| 80% | + | | |
| 20% | | + | |
| The results of direct assessment of competencies aimed at the development, maintenance and improvement of communications | | | |
| 80% | + | | |
| 20% | | + | |
| The results of direct assessment of professional competencies ("competence core"), including the competencies reflecting the need (requirements) of the regional and/or federal labor market, depending on the main consumers of the graduates of the programme | | | |
| 80% | + | | |
| 20% | | + | |

When conducting the quality assessment of education, the expert analyzed 10 graduate qualification works, which amounted to 50 % of the graduate works of the previous year in this field. The expert concluded that the analyzed graduate qualification works fully complied with all the requirements stated below.

## GRADUATE QUALIFICATION WORKS

| No. | Objects of assessment | Expert commentaries |
|---|---|---|
| 1. | Topics of graduate qualification works correspond to the field of study and current level of scientific and/or technological development in the programme field. | 100% |
| 2. | The tasks and contents of graduate qualification works are aimed at demonstrating competency formation in the graduate. | 100% |
| 3. | The degree to which data collected or received during the predegree practice and the implementation of course projects was incorporated in the independent research part of the graduate qualification works. | 100% |
| 4. | Graduate thesis topics are defined by the needs of manufacturers as well as the experimental purposes of teachers of the educational institution. | 100% |
| 5. | The findings of graduate qualification works can be applied in industry. | It is too early to assess the practical application of the findings of these graduate qualification works. However, all of them are pronouncedly practice-oriented and 100% implementable in the respective industries |
| 6. | The degree to which research findings of the chair, faculty and outside research and production and/or research organizations was incorporated in the independent research part of the graduate qualification works. | 100% |

***Conclusions and recommendations of experts***

**Conclusions**

The data collected by the experts suggests that Saint Petersburg's labor market in applied physics and mathematics is far from being saturated, which favors the development of this programme. The experts assessed the demand for graduates as well as the satisfaction of employers, graduates, and students as excellent, while the formation of key professional competencies in 2nd year Master's programme students was assessed as good. The weak point of the programme (which is probably limited to the specific group of students with whom the experts met) is the specialization of graduate students which is too narrow. For

instance, nearly all graduate qualification work topics that students in the Master's programme presented within the framework of direct assessment of competencies dealt with mathematical modeling of electrical phenomena in gases. Some students showed gaps in basic knowledge (e.g. had difficulties explaining mathematical symbols or the physical and mathematical meaning of the parameters that they were using). However, all students cannot have the same level of knowledge, and the average proved to be quite high.

The experts also found students to have a positive outlook.

The students' works are practice-oriented and can be presented at international conferences. English and presentation skills are high.

**Recommendations**

- Tight cooperation with employers is a major advantage of this programme, especially at the Master's level. It helps ensure graduate employment as well as their orientation to specific topical issues in science and technology. The experts recommend programme managers to maintain the connection and involve new employers in programme implementation to adapt to the extending labor market.
- Some employers and students suggested that the time for research work and work experience internship according to the curriculum should be increased. However, the focus on the graduate qualification work problem over other subjects might cause an even narrower specialization. In order to eliminate the risk, the experts recommend involving students in scientific seminars at the faculty at least as audience.

# QUALITY ASSURANCE OF EDUCATION

## *1. Strategy, aims and management of the programme*

***Criterion assessment: excellent***

***Strong points of the programme***

- The Development Strategy of this programme is part of the SPBU Development Strategy until 2020. Thus ensures stable development and high implementation quality for the programme.
- The programme aims at meeting the continuously growing demand of Petersburg companies for highly skilled experts in applied mathematics and physics, which makes the programme topical and its development well-planned.
- The programme management system is well-considered and integrated in the SPBU management system. The Programme Council is responsible for analyzing the programme and its promotion strategy as well comparing it with similar programmes; the Teaching Committee reviews the curricula and subject set; the Graduate Office monitors the demand for graduates; the Programme Office

maintains the teaching and learning documentation; and the Academic Unit organizes the learning process.

- Employers play a major role in programme management as they make over 50% of the Programme Council, contribute to teaching work, and attend meetings of the Teaching Committee.

***Recommendations***

The percentage of students who can only describe the purposes of the programme in a vague manner is as high as 73% according to the educational institution's self-evaluation report. This is probably due to poor involvement of students in programme management and bears the potential of decreasing study motivation in students. The managers of this programme should improve the student feedback mechanism (see the previous section for more details).

Subject-specific feedback as well as that for the entire programme can be arranged as follows:

1. Anonymous questionnaires to be filled out upon the completion of each subjects. Teachers can review them to obtain useful information.
2. Students can elect a course representative to attend meetings to discuss academic and general issues.

***Additional material***

In the process of self-evaluation of the educational institution, data on teachers' satisfaction with the personnel policy and applicable motivation system was presented. 29% of teaching staff implementing the Master's programme "Applied Physics and Mathematics" were fully satisfied with the personnel policy, 36% were partly satisfied, and 7% were unsatisfied. The data on satisfaction with the motivation system was about the same. The SPBU administration should develop the personnel policy and motivation system with more regard to teachers' opinion and suggestions.

## *2. Structure and content of the programme*

***Criterion assessment: excellent***

***Strong points of the programme***

- The managers of this programme have developed a competency-oriented graduate model that fully corresponds to the programme's purposes and the demand of the labor market. The competency-oriented model contains general cultural competencies that characterize an individual's personal skills, those aimed at developing communication skills, and specific professional competencies.
- The scope of subjects on the programme's curriculum fits its purposes and aims at developing the necessary competencies.

- Research work accounts for a large part of the curriculum, which is characteristic of Master's programmes.
- The set of subjects and their syllabi as well as all graduate qualification work topics have been agreed with employers through directs inquiries between employers and the Teaching Committee. Some subjects on the curricula were developed by external part-time employees.

***Recommendations***

- The experts believe that the SPBU Master's programme "Applied Physics and Mathematics" tends towards an excessively narrow graduate specialization. In order to overcome it, the expert recommend the programme management to offer students some opportunities to study the basics of related disciplines like Chemistry and Physical Chemistry that may be necessary for research work and further specialization as well as to involve more students in scientific seminars organized by the Physical Faculty so that their scientific interests grow broader.
- The percentage of employer-developed subjects (10%) is not too high as for a Master's programme. Experts recommend the management of the programme to increase employer involvement in developing subjects and teaching courses.

***Additional material***

The educational institution's self-evaluation report provides the data of a student questionnaire survey to find out if the structure and content of the programme meet students' expectations. 90% of the students reported the programme to fully or essentially meet their expectations. Student interviews that took place during the expert visit to SPBU confirmed the figures. This indicates the content of the programme to largely meet students' expecttions.

## *3. Teaching and learning materials*

***Criterion assessment: excellent***

***Strong points of the programme***

- This programme has all the necessary teaching and learning materials: subject and practice study programmes, test and exam materials for formative and interim control, study literature, electronic information resources, etc.
- The SPBU Library is one of Russia's best libraries. It possesses nearly all educational literature, monographs and scientific periodicals, and subscriptions to scientific abstract databases that students and teachers in the programme use.
- Teachers participate in the all-round review of all teaching and learning materials through the Programme Council and the Teaching Committee. This

ensures a high academic quality and topicality of the teaching and learning materials with due regard to the changing requirements of the labor market.

- The programme's curriculum contains a number of subjects within which students find out about the latest scientific developments and contemporary scientific literature.

***Recommendations***

- The procedure of all-round review and thorough documenting of subject programmes, test and exam materials, etc. are definitely helpful in terms of maintaining a high quality of the educational process. However, the formalization makes it less easy to find new development paths for the programme, like introducing new unparalleled subjects into the curriculum or modifying the content/instruction procedure of the existing ones. For instance, the requirement that each subject should have core study literature cannot be met for a subject that deals with a rapidly developing research area with no study literature available at the time. Yet, a number of textbooks were written based on the experience of teaching the subject. Thus, the SPBU administration and units that control the development of teaching and learning materials should develop a simplified procedure for introducing a small number of experimental subjects to curricula. The disciplines should be introduced on the initiative of teaching staff concerned who can develop a whole new course on their own or restructure an old one on agreement with the Programme Council, in which case the documentation procedure should be simplified. If the experiment turns out to be successful, the subject can become a standard element of the curriculum.

## *4. Educational technologies and methods*

***Criterion assessment: excellent***

***Strong points of the programme***

- The techniques and methods used in the programme "Applied Physics and Mathematics" fit the programme's goals and help develop the competencies provided for under the respective Educational Standard.
- Most classes have the well-established form of lecture, seminar, practical class, and laboratory class. It should be noted that all the above forms are naturally interactive since students can ask questions, suggest and discuss various solutions, consult the teacher when completing a laboratory assignment, etc. It is hard to estimate the percentage of time for which such classes account as it largely depends on the teacher's individual style, students' activity, and other factors, but the estimate of 40% that the educational institution provided in its self-evaluation report appears realistic.

- A large part of the Master's programme curriculum is students' independent research work. This is highly useful as independent research work develops the competencies that are key to the student's future occupation and that employers expect graduates in the Master's programme to have. Besides, it is independent work that enables students to obtain advanced knowledge and specialized experience in their spheres of interest.
- SPBU actively develops e-learning methods and techniques. It is hard to predict at this stage what role electronic courses will play in the learning process. However, the benefits and advantages of electronic devices and information technology, including the Blackboard system developed by SPBU, namely choosing elective subjects, receiving individual assignments as well as electronic educational literature, and exchanging organizational information are beyond doubt.

***Recommendations***

- The experts believe the techniques and methods used in the educational process of the programme "Applied Physics and Mathematics" to fully fit the programme's objectives and recommend to maintain the work mode and methods.
- Education should focus not only on knowledge but on understanding the physical laws and phenomena studied. An interview with students on the topics of their research works revealed some problems in this respect. Unfortunately, SPBU is not the only institution where this problem exists. It is largely due to the so-called clip thinking. It is obvious that understanding is impossible without knowledge. However, lack of understanding causes knowledge gaps in majors. For instance, knowing formulas without understanding the reasoning behind them is pointless in physics. This describes the concept of "physical meaning". Practical activities on handing in completed laboratory works seem to be the best way to start developing analytical thinking.
- In order to solve the second problem identified, namely lack of basic knowledge in related knowledge in preparing and especially understanding and presenting research works, measures should be taken to enable students to study the respective branches on an extracurricular basis.
- As has been mentioned above, the experts' additional recommendation is to encourage students in the Master's programme to attend scientific seminars by the Physical Faculty to broaden the scope of their scientific knowledge and ensure a deeper and less formalized approach to the subjects studied in the fundamental as well as practical aspect. This would enable students to develop analytical thinking, which is essential to their further specialization in science as well as industry.

While performing the desktop analysis of the self-evaluation report, the analysis of the curriculum and the schedule of classes, the experts determined interactive classes to account for at least 40%. The teaching and learning materials

of five subjects were studied in the course of the visit: Semiconductor Nanostructure Technology (active and interactive classes: about 60%), Laser Physics (about 25%), Laboratory Computational Practicum in Electrical Physics (about 40%), Experimental Methods of High Voltage Research (about 50%), and Computer Simulation of Biomolecular Systems (about 40%). Based on the data, the experts believe the forms of instruction, educational techniques, and the percentage of active and interactive classes to fully fit the purposes of this programme as well as the competency-oriented graduate model.

## *5. Teaching staff*
## *Criterion assessment: excellent*

### *Strong points of the programme*

- The educational process within the programme is ensured by a highly-skilled teaching staff. 46% of the teaching staff are Doctors of Science, and 44% are PhDs. All the teachers are active researchers, producing a total of 295 articles in RSCI, Web of Science, and Scopus-indexed journals over the past 2 years.
- Nearly all (98%) the teachers have a working experience in the respective field; 79% of the teachers combine teaching at the university with research work under internal and external grants.
- About 10% of lecturers in the programmes have carried out research and teaching work abroad int he recent years.
- The publishing requirements to teachers for the competitive selection (at least 3 works published in RSCI, Web or Science and Scopus indexed journals in the past 3 years for associate professors and 4 for professors) and the other qualification requirements appear to be well-balanced.
- Among the strong points of the programme is the aspiration to preserve the experience of teachers representing the older generation, the most outstanding of whom still continue their teaching career.

### *Recommendations*

- The findings of the teacher survey included in the educational institution's self-evaluation report indicate relatively low satisfaction with the university's personnel policy (29% fully satisfied, 36% partly satisfied, 7% unsatisfied, and 28% not sure). The University's administration should pay more attention to teachers' interests.
- It is a well-known fact that scientometric parameters do not ensure a 100% accurate assessment of academic staff qualification. As has been mentioned above, the experts believe SPBU's established criteria to be generally reasonable. However, a detailed justification, e.g. why publication activity has to be this and that, is welcome. Therefore, the experts recommend the programme and

University's management to thoroughly think out any formal requirements to teaching staff, in particular by referring to the average values of the previous years. Secondly, special cases should be provided for, such as employees who have been working on a very complex scientific problem for a long time, where formal parameters can turn out to be inapplicable. Importantly, a good teacher does not have to be a successful scientist, nor does the opposite apply. The results of student surveys as well as student knowledge assessment should be relied on.

- With due regard to the somewhat formal and compulsory approach to advanced training for teachers that is well-established in the Russian education system, the experts recommend the SPBU administration to use a broader interpretation of it, i.e. view articles published in high-rating journals and reports at international conferences as advanced training.
- The experts' interviews with students showed students to rarely use feedback instruments to contact programme managers, in particular for professional assessment of teachers. Even though a number of student surveys are carried out to study this aspects, the managers of the programme should take further action to improve the feedback mechanism. Firstly, student surveys should be a mandatory, systematic work procedure. Surveys to assess teachers' performance should be anonymous. Secondly, survey results should be reported to teachers, in which the programme management should take measures to implement the main suggestions of students.
- The self-evaluation report and interviews with representatives of the educational institution's administration showed actual competition for teaching positions with 2 or more candidates competing for a position to be rather rare. The position mostly goes to the teacher who has occupied it before. Thus, the procedure should be referred to as employee assessment for the purpose of contract renewal rather than competitive selection. Competition is more appropriate to employ a new worker where a new position has emerged due to a staff increase or when a teacher has been dismisses, retired, etc.

## *6. Material, technical and financial resources of the programme*

***Criterion assessment: excellent***

***Strong points of the programme***

- The experts found the scientific equipment offered by the SPBU Research Park to be very impressive. The University's material resources generally cover the needs of the programme and enable teachers as well as students to carry out cutting-edge physical and interdisciplinary research in science and technology. Essential facilities for the programme include the laboratories, the Computing Center, and the resource centers located in V. Fock Physical Research Institute Near the main teaching building for Applied Physics and Mathematics. Laboratory

and practical classes enable students to acquire experience of working in scientific laboratories, which is extremely important to their further employment in the field.

- The University has enough buildings and facilities to host classes as well as students' and teachers' research within the programme.

***Recommendations***

- The expert recommend the University's administration to carry out regular sanitary inspections in academic buildings and classrooms and do any improvements or repairs necessary.
- It should be noted that teachers would like timely allocation of funds for repair and maintenance of expensive scientific equipment. Those are usually big sums for specific laboratories that cannot be covered by the existing grants.

***Additional material***

During their visit, the experts interviewed students and teachers participating in programme implementation to find out how satisfied they were with the quality of classrooms. The information obtained suggests that the number and area of rooms used to implement the programme are sufficient. However, complaints were received regarding low temperature in certain classrooms. The experts recommend the managers of the programme and the University's administration to check the information and carry out any necessary renovation if necessary.

## *7. Information resources of the programme*

***Criterion assessment: excellent***

***Strong points of the programme***

- The SPBU possessed one of Russia's best university libraries with a vast collection of printed matter. The Library has subscriptions to all influential physical journals and electronic abstract databases. It provides teachers and students in the programme with up-to-date professional literature in a quick and efficient manner.
- The University offers convenient electronic services like Blackboard, student accounts, etc., which enable all parties to the programme to exchange information, make up individual curricula, control performance, handle electronic documentation, etc. All processes involved in the implementation of the programme use information and communication technology.

## *8. Research activities*

***Criterion assessment: excellent***

***Strong points of the programme***

- All teaching staff implementing the programme "Applied Physics and Mathematics" carry out large-scale research activities. The vast majority of them head or participate in internal and/or external funding grants. Teachers in the programme (Master's degree) have carried out a total of 88 research works over the past 3 years.
- To prove the academic activity and high qualification of the teachers, they have authored a total of 295 articles in leading Russian and international journals.
- Students are involved in research work on a regular basis. Masters' involvement mainly consists of graduate qualification work and work under grants. Over 50% of graduate qualification work subjects were suggested by employers and are definitely novel, which favors the development of research competencies in graduates.
- The excellent equipment that the institution's scientific and training laboratories offers undoubtedly enhances the programme as well as general research work.
- Student access to a broad range of scientific journals and other literature, which has been mentioned above, is essential to research activity.

***Recommendations***

- According to the educational institution's self-evaluation report, only 10% of students in the Master's programme are contractors under grants. Experts recommend the managers of the programme to increase the percentage as it would intensify students' research work and increase their interest in studies while helping them develop the necessary competencies.
- The student survey showed the scope of training to be somewhat too narrow as for the broad scope of students' research work. Students clearly lack basic knowledge in related disciplines from Physical Chemistry to Biochemistry. They should have an opportunity to acquire the necessary knowledge and broaden their scientific scope in the course of extracurricular activities.

## *9. Employer participation in programme implementation*
***Criterion assessment: excellent***

***Strong points of the programme***

- Employers contribute to every aspect of programme implementation at a systemic level through membership in the Teaching Commission, Programme Council, and State Examination Board, agreeing the curriculum and subject-specific work programmes, suggesting and agreeing graduate qualification work

subjects, reviewing graduate qualification works and research projects, teaching a number of subjects, acting as work experience internship supervisors, and helping students find employment.

***Recommendations***

- The experts recommend programme managers to maintain the connection with employers and involve new employers in programme implementation to adapt to the extending labor market.

***Additional material***

The interview with employers that the experts carried out during the sity visit to SPBU showed employers to be very interested in developing the programme "Applied Physics and Mathematics" and appreciate its graduates. The fact that graduates generally get high salaries upon completion of studies confirms it. A Master survey showed the starting salary of a graduate to be about 50,000 RUB.

### *10. Participation of students in determining the content of the programme*
***Criterion assessment: good***

***Strong points of the programme***

- SPBU in general and this programme in particular use a number of mechanisms for student governance and involving students in determining the content of programmes. The mechanisms include the SPBU Student Council, student surveys on the quality of knowledge, the questionnaire through which students can express their opinion of a subject / for of instruction that is part of the subject study programme.

***Recommendations***

- The student interview showed students to be largely unaware of how they can influence programme content and inform programme managers and/or the University's administration of their opinion and suggestions. The experts believe that some of the above mechanisms only exist on paper at present. The student questionnaire survey data included in the educational institution's self-evaluation report confirmed it with only 13% of students in the Master's programme reporting their opinion to be taken into account in developing the programme. The experts recommend the managers of the programme to improve the student feedback mechanisms. In particular, surveys and questionnaire surveys should be a regular work practice.

Subject-specific feedback as well as that for the entire programme can be arranged as follows:

1. Anonymous questionnaires to be filled out upon the completion of each subjects. Teachers can review them to obtain useful information.

2. Students can elect a course representative to attend meetings to discuss academic and general issues.

### *11. Student services at the programme level*
### *Criterion assessment: excellent*

***Strong points of the programme***

- Students in the programme as well as across SPBU enjoy a broad range of student services such as further competencies, sports, public work, and cultural events.

***Recommendations***

- The student interview revealed two aspects of student services that could be improved:

1) since the main academic building is located far away from the main part of Petersburg, dormitory accommodation should be provided to all students in the programme;

2) the working hours of campus food service facilities should ensure that at least one canteen is open on weekends.

# EXPERTS' CV

Full name of an expert: Andrei Indenbom

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|---|---|
| Company and position | Andrei Vladimirovich Indenbom |
| Academic degree and academic title | PhD in Chemistry |
| Additional titles and degrees | none |
| Education | Chemical Faculty, M. Lomonosov Moscow State University |
| Professional achievements | over 35 academic works |
| Research interests | Physical chemistry and bioelectrochemistry |
| Practical experience in the field of the programme subject to assessment | Supervision of graduate and postgraduate qualification works at MIPT (17 years), teaching Physical Chemistry (4 years) |

Full name of an expert: Dmitrii Stepanov

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|---|---|
| Company and position | Associate Professor, Department of Mathematical Modeling, Bauman Moscow State Technical University |
| Academic degree and academic title | PhD in Physics and Mathematics |
| Additional titles and degrees | none |
| Education | Faculty of Mechanics and Mathematics, M. Lomonosov Moscow State Universitz |
| Professional achievements | 12 academic works |
| Research interests | Algebra and algebraic geometry |
| Practical experience in the field of the programme subject to assessment | Experience as a Mathematics teacher at a technical higher education establishment (12 years) |

Full name of an expert: Sara Tanner

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|---|---|
| Company and position | Associate Professor, Department of Computing Science and Mathematics, Dundalk Institute of Technology |
| Academic degree and academic title | PhD in Applied Mathematics |
| Additional titles and degrees | |
| Education | Beloit College, USA; Newcastle University, UK |
| Professional achievements | Publications in astrophysics |
| Research interests | Analytical and numerical methods used to study the evolution of magnetic fields in the Solar System.<br>Analytical and numerical methods used to study solar coronal loops and prominences.<br>Analytical and numerical methods used to model solar magnetoconvection. |
| Practical experience in the field of the programme subject to assessment | Teaching and research activity |

Full name of an expert: Nikolai Asaturov

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|---|---|
| Company and position | Student, BMSTU |
| Academic degree and academic title | |
| Additional titles and degrees | |
| Education | |
| Professional achievements | |
| Research interests | |
| Practical experience in the field of the programme subject to assessment | |