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# TOPOLOGY PROCEEDINGS



Volume 6, 1981

Pages 179–193

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<http://topology.auburn.edu/tp/>

## A VIEW OF SOVIET TOPOLOGY

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### Topology Proceedings

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**ISSN:** 0146-4124

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## A VIEW OF SOVIET TOPOLOGY

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Topologists in general are familiar with the names Paul Samuelovich Urysohn, Paul Sergeevich Aleksandrov, and Andre Nicholaevich Tikonov, and all mathematicians with Nicholai Nicholaevich Luzin and Dmitrii Fedorovich Egorov. Of all these, the first three were influenced in the directions of their study by Luzin who in turn had been influenced by Egorov. In addition the world of Soviet mathematics, and topology in particular, owes much to the father of one of these men.

Nicholai Nicholaevich Luzin (1883-1950) was the only child of a business man of the same name in Irkutsh (Siberia) who solely for the sake of his son left his business between 1893-95 and moved his family 1000 miles to Tomsk. In 1901, when his son had completed his secondary education, the elder Luzin again transplanted his family, this time to Moscow, a distance of 2000 miles. These two moves were for a total of 3000 miles, a trip equivalent to a journey across the United States. The first part of the trip appears to have been equivalent in hardship to the travels of our American pioneers, since rivers and wagons were the only means of transportation in Siberia at that time. The move to Moscow was probably easier because by

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<sup>1</sup>The author and his family spent six months (January-June 1979) at the Steklov Institute for Mathematics as part of the exchange program between the Soviet Academy of Sciences and the United States Academy of Sciences.

1896 the first branch of the trans-Siberian railroad had reached the River Ob at Tomsk [N].

These moves were made for the benefit of the son's education, the first to enable him to study in a good secondary school. When it was discovered that Nicholas was doing poorly in mathematics, a tutor (from the recently established Tomsk Polytechnical Institute) was hired. This person discovered that although Nicholas found it difficult to reiterate mathematical proofs (a method of teaching prevalent at the time) he could easily deduce his own.

At the University of Moscow, Luzin enrolled in the Faculty of Physics and Mathematics since he knew that a good mathematics foundation was necessary in his desired career of engineering. It was then that Dmitrii Fedorovich Egorov (1869-1931) noted the mathematical promise in the young man and took it upon himself to guide him into a career in mathematics, which eventually would enable Luzin to influence Aleksandrov and Urysohn. This doesn't mean that Urysohn and Aleksandrov wouldn't have collaborated in their "Memoires on compact topological spaces" which was to direct Aleksandrov's life from then on if it hadn't been for the influence of Luzin, although neither came to the University because of him. (Sadly enough the story does not have a happy ending for the well-meaning father as he lost all his savings gambling on the Moscow Stock Exchange.)

Paul Sergeevich Aleksandrov (1896- ), the son of a rural country doctor, grew up in the small city of Noginsk

just to the east of Moscow and went to Moscow to study mathematics because of the influence of his school teacher, Aleksandr Romanovich Eyges. It was there that he came under the influence of Luzin and ironically it was because of Luzin that Aleksandrov almost left mathematics entirely. After initial research success on the cardinal number of Borel sets, Luzin presented him with the problem of the continuum hypothesis. Frustrated by his inability to solve the problem, Aleksandrov left Moscow to teach literature but returned in 1921 to take his Ph.D. examination.

It was at this time that he met Paul Samuelovich Urysohn (1898-1924) who had traveled 700 miles from his home in Odessa to matriculate at the University. Originally he planned to study physics (and indeed his first publication was in that field) but he too fell under the spell of Luzin and turned to mathematics for his career, and thus met Aleksandrov, setting the stage for their remarkable memoir and the development of compactness and its importance in the budding field of topology. However, if the two of them hadn't collaborated it would have been done by someone else, as the time was ripe. But the important thing to realize in this story is that it was the teachers and the desire for a good education that led to the development of the mathematics school at the University of Moscow.

Today Soviet school children enter school at the age of seven to start their ten year secondary school education. As a contrast, in his autobiography [P], Lev Semnovich

Pontryagin (1908- ) states that his education was nine years of elementary school and 4 years of college (versus the current five years), but despite the fact that he deemed it more than adequate, the increase of knowledge has almost demanded an increase in the length of education everywhere. In the Soviet schools the first four years are termed elementary, years 5-8 incomplete secondary, and years 9-10 complete secondary. The Soviet child attends school six days a week from September 1 through May 30.<sup>2</sup>

During the elementary years, the school day is 24 hours a week, 30 hours during the next four years, and 32 during the last two. Under current Soviet policy, in those republics in which Russian is not a native language, a study of Russian is required in addition to the study of the native language and this may necessitate an additional year of schooling.

Most westerners have a view of the Soviet school child being strictly disciplined in school, an opinion enhanced by visions of youngsters attired in freshly ironed and starched uniforms. In the author's experience nothing is further from the truth. During the six months spent in the Soviet Union, the three boys attended English Specialty School 4 in Moscow. Although uniforms were worn by about 90% of the students, the only place discipline was observed was in the apartment building. In school, bedlam seemed to be the rule, especially during breaks. Many times unruly students caused a teacher to cancel classes and

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<sup>2</sup>All statistics concerning the educational policies of the USSR may be found in [RZO].

the students went outside to continue their routines.

Two meals are normally eaten in school: a second breakfast of pastries and cocoa midmorning, and a complete meal at noon. (These meals cost about 45 cents a day.) For working parents, the school serves as an afternoon daycare center for the elementary portion of the school with special classes being run until 5 p.m.

Studies are broken into three parts:

The Humanities (literature, Russian, native or foreign language, history, social science, geography) comprise about 40% of the studies or 45-47% where Russian is a second language.

Natural Sciences including mathematics compose 35% of the time; and the remainder is taken up with physical training (2 hours per week) and labor shop training.

Also the older children receive some instruction in military discipline as an extracurricular activity, complete with sticks or carved wooden guns. This sense of military importance was evidenced on Army-Navy Day (February 23) when the girls presented the boys with congratulatory cards and badges and members of the various military branches visited the schools.

The natural question to ask about the education is "Do the Soviets really stress the natural sciences?" The author's experience would give an affirmative answer. The placement of the boys in the school was based solely upon a mathematics test--age was not considered. The seventh grader was placed in the fifth form (the students a year

younger than he) where he encountered algebra and biology. In a report to the National Science Foundation, Professor Izaak Wirszup of the University of Chicago, reports that 98% of the school age population "study mathematics through the calculus. By the time they graduate from secondary school, Soviet students have also completed 5 years of physics, 4 years of chemistry, 5 1/2 years of biology, 5 years of geography, and 1 year of astronomy" [W].

Upon successful completion of his secondary education (which is culminated with mandatory examinations) a student may enter a university with the only official entrance requirement being a passing score on a secondary school examination. There is no tuition. This as well as the many universities which have been built throughout the fifteen republics since the revolution, the Soviet educational system owes to the policies established by Vladimir Illych Lenin, policies which undoubtedly are a result of the difficult time which he had in acquiring his own education. To illustrate the increase in educational institutions, in 1914-15 there were 12 universities in Russia with 41,000 students; in 1975 there were 69 universities with more than 500,000 students.

Moscow State University (referred to hereafter as MGY) was in the time of Luzin's matriculation and is now the most prestigious university in the Soviet Union and boasts five nobel laureates on its faculty in addition to such past scientific names as Pavlov, Chebyshev, Mendeleev and Lobachevsky. Busts of these men are to be found in the

park on the Moscow River side of the university and it is interesting to note that despite the Soviet penchant for putting plaques up everywhere denoting where Lenin lived or Puskin slept, for example, these are the only commemorations for mathematicians which the author saw.

MGY has an enrollment of about 30,000 students whose study in 260 departments are directed by a faculty of 7,000 (this figure included research workers, i.e., laboratory assistants). Included in this number are 106 members of the Soviet Academy of Sciences, 950 doctors of science and 3,500 candidates of science. Academic titles at a university are assistant (assistant professor), docent (associate professor), and professor.

Many of the faculty and students have been housed in the main building on the campus since the early 1950's when the university moved from downtown Moscow near the Kremlin to Lenin Hills. Aleksandrov has had an apartment here as well as the dacha in Komoarovka on the Klazma River outside Moscow which he and Andrei Nicholaevich Kolmogorov (1903- ) have shared since 1935.

A university education takes five years and includes a thesis written during the last year--this makes the basic college degree the equivalent of our master's degree. Up to the age of 35, a student may pursue the degree of Candidate of Science which is the equivalent of our Ph.D. This degree normally takes three years of study if the student pursues it full time as an aspirant in an institute of the Academy of Sciences or at the University, or 4-5 years if

the studies are undertaken while employed as a research worker either in an institute or university. The degree is awarded upon successful completion of exams, a foreign language (which usually seems to be English) and a defense of a dissertation. A dissertation defense includes a 20 minute presentation by the aspirant and then brief criticism and/or support by two opponents. The dissertation (as well as the senior thesis) must then be approved by the VAK (Higher Attestation Committee), which is the central academic degree awarding authority established under the Council of Ministers of the USSR.

The Doctor of Science--a degree for which there is no equivalent in this country--is awarded to those candidates who present an additional approved dissertation which opens a new avenue in the corresponding branch of science. In 1916 Luzin was awarded his Doctor of Science in Pure Mathematics based on his candidate's dissertation, the first time such an award had been made in 60 years.

This degree may also be awarded based upon superior teaching or research performance. Nina Karlovna Bari (1901-1961) was awarded her Doctor of Physical-Mathematical Sciences in 1935 without benefit of a dissertation, based only upon her reknown as one of the world's specialists in the theory of functions of a real variable. In both circumstances, approval by the VAK is required.

Other than having a position as a university professor, a graduate may also obtain a position in one of the many research institutes of the Academy of Sciences. This

organization is similar to the United States National Academy of Sciences in name only. The latter organization (founded by an act of Congress) is purely honorary with no influence or research institutes. On the other hand, the Soviet Academy (founded in 1724 by Peter the Great) runs 250 research institutes employing 160,000 scientific workers of whom 2,000 are Doctors of Science and 12,000 are candidates of science.<sup>3</sup> These workers need not be members of the Academy. The institutes are similar in nature to the Institute for Advanced Study at Princeton, the Courant Institute in New York, and the Institute for Medicine and Mathematics at Ohio University.

The members of the Academy are in three categories: academicians or full members of which there are 245 in the Soviet Academy, corresponding members (447) and foreign members (80). Election to membership is by secret ballot of the full members of the Academy with a two-thirds majority needed for election. Although the election is ideologically based upon a person's scientific achievements, in fact it can be extremely political.

In 1927 Nicholai Nicholaievich Luzin was elected a corresponding member of the Academy. In 1929 he was proposed for full membership and was assured of the support of some of his students. However, during the election process some of his students turned against him. The results of the election were surprising: Luzin was elected Academic, but in the Department of Philosophy

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<sup>3</sup>All statistics regarding the Soviet Academy of Sciences are found in [K-VL].

and only later in mathematics. Among the other people mentioned, P. S. Aleksandrov became a corresponding member in 1929 and Academic in 1953; A. N. Kolmogorov became an Academic in 1939; A. N. Tikonov was made a corresponding member in 1939 and Academic in 1966; and L. S. Pontryagin became a corresponding member in 1939 and an Academic in 1958.

The election to membership is more than honorary. Among other things (which may include the use of Academy automobiles) a corresponding member receives a monthly bonus of 200 rubles (300 dollars), and an academic, a monthly bonus of 500 rubles (750 dollars). This is on top of the monthly salary earned at the person's other position. Examples of monthly salaries at a top level institute are:

- junior scientific worker with an academic degree earns about 200 rubles;
- senior scientific worker with a candidate of science degree earns 300 rubles;
- and a senior scientific worker with a doctor of science degree and 10 years of experience earns 400 rubles.

A professor at a university with a candidate of science degree earns 400 rubles per month. There are bonuses for contract research and teaching. An interesting comparison the author observed were advertisements for trolley drivers which had, among other benefits such as day-care centers, a starting salary of 250 rubles/month.

Institutes of the Academy in Moscow have security guards at the entrances (in most cases just elderly men or women earning their pensions) and visitors must have a photograph accompanied by a written pass which is kept under glass at the security table. However in Leningrad at the mathematics institute and even at the presidium of the Academy in that city, there did not seem to be guards. The guard outside the building in which Academic Mikhail Alekseevich Lavrent'ev (1900- ) has his Moscow office was a police officer; probably because Lavrent'ev is a member of the Presidium of the USSR Academy of Sciences as well as a member of the Supreme Soviet since 1958 (he was admitted to membership in the Communist Party in 1952).

The Steklov Institute for Mathematics in Moscow, an institute of the Academy, is headed by Ivan Matveevich Vinogradov (1891- ).

Within the Steklov Institute are housed topical groups, each headed by an Academic, who is Aleksandrov in the case of the topological group in Moscow. Other members of the group and their areas of study are:

- K. A. Setnikov, who, along with his current aspirant, studies geometrical questions of the homological theory of compactness;
- M. A. Shitanko who is currently studying the embedding of compacta in manifolds;
- M. M. Postnikov studies the basic theory of homotopy;
- E. V. Shchepin is investigating the construction of spectral theory; and

A. A. Mal'tsev and his current aspirant study topological algebra.

These people are appointed for a set period at the end of which they are reviewed to determine if their accomplishments merit another term. There seems to be no government direction of research, that mathematicians--at least in the Academy institutes--are as free to study what they want as we are in this country, despite the fact that the Academy is financially supported by the government.

Publication is encouraged by payment for papers and foreigners who publish in Soviet journals must waive such payment. Many of these people also supplement their salaries by teaching in technical institutes.

The topology group is housed in two small offices (each of them is about 100 square feet) which other than almost daily use by Mal'tsev in his capacity as Aleksandrov's secretary are usually occupied only on Thursdays (which are traditionally library days). The group members do their research at home. This is not typical of all institutes as a friend of the author's worked at her institute 8-5, five days a week.

The library seems to be fairly well equipped with books and journals although the American journals arrive several months after they do in the States. Almost all foreign journals in the library seem to be acquired by exchange with the publisher of the journals. The reason for this is that the Soviet ruble is not an international currency and thus payment for journals is difficult.

Another example of the difficulties encountered is something which is taken for granted in this country: xeroxing of journal articles--the library in the Steklov Institute did not have a xerox machine.

Also the library books have to stay in the institute and may only be held overnight. The building in which the institute is housed is owned by the computer institute. Plans to construct a building for the Steklov Institute had been pushed aside by the Olympics.

Current results and ideas are exchanged at a seminar held weekly on Wednesday afternoons during the academic year at MGY. This seminar has been in continuous operation since it was founded by Urysohn in January of 1924. This contradicts the date as stated by Aleksandrov in his autobiography [A]. There he states that the seminar was started in the spring; but during a conversation with Aleksandrov and the author, Andre Nicholaevich Tikonov (1906- ) recalled that Urysohn started the seminar in January and Aleksandrov joined it in the spring.

At that time, the seminar met in three groups:

the first group studied the topology of the continuum;  
the second was of a teaching nature and studied surfaces;

the third considered the abstract character of topological spaces.

This was the section attended by Viktor Vladimirovich Nemytskii (1900-1967) (who later married Nina Karlovna Bari) and Tikonov. The world of mathematics is well aware

of the important, but brief, research of Tikonov in topology which resulted from this seminar and in which the influences of his first teacher are so evident.

The current seminar is of a nature different than any other which the author has ever attended since conversation between members is constant as are comments of criticism and/or support (clarification) between lecturer and other participants. Most of the talks are scheduled for 1 hour (beginning at 4) except for the first and last sessions of each semester which are for briefer announcements of results. Paul Sergeevich sits near the front with his eyes closed and his head down and in all appearances is asleep--he does this because his vision and his hearing are bad and he must concentrate to listen to the speaker. Despite these handicaps he is the first with praise or biting criticism. When Aleksandrov is not there, Yu. V. Smirnov is usually in charge.

There is a question of what will happen to each of these two groups, the seminar and the Steklov topology groups, when Aleksandrov dies. He was 85 on May 7, 1981. The seminar will go on, probably chaired by Smirnov, but at the present time there is no Academic to head the Steklov group.

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