

# The Reception of American Mathematics Education in Soviet Pedagogical Journals of the 1960s and 1970s

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**Abstract** North American historians of mathematics education have provided detailed accounts of the 1960s “new mathematics” movement, its goals, features and aftermath. Parallel to the reforms in the West, but somewhat later, innovative and fundamental changes to mathematics education were being carried out in the Soviet Union. Soviet educational theorists were aware of the Western developments and discussed them in periodicals devoted to mathematics education. The Soviet reforms and their legacy have not been covered adequately in the literature. The paper will examine the reception of American mathematics education in Soviet pedagogical journals of the 1960s and 1970s and provide a comparison of the Russian experience with what took place in the West.

**Keywords** New math • Soviet Union • Mathematics education • Journals

## 1 Introduction

The decades that followed the end of the World War II were marked by political and social turmoil associated with the onset of the Cold War and its consequences. The Union of Soviet Socialist Republics and the United States of America were constantly trying to surpass each other in terms of creating advanced space technologies and weapons of mass destruction. However, military glory and sci-fi-like ideas of space exploration were not the only topics preoccupying the governments and the societies of both countries. Public education was the subject of concern for politicians and the general population alike.

The mathematics-curriculum reform called the “new mathematics” movement, which took place in the USA in the 1950s, and its goals, features and aftermath have been thoroughly analysed by historians of mathematics and education. A decade later, almost parallel to the reforms in the West, innovative and fundamental

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mathematics-education reforms were carried out in the Soviet Union. They were often referred to as “Kolmogorov’s reforms”, after the prominent Russian mathematician and educator Andrei Kolmogorov. In 1970 he became the head of the committee responsible for rewriting the mathematics curriculum. This committee consisted of professional mathematicians and teachers. However, most of them were either completely immersed in mathematical research or specialized in teaching gifted high school students or university students who were already interested in mathematics. As a result, the reformed curriculum was influenced more by trends in modern mathematical research rather than by pedagogical innovations. High school teachers often criticized the new curriculum for its changes in methods of presentation of the material and insufficient time for adjusting to the new guidelines (Abramov 2010, 81–140). Although teachers and curriculum authors often published their opinions in pedagogical journals, such as *Mathematics in the School*, the reforms and their legacy remain largely undocumented in the historical literature.

Soviet and American mathematics-curriculum reforms may seem similar at first glance. The fact that the “new mathematics” movement started earlier than the Soviet reforms may create an impression that Russian educators were using Western ideas and implementing them in local schools. However, the reasons for the implementation of the reforms, as well as the political and intellectual context in which they were carried out, were very different. The US government interpreted the launch of the Soviet satellite Sputnik in 1957 as a “scientific Pearl Harbor” and as a real threat in the space race. The American mathematics curriculum reform benefited from the increased funding of science and mathematics education programs provided by the government as a part of National Defence Education Act following Sputnik. (Walmsley 2003, 13). The Soviet mathematics curriculum reform, in turn, was part of the larger set of government-initiated education reforms of 1958. The latter reforms were intended to bring the school curriculum closer to students’ daily lives and to emphasize the practical aspects of each subject. While Soviet educators were aware of the changes in the Western mathematics curriculum, they were never simply borrowing Western ideas.

In this paper we will examine a prominent Soviet journal for mathematical pedagogy called “Mathematics in the School” and document some of the published opinions, criticisms and discussions that Soviet teachers presented regarding Western mathematics education. These discussions occupied a not insignificant place in Soviet mathematics education in the 1960s and the 1970s. Surprisingly, they have not been studied by historians of mathematics in any detail. This void in the literature can be explained by the secretive atmosphere surrounding the Soviet Union, hidden behind the “Iron Curtain”, and by the seeming lack of necessity for providing professionally written historical rather than pedagogical accounts of the reforms.

Many authors have discussed the peculiarities of the teaching techniques and new ways of presenting ideas to students that emerged during the 1960s and the 1970s

in Russia.<sup>1</sup> However, the accounts that address the political, social, intellectual and historical contexts of Kolmogorov's reforms have either been brief, or have focused on general aspects of education reform, without emphasizing the changes in the mathematics curriculum in particular. Nevertheless, numerous primary sources such as pedagogical journals, textbooks and articles dealing with mathematics education are now available through digitalized archives of government-issued documents or libraries. Many of these primary sources are in Russian and have not been translated into English. This paper will seek to provide more information on the topic of the Kolmogorov reforms and to give a brief history of education in Russia in order to better understand the historical context in which these reforms took place.<sup>2</sup>

## 2 Comparison with the “New Mathematics” Movement in America

The Soviet mathematics-curriculum reform of the 1960s did not initially imply any drastic changes to the curriculum's academic content. However, the presentation of the content changed. The new curriculum involved the introduction in elementary school of set theory and a deductive logical approach to the subject. It is important to note that an emphasis on set theory and logical deduction was not novel in the international community of mathematics educators. From the 1950s into the 1960s the USA had undergone a major mathematics-curriculum reform – referred to as the “new mathematics movement”, or simply the “new math”.

By the 1940s American society had begun to recognize the limits of traditional mathematics education. Youth lacked basic mathematical skills. This was most evident in military settings, where army recruits were often unable to succeed even in activities related to bookkeeping. A program called the “life adjustment movement” emerged in the mid 1940s. The proponents of this movement – mostly members of the education community at the early stages, later joined by the general public – stated that over 60% of students did not possess the intellectual skills that would enable them to go to college or to hold a position requiring specific skills. Hence, they proposed that the new courses in mathematics must focus on purely practical applications of knowledge. Home economics, insurance and taxation were favoured over algebra, geometry and trigonometry – these were excluded completely. The life adjustment movement was resisted and criticized by groups of parents and journalists for dramatically reducing and simplifying the academic content of the mathematics curriculum. However, most educators favoured it and even demanded to increase the level of its availability (Klein 2003).

In the early 1950s American student's knowledge of mathematics continued to decline. There is no evidence to assume this was a direct result of the life-adjustment

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<sup>1</sup>Such authors include Alexander Karp, Alexander Abramov and Igor Kostenko.

<sup>2</sup>Unless otherwise noted, the translations from the Russian in the present essay are by the author.

movement. However, it was evident that students' performance was not improving. At the same time, the political tensions with the USSR, and the arms race and the space race led to a demand for a steady flow of specialists qualified in mathematics and physics. As a result, the government granted substantial funding to mathematics education (Walmsley 2003).

A new group of progressive educators, who generally stood for hands-on discovery-based learning which would help students develop social responsibility and critical thinking skills, concluded that "mathematical education had failed because the traditional curriculum offered antiquated mathematics, by which they meant mathematics created before 1700" (Kline 1973, 17). These educators did not appreciate the fact that mathematics is a cumulative discipline and that students need to firmly grasp the older concepts before they can proceed to learn and understand modern research. Nevertheless, the idea of modernizing the curriculum took hold in the community of educators and the new mathematics movement was implemented throughout the 1950s.

New math was marked by an emphasis on formal notation, concepts of set theory, the structural laws of algebra and an axiomatic approach to the subject, starting at the elementary school level. For instance, elementary and secondary school students were expected to understand the distributive, associative and commutative laws of algebra even if their mathematical skills were not yet strong. The new math was developed and implemented in a different social and intellectual context from Kolmogorov's reforms and was in decline by the 1970s. Nevertheless, the characteristic criticisms of the new mathematics movement would also apply to the reforms advocated and implemented in the Soviet Union by Kolmogorov and his proponents.

During the nineteenth century mathematics expanded greatly, with whole new subjects being invented and existing subjects being expanded deepened and transformed. As the century came to a close mathematicians increasingly used a deductive-logical approach to formulate new results and subject areas. Hilbert (1990) emphasized the importance of rigour and clarity as well as an axiomatic approach to various mathematical subjects, of which the theory of probability was an important example. Prominent mathematicians in the first half of the twentieth century such as Emmy Noether, Bartel van der Waerden, the Bourbaki group, and Saunders MacLane believed that an increased emphasis on rigour, a focus on the concept of mathematical structure and an axiomatic approach were the signal characteristics of "modern" mathematics. (See Corry (1997) for an account of the emergence of modern mathematics.) Kolmogorov was well known for his work in probability in the 1930s, and the formal deductive approach he followed – including his famous axioms – in presenting his results.

The educational reform movements in mathematics in the second half of the twentieth century were a response to a complex variety of interests. Among these were professional and governmental organizations, as well as changes in demographics, industrialization, urbanization, and so on. At a more general level changes in the ideology of research mathematics and the emergence of what is known as "modern" mathematics, influenced the thinking of Western and Soviet educators

alike, and must be taken into account in understanding the wider theoretical culture that informed educational reform. Among other things, the authority of Kolmogorov – in many respects a stereotypical modern mathematician – in the world of professional and educational mathematics was very substantial in both the USSR and in the USA.

Some professional mathematicians in America believed the introduction of set theoretic notions would only create confusion among elementary school students, especially because the “material about sets [was] never used – nor [was] any explanation given as to why the concept is of any particular interest or utility.” The physicist Richard Feynman asserted that “often the total number of facts that are learned [was] quite small, while the total number of words [was] very great” (Kline 1973, 69).

It is important to note that American and Russian schools were often understaffed in the 1950s, 1960s and 1970s. Moreover, teachers also lacked time to learn the ins and outs of the new curriculum. Insufficient preparation of school teachers and the lack of an adequate time frame to prepare the new curriculum documents contributed to the ineffectiveness of the reforms in both countries (Wu 1998). The principal authors of the new curriculum in the USA and USSR were teachers and professional mathematicians who were accustomed to working with gifted students. However, a curriculum that was designed for gifted students could not be implemented for a general audience without a thorough training of teachers and modifications of existing pedagogical techniques. Unfortunately, the time frame of the reforms in both the USA and the Soviet Union did not allow for a re-training period. Even though additional courses were offered to teachers, educators could rarely complete them due to their heavy workload (Walmsley 2003).

### **3 The Reception of American Mathematics Education in the Soviet Union**

American mathematics educators launched the new math curriculum in the early 1950s and had identified its shortcomings by the early 1970s. Soviet mathematics reforms began in the late 1950s and continued for the next three decades, finally falling out of favour with the Soviet regime by the 1980s. Given the parallel nature of the two reforms, is it natural to assume that the programs borrowed ideas from one another. More precisely, did the proponents of Kolmogorov reforms borrow from the new math?

There are many reasons to conclude that direct borrowing was unlikely. Listing and discussing all of them is beyond the scope of this article. We will focus on the reflections and impressions of Western mathematics education in Soviet pedagogical journals. It will become evident that Soviet educators were informed about the American trends in mathematics education. However, they were not inclined to implement these trends directly in the Soviet setting. Western innovations in the

teaching of mathematics were often presented in a neutral light without substantial praise or criticism. Even the rare cases of harsh criticism of Western educators were rather a product of biases which were specific to the particular author.

The pedagogical journal *Mathematics in the School* has been publishing various articles related to teaching mathematics abroad since the 1930s. However, the frequency of the appearance of such articles and the countries that they were dedicated to varied over different time periods. For instance, there were numerous articles dedicated to teaching of mathematics in America and Europe, as well as Asia, during the 1930s and 1940s. Many of them were neutral in terms of political and ideological content. Articles dedicated to pedagogy in non-Communist foreign countries during the 1940s emphasized the superiority of the Communist state over capitalist states. Professor of mathematics Ivan Depman wrote in his 1949 article “Some Information about the State of Mathematics Education in Contemporary Foreign Schools” (Depman 1949, 39) that the mathematics curriculum in capitalist countries, including the USA, relied too heavily on textbooks that focused purely on “arithmetic for commerce.” He added that these textbooks lacked ideological education, and all of the proposed tasks and word problems were intended to teach “commercial transactions” (Depman 1949, 39). He then cited other Soviet authors who were familiar with American mathematics education and concluded that the majority of American youth lacked an adequate knowledge of basic mathematics. According to Depman, students in the USSR were able to master the tasks from the American mathematics tests much better than their American counterparts. However, it was not clear which specific groups of Russian students Depman referred to, since he only mentioned that he asked several teachers from Leningrad to give their students some mathematics tests produced in the USA. The teachers had proposed these tests to the students when a free hour of class time was available (Depman 1949, 40). Although this evidence is significant, the results cannot be considered reflective of the situation in the entire USSR. Depman asserted that the mathematics that the American students were learning in high school was insufficient for entering post-secondary education programs in engineering and science-related fields (Depman 1949, 48). Although his and other articles were clearly biased in favour of Soviet education, the Soviet educators and American educators were at least in agreement that the mathematical level of American students was insufficient and needed improvement.

Over the course of the 1950s when the Cold War was at its peak, articles on foreign teaching methods published in *Mathematics in the School* focused primarily on European countries and Communist countries. Policies and pedagogical techniques of communist countries were represented more favourably than the experiences of teachers from capitalist countries. For instance, the teaching of mathematics in France was described as too theoretical (Depman 1949, 40). The article “On Teaching of Trigonometry in Some Foreign High Schools”, published in 1957, indicated that the US curriculum lacked coherence in comparison with the USSR curriculum (Lebedev 1957).

Articles on American mathematics education appeared regularly in *Mathematics in the School* during the 1960s, although the term “new mathematics” was not used

to characterize the new tendencies in education. Published articles demonstrate that Soviet educators, professional mathematicians and authors of the reformed Soviet curriculum were aware of Western developments in teaching mathematics. These articles were informative in nature and did not carry political meaning. For instance, an article by D. I. Marchenko, "Overview of Algebra Textbooks for Public Schools of the U.S.A.," published in 1961, summarized the American mathematics education system and presented excerpts from textbooks used by Western educators. Marchenko stated that American mathematics teachers were free to choose any textbook that suited the intellectual needs of their students. The topics that were included in textbooks were chosen by the authors. Hence, the content of textbooks intended for the same grade level was often very different. The teachers had to be mindful of the peculiarities of each textbook in order to cover all the topics that were contained in the curriculum. Marchenko also presented several excerpts from textbooks that contained word problems and their solutions. The word problems were designed to stimulate logical thinking and to illustrate practical applications of mathematics in everyday life. For instance, Marchenko stated that many word problems were based on a scenario where a swimming pool was being filled with water. Solutions to these word problems did not seem to emphasize rigorous notions of set theory (Marchenko 1961).

In 1962 a direct excerpt from the *Report of the Commission on Mathematics. Appendixes. College Entrance Examination Board* that was originally published in New York in 1959, and translated by the prominent Russian mathematician, educator and historian of mathematics Aleksei Markushevich, was published in *Mathematics in the School*. The very fact of this publication demonstrated that professional mathematicians and leading figures in mathematics education were interested in learning about mathematics educational practices in the West and wished to make this knowledge accessible to teachers across the USSR. The excerpt from the aforementioned book contained instructions for teachers on presenting the topic of irrational numbers to students. Teachers were advised to specify the difference between rational and irrational numbers to the students and then explain the nature of irrational numbers in multiple ways. For instance, it was suggested that a diagram be presented to students to assist a numerical understanding of an irrational number American Committee for Mathematical Pedagogy 1962).

Articles on American mathematics pedagogy that appeared in *Mathematics in the School* in 1964 and later in the decade contained more information on the ways that Western educators were using set theory to teach mathematics to students of school age. V. B. Yudina summarized information that was originally published in the American journal *The Mathematics Teacher*. She called attention to the importance that Western educators placed on the teaching of symbolic logic and basic concepts of set theory. For instance, students were expected to be familiar with concepts of union and intersection of sets and to construct truth tables. She reported that the numerous diagrams and charts that were used to aid the understanding of these concepts could be challenging for the students. Yudina also emphasized that American educators placed importance on the deductive nature of learning and on the teaching of concepts related to symbolic logic (Yudina 1964). 1 The



American author and professor of mathematics education Bruce Vogeli, whose article “Modernization of Teaching of Mathematics in American Schools” was published in *Mathematics in the School* in 1964, summarized the main goals of the mathematics curriculum reforms that were taking place in the U.S.A. He did not use the term “new mathematics” explicitly, but noted that changes that took place in mathematics education over the previous decade were “revolutionary”. Vogeli acknowledged that American educators were dissatisfied with the way students memorized by rote various mathematical facts. He stated that the newly formed American curriculum was designed to encourage the students to make discoveries rather than to simply memorize facts. Students were expected to learn the basic notions of set theory at early stages of elementary school. The concept of negative numbers was also included in the curriculum of elementary school. It was also implied that teachers’ work was being valued and respected, and that students were keeping up with the fundamental requirements of the curriculum when sufficient assistance was provided. Overall, Vogeli presented a positive picture of the new trends in American mathematics education (Vogeli 1964, 88–90). However, his ideas were never explicitly praised or rejected by authors in any of the following issues of *Mathematics in the School*. There is no evidence that Soviet educators were planning to implement any of the American innovations in teaching mathematics, even if they had a beneficial impact on American students.

Another well-known Russian mathematician, educator, and author of mathematics textbooks, Isaak Yaglom, published an overview of various American textbooks on geometry in his article “Geometry in the Schools of the U.S.A.,” published in *Mathematics in the School* in 1967. Yaglom observed that American authors valued an axiomatic approach in learning and teaching various concepts in geometry. He stated that textbooks contain numerous definitions that the students are expected to learn in order to derive more complex theorems and statements. Although he did not give any detailed examples of the ways in which geometry was presented to students in these textbooks, he expressed the concern that such trends in pedagogy might not be suitable in the Soviet setting. Nevertheless, he emphasized that it was important for Soviet educators to be fully aware of the work of their American colleagues (Yaglom 1967, 96).

In the same year 1964 another article on American mathematics education was published by one P. A. Alexandrova in *Mathematics in the School*. Alexandrova examined the American presentation of concepts of arithmetic and algebra in textbooks for students in grades seven to nine. She briefly summarized the curriculum requirements of each grade level and then provided several examples of problems and concepts that American students were expected to learn. Students needed to be familiar with rational numbers, irrational numbers, and integers. They were to have a basic knowledge of set theory which included knowing the properties of various sets, understanding the concepts of union and intersection of sets, and so on. She noted that the concept of function was not fully explained to American students at the early stages of their mathematics education. At first the students were encouraged to develop an intuitive understanding of functions. Later they needed to learn that a function was a relationship between the elements of various



sets. A detailed definition of a function and examples of complex functions were presented to the American students at the senior school level (Alexandrova 1967).

One paper that touched upon the new trends in American mathematics education was published by Rolf Nevanlinna in 1968 in *Mathematics in the School* in 1968. Nevanlinna noted that axiomatic and deductive approaches found their way into most areas of modern mathematics. He emphasized that influential mathematicians such as David Hilbert and the Bourbaki group were promoters of this trend. Naturally, these ideas were bound to influence the field of mathematics education. While Nevanlinna did not provide detailed comments on the effectiveness of the new methods used by Western teachers, his article was informative and concise (Nevanlinna 1968).

## 4 Conclusion

It is evident that Soviet educators were aware of the work of their Western colleagues. However, this awareness does not seem to have involved any direct borrowing of Western ideas or any overt influence of American mathematics educators on Russian educators. Even if such influence existed, it can at best be described as indirect. However, modern mathematics was a significant factor that simultaneously influenced American, European and Russian mathematicians and educators. Modern mathematics encouraged an interest in set theory and structures within mathematics. American educators incorporated these ideas into the mathematical school curriculum in explicit ways (such as emphasizing the structural laws of algebra at elementary school level (Kline 1973)). In contrast, Russian educators rarely made explicit references to structures in mathematics at the school level. In both countries the curriculum was rewritten by professional mathematicians and educators who were more accustomed to working with talented children, or even university students (Abramov 2010, 87–140). Their expectations for the overall academic aptitude of ordinary students might have been too high to begin with. Since many authors of the new curriculum in both countries were professional mathematicians it was natural that their ideas on education would have been influenced by the latest trends in mathematical research (Kline 1973). We can conclude that modern mathematics influenced the minds of the curriculum reformers in both countries, while there is relatively little evidence of a direct influence of the new math on Kolmogorov's reforms. Given the political tensions between the USSR and the USA in the 1950s and 1960s, the Soviet educators would have been hesitant to publicly admit any direct borrowing of Western ideas. Doing so could have been viewed as support for Western culture, something that was discouraged during the Cold War period. While further investigation of this point is necessary, the published and unpublished sources that could shed light on it appear to be scarce.

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