Popularization of math: sketches of Russian projects and traditions

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Abstract

We give a guided tour of unique Russian traditions of math popularization. While many have already become part of the worldwide practice, some are yet to follow suit. What unites them is the desire to not only amuse people with clever puzzle-solving, but explain the math behind it. This is a preliminary abriged version.

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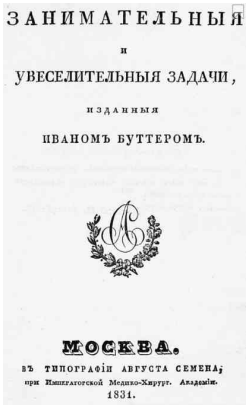
Throughout the 20th century, Russia had accumulated a great wealth of unique traditions in mathematical education and popularization of mathematics. Many of those, such as mathematical circles or clubs and summer schools, have already become part of the worldwide practice of popularizing mathematics. Other ideas and projects, especially those that only emerged in the 21st century, are yet to follow suit. Below we try to give a guided tour of different tarditions. What unites them is the desire to not only amuse people with clever puzzle-solving, but explain the math behind it.

The first printed mathematical textbook, Arithmetic by Leonty Magnitsky, was published in Russia in 1703. The textbook was written at the behest of tsar Peter the Great, for the Moscow School of Mathematics and Navigation that he had established. Arithmetic was followed by Geometry (The Methods of Compasses and Ruler, or the Selected Fundamentals in the Mathematical Arts) translated by the tsar's associate James Bruce. The year was 1709, the Northern War was far from over, and Peter edited the manuscript right at the front lines. A copy of Geometry with the tsar's edits is preserved in the archive. For one of the editions, Peter the Great personally wrote a chapter with precise geometric instructions on how to make an accurate sundial! At about the same time, in 1705, the first mathematical poster was published - a wall table *"A new method of arithmetic theoretic or visual"*, compiled by V. Kiprianov, engraved by F. Nikitin with M. Petrov.



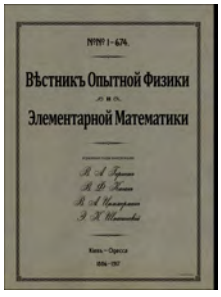
Left: Geometry textbook with corrections by Peter the Great **Center:** The first Russian math poster
Right: Cover of the Amusing and Entertaining Problems and Riddles

In the next 170 years, mathematics in the Russian Empire became part of university and school curriculum. During the same period, Russian mathematics became associated with such names as Leonhard Euler (1707–1783), N. I. Lobachevsky (1792–1856), N. D. Brashman (1796–1866), M. V. Ostrogradsky (1801–1861), V. Ya. Bunyakovsky (1804–1889), P. L. Chebyshev (1821–1894) and others. And while, at the time, there was no pressing need to popularize mathematics just yet, some steps were already taken in that direction.

The first Russian outreach book on arithmetic was called *"Arithmetic Guesswork for Fun and Pleasure"* (62 pages, 41 problems), by I. Krasnopolsky. This book (or rather, a small

booklet by modern standards) was published in 1789. The year 1831 saw a remarkable book by I. Butter: *"Amusing and Entertaining Problems and Riddles"*. Its second edition, with 56 pages, followed in 1844. From about the middle of the 19th century, amusing mathematical problems and publications about mathematicians and their achievements would even make an occasional appearance in mainstream newspapers and magazines. The first attempts at publishing specialized journals were made as well: the more specialized Educational Mathematical Journal (1833–1834, K. Ya. Kupfer) and the Bulletin of Mathematical Sciences (1861–1862, M. M. Gusev), with a target audience of both educators and anyone curious about math. One of the world's oldest mathematical societies, the Moscow Mathematical Society, began publishing its own journal, Mathematical Collection (or Sbornik in Russian), in 1866. During the first few years (from 1867 to 1882) the journal had not just the research section, but also a second section, designed for teachers of mathematics.

Appearance of the Bulletin of Experimental Physics and Elementary Mathematics https://vofem.ru/ in 1886 had a lasting influence on popularization of mathematics in Russia. In the first issue, editor-in-chief E. K. Shpachinsky wrote on behalf of the editorial board: *"Our journal is intended mainly, but not exclusively, for the young people studying at our educational institutions, and therefore it will, first of all, aim to satisfy, in the field of physical and mathematical sciences, the need to broaden one's mental horizons, which is especially strong in adolescence and is always found among the young students in the form of an irresistible urge to know more than what the official curriculum provides. [...] Furthermore, our journal is also intended for all teachers of physics and elementary mathematics in general, mainly for the purpose of uniting our educators, scattered as they are across Russia"*.



Left: The cover of the Bulletin of Experimental Physics and Elementary Mathematics
Center: Its web archive **Right:** Web archive of Mathesis

This Bulletin can be considered the first popular physics and mathematics journal in Russia. It was this journal that laid the foundations of this Russian-language popularization genre: fundamental articles, publication of new problems with solutions by the author, and updates on the events in the mathematical world, including reviews of new books.

Around the same time, different publishers started mass producing popular science literature. The most noteworthy books of that period include *In the Realm of Ingenuity*, by Ignatyev (a three-volume collection of entertaining problems and puzzles). Among the publishing houses, the Odesa-based Mathesis, a "publishing house of scientific and popular

scientific works from the field of physical and mathematical sciences," stands out in particular https://www.mathesis.ru/. It published more than 150 books, many of which sold thousands of copies and are being republished to this day. Many of the books were translations, and in this field, Mathesis established a tradition of selecting, supplementing, and commenting on the source material (sometimes commentaries formed a significant part of the publication).

A truly large-scale popularization of mathematics in Russia began with the works of Yakov Isidorovich Perelman (1882–1942). While still a student, he began to collaborate with popular science magazines and later became the author of many fascinating and accessible books on mathematics and physics that won recognition and popularity. In Perelman's books, math is given a modern twist: he both offers logic problems for young readers and popularizes the latest scientific advances in an animated and engaging way. Perelman's stories about the world around us become visual models for the reader's understanding of physics and mathematics. His books remain in print to this day, with many million copies printed in Russia alone!

In addition to being an author, Perelman was one of the main founders of the House of Amusing Science in 1935. This museum had over 500 large exhibits, along with many small ones, grouped by field: mathematics, physics (with an optics room), astronomy (with a meteorology section), and geography (with a geology section). Most of the exhibits were interactive, as Perelman believed that the visitor should be able to figure out the exhibit's structure and learn to work with it in a meaningful way. The House of Amusing Science



Yakov Perelman and two of his books

resembled modern museums in many ways, including interactivity as much as the activities that took place there. It had more than fifty youth clubs, attended by students from different schools. Math and physics contests and debates were held regularly. Museum staff gave lectures at schools and factories, opened small exhibitions at the district young pioneer houses, and published miniature brochures on various fields of science and technology.

There is a wonderful historical anecdote about Perelman. In 1934, Herbert Wells, the father of modern science fiction, came to the Soviet Union. He was brought to a meeting with a group of Leningrad writers and popular scientists. During this meeting, Yakov Perelman

took the floor and told Wells that the hero of his Invisible Man should have been blind. The reason is that if a person is truly, completely invisible — that is, transparent — their eye lens will also become transparent. And, therefore, it cannot refract light, making eyesight impossible.

The attitude toward the popularization of science in the Soviet Union was extremely serious even during the Second World War. On the 150th anniversary of N.I. Lobachevsky in 1942, the loudspeakers that would usually broadcast news from the front lines shared a popular science lecture about non-Euclidean geometry.

The middle of the 20th century saw the publication of a great deal of popular science literature. Books with the most serious educational content (both original ones and translations) often had circulation in hundreds of thousands. There were several very popular series of books: “Popular Lectures on Mathematics”, “Math Club Library”, and “Physics and Mathematics School Library”,. . . Many of the best foreign books were translated.

In 1970, “Kvant” or “Quantum”, a popular physics and mathematics magazine, saw the light for the first time https://kvant.ras.ru/. The publication was designed for schoolchildren, and its first editors-in-chief were prominent Russian scientists: the physicist I. I. Kikoin and the mathematician A. N. Kolmogorov. Articles for the magazine were written by teachers and prominent mathematicians. With a circulation of several hundred thousand, it reached many schoolchildren often becoming the gateway to serious science. It also had a monthly problem section, and schoolchildren could send in the solutions, which were checked and graded. An associated series of popular books “Kvant library” published many excellent popular introductions to science.

A back cover of Kvantik with a “picture-problem”

Quite possibly the most striking recent innovation has been the monthly “Kvantik” (or “Quantik”, diminutive of Quantum) magazine https://kvantik.com/, which celebrates its 10th anniversary in 2022. The founder and permanent editor-in-chief is Sergei Dorichenko, chairman of the Tournament of Cities and member of the editorial board of the Kvant magazine. The “younger brother” of the Kvant journal is accessible to younger children and combines not only mathematics and physics, but also publishes meaningful, yet accessible and fascinating articles on linguistics, biology, and the history of science. This is a magazine for the curious schoolchildren, and not only them. The design of the magazine, which is created by a large team of artists with different visions, immedeately attracts attention and draws children into reading. The journal has retained the tradition of monthly problem contests, the answers to which are sent by readers to the editorial office and the editorial office

is in correspondence (often by paper letters!) with schoolchildren. And seeing their name published in their favorite journal among the contest winners is a big stimulus for children. School librarians in different regions of Russia note that Quantik has become the most popular demand among both schoolchildren and teachers. The back cover of the magazine is traditionally an interesting "picture-problem", containing almost no text. Each New Year, the magazine creates monthly calendars from such covers, which have become very popular.

One of the most important practices in the popularization of mathematics are the Olympiad competitions. The first modern style Mathematical Olympiad was organized in Leningrad by Boris Delaunay in 1934. In the 1950s, the Olympiad competitions became a mass movement. The gained the now commonplace pyramid structure: the competitions were held in several stages, first within one school, then within the city, region, and so on. The first stage — the school stage — took place in most schools around the country. Olympiad participation encouraged the students to be passionate about mathematics, and prominent scientists delivered popular talks during the closing ceremonies of various stages. Besides being sport-like competition, Olympiads play an important role in attracting schoolchildren to mathematics with interesting problems, and their outreach is in the millions.

A.N. Kolmogorov with students of School 18 ("Kolomogorov's school"). Courtesy of A. N. Shiryaev

Such Olympiads became now universally popular around the world, but a few new practices were introduced in Russia. Among such new math Olympiads, Tournament of the Towns stands out https://www.turgor.ru/. Currently it takes place in more than 25 countries. A distinctive feature of the tournament is the scoring system. Participants are offered a list of tasks and are credited for making progress on three tasks, where they attained the maximum number of points. Those who submit the best solutions are invited to the Tournament's Summer Conference, where students attempt to attacke research-grade problems.

Another non-standard Olympiad is the Lomonosov Tournament. It stands out because it is a multi-subject competition in math and mathematical games, physics, astronomy and earth sciences, chemistry, biology, history, linguistics, and literature. And it works! There have been cases where a school student that was planning to tie their whole life to a specific science, suddenly found out at the tournament that other subjects are also interesting, and became a professional in one of them. Both tournaments were created by Nikolai Konstantinov.

A really singular Olympiad-style event is Matprazdnik (literally, "Mathematical Celebration"; https://olympiads.mccme.ru/matprazdnik/), a math Olympiad for children between 12 and 14 years of age, where they solve engaging math problems (tricky, but not requiring

extensive knowledge) for two hours and then are entertained with lectures in popular science and games.

Finally, the Caucasus Mathematical Olympiad (CMO https://cmo.adygmath.ru/) is not simply a math competition, but also aims to build bridges of friendship and understanding between students of different countries of the Caucasus and the Black Sea region. For more details, see the article "Caucasus Mathematical Olympiad",(Russian Math. Surveys, 75:5 (2020), 991–993).

The Moscow Center for Continuous Mathematical Education was organized in 1995 (https://www.mccme.ru/) and quickly became a focal point for math popularisation. Clubs, various olympiads and tournaments, seminars for teachers are held within its walls and under its auspices. It is hosting the best publishing house of popular scientific literature on mathematics in Russia, both maintaining interest in old reprinted editions and releasing new books.

Math clubs or math circles (as they are called in Russian) are another excellent tradition. Once a week, school students come together to solve and discuss problems on various mathematical topics. Classes are supervised by both experienced teachers and university students. Most often, such clubs would function at universities, accepting students citywide. At some point, math clubs began to appear at specific schools with a strong math curriculum.

In addition to face-to-face clubs, there were long-distance correspondence schools. The most famous schools of this kind were the All-Union Correspondence Mathematical School at Moscow State University and the Correspondence Physics and Technology School at MIPT. Tasks and methodical brochures were mailed out to students. They, in turn, mailed back their solutions. Feedback was an important part of such schools. Many famous scientists participated in running those schools, starting with Israel Gelfand.

Just like math clubs, Russia has a large number of summer schools or camps, which play a very important role. These are usually summer camps close to nature, where math classes are mingled with sports and recreation. Many math circles and mathematical schools organize them for many decades.

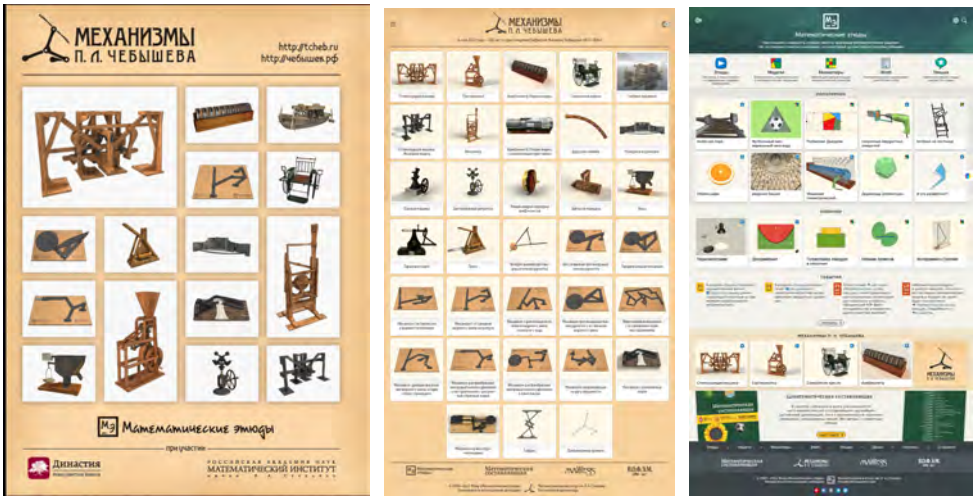
An informal seminar in Dubna

A very special annual Summer school “Modern Mathematics” has been operating on the Dubna and Volga riverside every summer since 2001 (https://mccme.ru/dubna/). During two weeks, about 100 participants – first-year college students and school students from the last two high school grades – take part in 100 lectures and seminars. This mix of both high school and university students creates a very special atmosphere. Apart from lectures, students can chat with prominent mathematicians in an informal and friendly setting. Brochures have been published on the materials of the classes and videos of most of the lectures hvae been made available online.

The summer school's traditions were established by Vitaly Arnold (1968–2017). Its teachers were well-known mathematcians Dmitri Anosov (1936–2014), Lev Beklemishev, Andrei Bolibrukh (1950–2003), Victor Buchstaber, Victor A. Vassiliev, Alexander Gaifullin, Alexander Kirillov, Alexander Kuznetsov, Sergei Lando, Yuri Matiyasevich, Sergei Novikov, Andrei Okounkov, Dmitri O. Orlov, Ivan Panin, Vladimir Protasov, Alexander Razborov, Andrei Raigorodskii, Stanislav Smirnov, Alexei Sossinski, Vladimir Tikhomirov, Albert Shiryaev and Vladimir A. Uspensky (1930–2018), as well as recent graduates who have just started their career in science.

Proliferation of personal computers created new possibilities for math popularization. While it is difficult to surprise colleagues with computer databases of math problems, some stand out nevertheless. Moscow teacher R. K. Gordin has collected an outstanding database of geometric problems https://zadachi.mccme.ru/2012/jndex.html, with more than 15 thousand entries. Painstaking daily work for more than two decades has borne fruit – the database has been verified, cross-referenced, tagged, and beautiful and mathematically accurate illustrations have been drawn. Another well-known database that has absorbed math problems from most Russian textbooks is available at https://problems.ru/.

The addiction of today's children to smartphones opens up new opportunities to popularize mathematics. For example, the Euclidea app (https://www.euclidea.xyz/) presents a modern and unusual approach to studying geometry. Instead of memorizing theorems and ready-made recipes for geometric constructions, you discover the properties of figures and their relationships on your own: by trial and error, by applying logic and intuition and by studying dynamic drawings. Euclidea requires you to solve problems using the smallest possible number of moves, which turns even standard problems into mindbenders.



Left and center: Mechanisms of Tchebyshev DVD cover and web page **Right:** Mathematical Etudes webpage

As was mentioned, an exceptional feature of mathematical popularization in Russia has been the prominent part played by leading scientists. from its very beginning has

been the main role always played by leading scientists. Following this tradition, the Steklov Mathematical Institute launched in 2010 a specialized Laboratory of Popularisation and Propaganda of Mathematics after a long preparatory work. This Laboratory became a pioneer in the promotion of mathematics in Russia, setting new standards in the popularization of mathematics and stimulating the development of this field. Among the projects of Laboratory are

- films "Mathematical Etudes" (https://etudes.ru/). This is a series of more than 70 movies, made using modern 3D computer graphics, devoted to some solved and unsolved mathematical problems. The project includes an online encyclopedia of visual mathematical models
- book "Mathematical Essence" (https://book.etudes.ru/) authors of which are leading Russian mathematicians.The main purpose of this book is to unveil and emphasize the mathematical "essence" of some of the greatest achievements of our civilization, as well as to show the mathematical "content" inside regular everyday things.
- internet-museum "Mechanisms by Tchebyshev" (https://tcheb.ru/). This is a collection of movies and other materials on mechanisms suggested and constructed by the great Russian mathematician of the 19th century. Among other things, it includes animations and detailed explanations.
- Mathematical park in the open air in the Republic of Adygea (https://mathpark.ru/ru/). More details can be found in the article Mathematical Etudes: Evolution from Multimedia to a Book (EMS Newsletter December 2016, pp. 38-43).

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