

# Undergraduate Mathematical Education at St. Petersburg State University: Old Traditions and New Developments

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In 2015 St. Petersburg State University opened a new bachelor program in mathematics. While the existing 5-year diploma program had historically been very successful, recently a need to address modern challenges became clear. Below we describe the new program, which keeps the traditions of fundamental education but at the same time offers its students greater flexibility in choosing their educational trajectories.

SPbSU (known as Leningrad State University during the Soviet times) is the oldest Russian university; it boasts a long tradition of mathematical education, dating back to Leonard Euler and Bernoulli brothers. Its professors authored most of the textbooks used in Russian higher education up to the beginning of the twentieth century, and it has educated a great number of well-known pure and applied mathematicians, as well as scientists from other disciplines and engineers over the last 300 years.

Mathematics was originally part of the Department of Physics and Mathematics until 1933, when the Department of Mathematics and Mechanics was created (which also includes astronomy). The now prevalent undergraduate educational system crystallized in the early twentieth century and was more or less the same throughout most Soviet universities. It relied on a rigid system of mandatory courses given over a period of 5 years, after the completion of which students would receive their higher education

diplomas. During the third year, students would write a term paper and choose a chair to be associated with, which would in the end influence their diploma thesis topic as well as the choice of the only four optional courses they could take.

While at the first glance the system seems to be very rigid and has a number of drawbacks, it used to be highly successful at SPbSU (and its Moscow counterpart Moscow State University) due to the following reasons:

- Mandatory courses were covering most of the mathematical areas at a fairly deep level, and graduating students were getting a much more solid and universal background than many of their peers abroad.
- While the system itself was rigid, the curriculum was regularly updated in an attempt to cover modern developments. E.g., SPbSU was one of the first world universities to include some new subjects, like Lebesgue integration, and — later — functional analysis into its curriculum.
- Small number of optional courses was compensated by an abundance of informal seminars and discussion groups, with students learning as much in the evenings as during the daily lectures.
- The high level of both faculty and students ensured good educational level. They were in close contact, and students were actively involved in scientific research.
- There were strong connections to applied disciplines, with many professors (notably Leonid Kantorovich) working both in pure and applied mathematics.

Though quite successful for a long time, the system had, nevertheless, several serious drawbacks:

- Emphasis on lectures rather the seminars led to lack of feedback from students.
- Rigid division into chairs forced many students to choose their specialization too early, thus limiting their education.
- At some point, existing chairs stopped covering all the aspects of modern mathematics, leading to gaps in curriculum.

In the 1970s, the Department of Mathematics and Mechanics moved from city center to the Peterhof campus, which created many problems. At the new location informal courses and seminars, which used to run until midnight, practically disappeared, as transit consumed much more time. This also coincided with the system becoming more bureaucratic and rigid, and the curriculum became almost

frozen in time, lagging behind modern mathematics.

In the late 1980s, a group of mathematicians from SPbSU and the St. Petersburg branch of the Steklov Mathematical Institute of Russian Academy of Sciences (PDMI) addressed many of the problems by organizing so-called “PDMI classes” for undergraduate students, which provided alternative versions of the mandatory courses. Systematic approach was applied to revising and modernizing the curriculum. Moreover, most lectures were held at PDMI building in city center, so the students had regained easy access to seminars. Many of the courses were taught by PDMI researchers, expanding the choice of areas covered and raising the students’ academic level.

This significantly improved the situation for the next decade, effectively resolving many problems. However, the rigid chair structure remained, and many professors left the country, which led to poorer choice of courses and topics. Moreover, due to bureaucratic problems, PDMI classes had to function as an unofficial structure, essentially forcing students to take all the exams twice. In the end, students were left with a curriculum that needed revision and a much smaller choice of additional courses to take or professors to work with. To complicate things, the rigid 5-year program was hardly compatible with the Bologna Declaration, limiting options for student exchange.

Soon it became clear that undergraduate mathematical education in St. Petersburg was in urgent need of revision in order to achieve compatibility with international standards for bachelor-level education. One could argue that the old comprehensive system works better for talented students, provided they are given access to many optional courses. However, it seems that the current realities are such that most students just do not have enough time to follow many additional courses and seminars, thus a once perfect system has become too rigid and restrictive.

Different approaches to the problems were discussed and in the end, it was decided to revitalize PDMI classes, while the university overall was shifting towards the Bologna system of 4-year undergraduate education. A new program opened in 2015 (with the classical one still running).

The new undergraduate program is still a work in progress but we strive to adhere to the following principles:

- **Flexibility of education**

The mandatory part of the curriculum has been reorganized and modernized, having been reduced to roughly one half of the total number of courses throughout 4 years of the program. They now amount to 100%, 66% and 33% of the courses during the first three years respectively. Basic courses cover all fundamental disciplines at a level allowing for further studies. A gradual introduction of optional courses together with personal mentors will allow students to pick their individual educational trajectories consciously, in a way that suits their personal needs.

- **Multitude of future careers**

It is no longer assumed that all the graduates will become professional mathematicians; on the contrary, a variety of mathematics-intensive careers is now recognized. Already, a Theoretical Computer Science option was created, one of the first in Russia. The individual trajectories can lead to employment in applied fields or towards graduate-level education in mathematics or other disciplines, fulfilling the modern need for multidisciplinary researchers. SPbSU and PDMI plan to offer a wide range of optional courses, and we intend to develop collaboration with institutes and enterprises in order to create specialized courses in applied mathematics, thus expanding our students’ career prospects.

- **Integration with research**

The new bachelor program will keep the old traditions of early introduction to research work through collaboration with PDMI and Chebyshev Laboratory of SPbSU. A more problem-oriented approach to course development has been adopted. Furthermore, students will have a chance to participate in workshops and conferences, as well as exchange programs.

Much planning and energy has been spent on creating the new program and attracting good students. An advisory board of prominent mathematicians from St. Petersburg and elsewhere was created to steer the program. Last but not least, classes have been moved back to city center, leaving students more time for seminars and cultural life. Of great help was one of the Russia’s leading companies, JSC Gazprom Neft, which has made it possible to attract talented school graduates from various Russian regions and has extended financial support to a significant number of students. Suffice to say, more than half of the 45 places available at the program in 2015 were occupied by the winners of various academic competitions for high-school students (usually referred to as Olympiads), many of them coming from provincial schools. Moreover, the program has attracted more winners of the national Mathematical Olympiad than any other undergraduate mathematics program in Russia.

We are sure that the new program will be as successful as the previous ones offered at SPbSU. The first year saw 45 students — almost double compared to the old program. In 2019 (i.e., when the first class graduates), SPbSU is expected to open a master’s program in mathematics with eventual instruction in English.

