Soviet Mathematics Education in the Late 1970s : New Concerns

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My research has focused on mathematics-curriculum reforms in the USSR throughout the 1960s and 1970s and their effects on the further development of Soviet mathematics education. (On the textbooks used before the reforms, see [2].) Andrei Kolmogorov (1903-87), professor of mathematics at Moscow State University, took the lead in designing the new curriculum. The changes were part of Nikita Khrushchev's larger education reforms, which were intended to bridge the gap between school academic programs and the practical needs of the state, and to prepare students for entering the workforce upon graduation. The authors of the new curriculum were predominately professional mathematicians, university professors, and teachers of gifted students—so their perception of the academic needs of ordinary students could have been skewed. The curriculum was rather conceptual, introduced set-theoretic notions at an early stage, and emphasized deductive reasoning and the axiomatic method. In some respects, it resembled the "new math" curriculum introduced in North America in the 1960s. Overall, the Kolmogorov curriculum proved to be too conceptual and abstract for the majority of Soviet students.

A decline in grades on entrance exams to postsecondary institutions in the late 1970s was one of the first concrete signals that the new curriculum needed further modification. These exams were administered by individual institutions, following the general curriculum guidelines established by the government. Lower grades were seen not simply as an indication of students' declining level of success, but also as indicating weakness in the entire education system. Soviet culture at that time valued constant growth and continued increases in productivity. Citizens and state enterprises were in competition to produce more goods, while educational institutions aspired to produce more research papers. Students and children were encouraged to obtain better grades and to improve their academic skills. This phenomenon is also referred to as "socialist competition"—a term originally proposed by Vladimir Lenin in his essay "How to Organize Competition", written in 1917 [5]. Soviets thus blamed the educational system's apparent decline in competitiveness on the new curriculum.

However, there was a curious pattern in students' results. They were able to solve abstract tasks and to compose outlines of complex proofs, but they were not always successful in technical tasks, such as computations or solving equations [3, p. 44]. By 1978 postsecondary educational institutions faced a challenge in designing their entrance examinations. Kolmogorov and his proponents thought that these institutions should produce questions that would test the students' mental readiness for learning complex concepts rather than the level of their technical skills. But changing the entrance examination system and the content of the examinations required an abundance of resources and a liberal timeframe, so this idea was rejected by higher-education authorities [1, pp. 89–103].

In addition to noting insufficient technical skills, the examination committees observed specific gaps in students' knowledge. One committee member, Yuriy Krivodub, stated, "Students, in general, are able to differentiate and integrate (within the limits of the school program). However, the problems that involve practical applications of derivatives caused difficulties [for the students]" [3, p. 44]. Krivodub described the students' performance as "satisfactory," but the connotation of this term in the Russian language is not the same as in English, especially when it is used in the context of grades and assessments. Usually, the term "satisfactory" was used to indicate that a student barely met curriculum requirements. Krivodub observed that students generally struggled with geometry and, in other portions of the examinations, made many small but significant errors, such as forgetting to take the square root of an expression on both sides of an equation.

Another examination committee member, Elena Petrova, observed that many students were unable to give coherent formulations of fundamental definitions and theorems, such as defining a parallelogram and a rhombus or listing all the properties of these figures and naming the key differences between them. Compared to students who had entered postsecondary institutions in previous years, students in 1977 and 1978 were often unable to distinguish between a theorem and a definition. Between 85 and 88 percent of students throughout the country were unable to prove theorems that dealt with the general notion of a derivative. Surprisingly, most students were still able to compute simple integrals, even though the concept of an integral was considered more advanced than that of a derivative. They could not identify different types of geometric progression. Many students could not plot a graph of the inverse of a function [3].

Only a modest percentage of students received good grades on the entrance examinations. Most students needed to improve some of their technical and presentation skills and to review the fundamentals of geometry and algebra. But despite all of these shortcomings, the examination- committee members were impressed by students' ability to solve problems that required more intuitive thinking and dealt with mathematical objects that students had experience with [3].

Because students did make improvements in the areas emphasized by the new curriculum, it was not evident that mathematics reforms were the chief reason for declining test scores. Additionally, the curious pattern in students' performance on entrance examinations could have been influenced by the content of *Kvant* (Quantum), the journal for high school students and prospective university students, which after 1975 emphasized more abstract content. Kolmogorov had been one of the authors and editors of this journal since 1970. *Kvant* published miscellaneous mathematical problems, puzzles, discussion topics, and interesting facts from the history of mathematics. A separate section was dedicated to study tips and sample problems for prospective university and college students.

The issues of *Kvant* published in 1975 and later years contained a greater number of abstract problems in the section for prospective university students, which could explain why students who wrote the entrance examinations in the late 1970s were better prepared for more abstract material. For example, one of the issues contained a problem set on periodic functions, where some properties were stated and their proofs solicited [4]. Students who were exposed to this type of material at the beginning of the school year would assume that they would be tested on it at the end of the year, during the entrance-examination time period, which was often in June and July.

In theory, university and college examinations were supposed to be designed in such a way that a good student could pass them relying just on knowledge of the school curriculum. But teachers noticed that students needed a good deal of supplemental tutelage, and so extracurricular activities and organizations devoted to secondary-school mathematics became common across the country.

Soviet culture was success-driven. Increasing success metrics in all areas of industry, as well as in education, was valued by the government and by Soviet citizens. Declining performance on examinations for entrance to higher-educational institutions therefore became an important point of concern for mathematics educators throughout the USSR. Meanwhile the Soviet government emphasized the importance of competing with the capitalist states, and socialist competition was a convenient way of integrating this spirit into the daily lives of citizens of all ages and professions. Enterprises and individuals who showed increasing success and productivity in their fields were highly praised, while the ones who failed to keep up were publicly criticized. In this context, why and how mathematics scores were declining was not as important as the basic fact that they were declining. Thus, mathematics educators, the Soviet government, and Soviet citizens all understood decreasing marks on entrance examinations as an indication of a more general problem, and not just a shortcoming of mathematics education. For this reason, they united in calling for a new round of reforms.

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