

THE SOVIET CHALLENGE

The new mathematics curriculum required of all students in the U.S.S.R. is superior to that of any other country.

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In the last decade the Soviet Union has made dramatic gains—both quantitative and qualitative—in mathematics and science education and in training at the preuniversity level. For the 98 percent of the school-age population that now completes secondary school or its equivalent, the Soviets have introduced science and mathematics curriculums whose content and scope place them far ahead of every other nation, including the United States. Their foremost scholars and educators are engaged in a concerted drive to provide mass education of unmatched quality.

In order to appreciate the scale of Soviet educational expansion, it is worth remembering that during the Stalin era the secondary school graduation rate was as low as 5 percent—out of 1,000 children entering the first grade in 1930, only 49 completed the tenth grade in 1940. In 1957—the year of Sputnik, and just prior to the Khrushchev reforms of 1958—no more than 1,728,000 students graduated from secondary schools. In June of 1978, however, after years of extraordinary investment and effort culminating in the introduction of compulsory ten-year schooling in 1975, over 5,200,000 students graduated from secondary schools of all types, a success rate of 98 percent. (In the United States, by contrast, about 75 percent graduate from high

school.) In the same year, 2,300,000 students graduated from technical-vocational schools, with qualifications for skilled work. (These schools are expected to produce 11,000,000 such graduates during the period 1976-80.) Over 1,200,000 students graduate annually from secondary specialized schools for middle-level professionals, over two-thirds in engineering, agriculture, and management. In combination, these school systems produce over 3,000,000 skilled workers and middle-level technicians for the Soviet economy each year, a formidable trained labor force.

The major impetus for the tremendous changes that have taken place was a 1966 resolution by the Central Committee of the Communist Party of the Soviet Union that addressed demands of the "scientific and technological revolution" for a skilled labor force with a broader general education and a higher intellectual level. Responsibility for the reform in general education schools was assigned to the highest scientific and educational institutions of the Soviet Union—the U.S.S.R. Academy of Sciences and the U.S.S.R. Academy of Pedagogical Sciences. A team of scholars from both academies, headed by A. N. Kolmogorov, has been responsible since 1964 for the entire mathematics reform. Kolmogorov, one of the century's great mathematicians, worked in close collaboration

with other outstanding scholars and educators to set the goals of the new program, design the curriculum in every detail, decide on ways of treating various topics, and write the texts and manuals for students and teachers.

The result of their 15-year effort is a program for mathematics instruction that is modern in content, innovative in approach, well-integrated, and highly sophisticated. It gives strong emphasis to theoretical foundations and logical rigor as well as to applications. The program culminates in a calculus course taught in grades nine and ten. Moreover, advanced Soviet research in the psychology and methods of learning and teaching mathematics has been applied in the new curriculum, which now surpasses in quality, scope, and range of implementation that of any other country.

In only ten years, the Soviet compulsory mathematics program for all students covers the equivalent of at least 13 years of American schooling in arithmetic, algebra, and calculus, and does so much more thoroughly and effectively.

For example, over 5,000,000 graduates of Soviet secondary educational institutions in 1978 and 1979 have studied calculus for two years, while 105,000 United States high school students have taken a one-year calculus course (1976). This shocking situation is not ameliorated substantially by study at our institutions of higher learning. In the

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fall of 1975, only 397,000 American college students were enrolled in calculus courses. The majority of Soviet students at institutions of higher learning are studying engineering or science-oriented disciplines, and more than half of the 1,000,000 entering higher education each year have intensive training in mathematics, starting with a comprehensive course in calculus.

Still another consequence of the 1966 resolution was the emergence of elective studies in various school subjects. Besides taking the compulsory school mathematics curriculum, which accounts for six hours per week in each of grades one through eight and five hours in grades nine and ten (a total of more than 2,000 class hours over ten years), over 1.6 million students in grades seven through ten participated in elective studies in mathematics during the 1973-74 school year. Elective courses, which extend and deepen the compulsory curriculum, were established primarily to foster habits of independent and creative work.

Moreover, hundreds of thousands of youngsters take part in an exceptional range of extracurricular activities—mathematics clubs, circles, and olympiads—or study in unique secondary schools specializing in mathematics and physics, all designed to discover mathematical talent and to train it from the earliest possible age.

It is extremely difficult to compare educational achievements in two



countries as fundamentally different as the Soviet Union and the United States, but the following may be helpful.

Virtually the entire young Soviet population has been receiving ten years of compulsory schooling in mathematics, comprising:

- Three years of arithmetic (grades one-three)
- Two years of arithmetic combined with algebra (grades four-five)
- Five years of algebra (grades six-ten)

- Ten years of geometry (five of intuitive geometry in grades one-five; three of semi-rigorous plane geometry in grades six-eight; two of semi-rigorous solid geometry in grades nine-ten)

- Two years of calculus (grades nine-ten; in the future calculus may be taught in grade ten only).

In addition, the curriculum of the Soviet general education school includes:

- Five years of physics
- Four years of chemistry
- One year of astronomy

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- Five and one half years of biology
- Five years of geography
- Three years of mechanical drawing
- Ten years of workshop training.

All of these courses are compulsory.

Because the Soviet secondary school system branches into separate general education, technical-vocational, and specialized professional systems, to one of which each student proceeds after the eighth grade, the pace of an individual's study of these compulsory courses varies. What takes two years to learn in the general education schools may be distributed over four years in the technical-vocational schools. This assures that the compulsory curriculum is a truly universal one, accessible to students of different abilities.

Let us assume that a U.S. high school graduate has acquired a science background since entering elementary school equivalent to the Soviet background:

- Three years of natural science (grades two-four)
- Three years of geography (grades five-seven)
- Two years of biology¹ (grades five-six)
- One year of physics (grade six).

We find that every Soviet secondary school graduate has received in comparison to the average American college-bound high school graduate, at least (in years, not in hours):

- One-two years more training in algebra
- Eight years more training in geometry
- One-two years more training in calculus
- Four years more training in physics

- Three years more training in chemistry
- Three and one half years more training in biology
- One year more training in astronomy
- Three years more training in mechanical drawing
- Six-ten years more training in workshop.

Many of the Soviets have an additional several years of elective courses and extracurricular activities in mathematics, science, or technical fields in school, in Pioneer Houses, or at an institution of higher learning.

The disparity between the level of training in science and mathematics for an average Soviet skilled worker or military recruit and that for a non-college-bound American high school graduate, an average worker in one of our major industries, or an average member of our all-volunteer Army¹ is so great that comparisons are meaningless. Consider, on the one hand, the Soviet youth's educational background in mathematics and science, and on the other, the average American's eight or nine years of arithmetic, one year of algebra, one year of geometry (at most), and lack of high school level physics, chemistry, biology, and astronomy.

It is true that the new mathematics program, especially in combination with demanding science courses, has in many respects overburdened the Soviet educational system: students have been overworked, many teachers have been exposed to nearly insurmountable hardships, and parents have been dissatisfied. The program exposed and aggravated the differences in cultural levels and educational standards existing, first, between metropolitan and rural areas and, second, between the western

Soviet Union and the eastern (Asian) republics, at a time when authorities were priding themselves on narrowing these gaps. The problems encountered in various school programs prompted a 1977 resolution of the CPSU Central Committee ordering a review and revision of all school curriculums, and of mathematics in particular.

This resolution initiated sharp public discussion among the foremost Soviet mathematicians, a continuing polemic that has caused an open split in the U.S.S.R. Academy of Sciences. All the mathematicians praise the inclusion of calculus in the compulsory school mathematics program and do not question the range of the curriculum. But Kolmogorov's modern approach and rigor have been attacked by academicians who advocate a return to more traditional methods. Meanwhile, other scholars have taken up the defense.

Although disagreements will persist and discussions continue, the Soviets will doubtless overcome most of the obstacles. The Communist Party and the government are determined to adopt the highest possible educational standards and maintain the scale of mobilization they have recently achieved. The individual youngster is earnest, well-disciplined, and intensely motivated, and will pursue maximum education and training in spite of the dislocations involved. Not only is this the main criterion for success in a society that has become increasingly compartmentalized by educational achievement, it is practically the only secure avenue to a more comfortable standard of living under Soviet conditions.

The Soviet Union's tremendous investment in human resources, unprecedented achievements in the education of the general population, and immense human pool in science and technology will have an immeasurable impact on that country's scientific, industrial, and military strength. It is my considered opinion that the recent Soviet educational mobilization, although not as spectacular as the launching of the first Sputnik, poses a formidable challenge to the national security of the United States, one that is far more threatening than any in the past and one that will be much more difficult to meet. ■

¹In 1977 only 59 percent of the Army's entrants possessed a high school diploma.

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