Schools for gifted children

Victor Firsov

Hur och när stimulerar man intresse för matematik hos unga elever och hur tar man tillvara detta intresse på bästa sätt? Vilka möjligheter och svårigheter uppstår? Hur och när kan elever tas elever ut till en avancerad matematikundervisning? Här redovisas ryska kunskaper och erfarenheter. I kommande nummer ger vi exempel på uppgifter som används vid uttagningen.

There is a peculiar myth that was created among the Western politicians in the middle of the cold war – the myth about the development of a special educational network of schools for gifted future mathematicians and scientists as a new Soviet secret weapon. The myth appeared as a reaction to the first space shot of the "Sputnik" (1957) and to Gagarin's first space flight (1962). The superiority of the Soviet space technology of the fifties and the sixties needed an explanation, and it was found in the spread of the schools for gifted children. This opinion was confirmed by the impressive successes of Soviet teams at International Mathematical Olympiads (started in 1959) where for a long time almost no one could compete with Soviet graduates from the advanced mathematical classes. The explanation corresponded with the high prestige of Soviet professional mathematicians and with the common belief in the high level of general mathematical education in the Soviet Union.

Nevertheless this explanation was wrong: the irony of the situation was that the first special school with advanced mathematical education in the upper stages was created by Semyon Schwarzburd, the mathematics teacher at Moscow school No. 444, in 1959! The popularity of such schools grew fast, and from the beginning of the sixties until now, most of the gifted students interested in mathematics have been gathered at advanced mathematical schools. Now these schools are a natural part of the Russian System of Education that interacts with its other elements and influences them. Moreover, the broad spread of advanced mathematical schools for students of the last two – three grades indicates one of the modern trends in the development of the Russian Education System – streamlining of students of upper secondary schools according to their interests, intents and abilities.

The main goal of the line for advanced mathematics is the development of the students' mathematical abilities; their individual achievements in mathematics and other connected fields should be at a level that will allow the students to continue their education at the universities and at technological institutes with high requirements in mathematics. The line, offered at upper secondary schools that participate in the special system of advanced education, is open to students who have graduated from low secondary schools who have manifested their interests, intents and abilities to study mathematics. In the big cities this system is carried out mostly at schools with advanced mathematical education; in the small towns, in classes with advanced mathema-

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tical education of ordinary or streamlined schools; in rural areas – in such classes or in special boarding schools. The schools most well-known abroad, such as the boarding schools of Moscow and Novosibirsk Universities (initiated by such famous Russian mathematicians as A. Kolmogorov, M. Lavrentyev and A. Lyapunov), belong to the last kind of schools. A great number of "usual" advanced mathematical schools are also affiliated with universities, technological or pedagogical institutes.

The study plan of the advanced mathematical schools is flexible. It divides all the subjects into two parts. The profiled subjects are usually algebra (with elements of calculus), geometry and informatics (the computer and its use). School is permitted to devote up to one third of all lessons (12 academic hours per week) on the profiled subjects. This provides the school with the opportunity to construct far more advanced courses in comparison with ordinary schools. All other subjects in the traditional study plan of the comprehensive school are non-profiled and are studied as in ordinary schools.

The Curriculum for advanced schools is drawn up by the Laboratory of Mathematical Instruction of the Russian Academy of Education and is recommended by The Russian Ministry of Education. It is very flexible; so each advanced school can construct its own curriculum depending on the possibilities of the school and its students.

The advanced courses are not constructed by the addition of new topics to the ordinary courses' content. On the contrary, the advanced courses provide a more systematic exposition of the same topics with increased requirements as far as mathematical and logical rigour are concerned (including the determination of an axiomatic basis of the theory and the demonstrations of the main theorems). The courses also contain a large number of problems at a higher level of difficulty and complexity. Finally the courses presuppose a considerable amount of original individual work by students when studying the theory and especially when solving the problems.

The selection – how and when

The selection of the students being admitted to upper secondary school with advanced mathematics is made when leaving the low secondary schools according to the wishes of the students (not necessarily from one school) with high results in mathematics. Rather often the school is not able to provide advanced mathematical education for all those who wish: that is quite normal at least for more respectable schools. In that case, the school arranges oral or written entrance examinations. For some of the most prestigious schools the procedure of selection becomes even more complicated. For example, for a student to be admitted to the boarding school of Moscow University, he/she must show high academic achievements at his/her own rural school and good results at local mathematical olympiads. After that, he/she must pass a written examination by correspondence, requiring the solution of non-standard problems. At last, the best students are invited to take part at a one-month mathematical summer school at the University where they must demonstrate their achievements in mathematics and their ability to master the new mathematical materials.

The important practical question of the most desirable age for streamlining of education according to the abilities and interests of students has a serious theoretical background. Some of the students' abilities have a more general character, some of them are more specified. For example, special musical abilities can often be determined in early childhood. According to the research of psychologists, apparent mathematical abilities spring up much later and are formed actively during primary and low secondary education. So the broad streamlining of students before 14 – 15 years old should be considered as undesirable; we can make serious mistakes by assigning students to lines whose orientation does not correspond to the students' abilities. On the other hand, we risk losing some students whose talent for mathematics would show itself later.

The students' apparent mathematical abilities are usually correlated with highly developed interests in mastering mathematics. But education at the advanced level requires that the students have a stable interest in studying mathematical theory, in solving difficult problems and in being occupied by a systematic and intensive mental work in abstract fields. Our practical observations reveal that, as toddlers, children's interests in concrete subjects and matters are mostly unstable. This also speaks against the early streamlining of education.

The considerationsabove convince us that a high level of development of children's abilities and interests in mathematics is the necessary condition for the successful existence of schools with advanced mathematics. But during the years of education at basic school the inborn qualities and potentials of students are not always turned into abilities. The child's spontaneous interest in mathematics could be lost without special efforts on the part of the teachers and the school. Here we come to the core of our problem: I believe that the real foundation of the advanced mathematical schools in Russia is the well structured and consecutive system of developing children's interests and abilities in mathematics, realized in Soviet low secondary education from the middle of the thirties. This system trains the future students of advanced schools and carefully cultivates the beginning of their abilities and interests in mathematics. We are indebted to this system for the impressive achievements of the period when the schools with advanced mathematics did not exist. In that sense the schools with advanced mathematical education at upper grades represent just the vertex of an educational pyramid oriented towards developing gifted children.

The system contains different kinds of in-school and extra-curricular mathematical activities for the children. Starting in the primary school, the textbooks and problem books include special parts with more difficult materials and problems for voluntary reading and solution. Children can also find more difficult questions and problems in any chapter of the textbooks. Thus students can meet the challenge in mathematics in any lesson. On the walls of the mathematical classrooms children can see portraits and biographies of famous mathematicians, invitations to mathematics evenings, the traditional mathematical wall newspaper (prepared by the students with the help of the teacher) with some amusing materials and, of course, with new problems.

The heart of this activity at school is mathematical circles for children led by the teachers of mathematics (and often by students of mathematical faculties of universities and pedagogical institutes).

The author of this paper remembers himself in the second half of the fifties as a member of such a mathematical circle. A group of about 40 students from different Moscow schools met once a week for 4 years. Participation was voluntary. The lessons were usually devoted to a definite topic in mathematics inside and sometimes outside the school's curriculum: one lesson about the mathematical induction, another one about the geometrical transformations, a third one about the set theory, and so on. The teachers (students of Moscow University) did not present any theory to us. We had to "open" it by solution of more and more difficult problems suggested by the teachers.

Mathematical olympiads

The crown point of the circles' activity was the regional mathematical olympiad. In Moscow this event usually attracted thousands of students. The participation in the mathematical olympiads gave us the possibilities to examine our level of achievements in the solution of non-standard difficult problems, to compare our own achievements with the results of other participants and to discuss a variety of new problems with new friends. In this atmosphere of common love for mathematics, good results in the olympiad were considered very prestigious, although the prize for winners consisted only of some mathematical books. There were actually times when the famous slogan of

Pierre de Coubertaine, the founder of modern sport olympiads – the participation is more important than the victory – had a non-rhetorical sense for all of us.

Books for children

The real root that gave life to the system was popular literature in mathematics. Before and after the war a great deal of popular books for schoolchildren were published. Among them there were the well-known series of "The Popular Lectures on Mathematics" and " The Library of Mathematical Circle", books by world-famous masters of mathematics popularisation, Y. Perelman and I. Yaglom. Many magazines for schoolchildren published amusing and cognitive mathematical materials, including collections of mathematical problems. At the end of the sixties the special popular magazine on Mathematics and Physics for schoolchildren "Kvant" appeared...

The readers may feel a little drop of nostalgia in the author's reminiscences. The author participated in and witnessed the described events during this very romantic period of the creation of a system to work with mathematically talented children. Over the years this movement became more regular and rational; the romantic impulse was replaced by organization. The olympiads became more hierarchical and lost their original disinterested spirit, in its place came a sense of competition and of straight personal advantages. The appearance of schools with advanced mathematical education killed the mathematical circles for students of upper secondary schools. So new times generate new problems.

Math stars?

One of the most serious problems that appeared with the development of advanced schools has an educational character. The essence is that the selection of gifted children and their unification at mathematical classes generate very special educational "diseases" that require treatment.

The selection takes the children from their usual situation and unites them in the group with very special values and relations. Studying mathematics becomes the main goal of life, and their achievements in mathematics become their only indicator of personal success. The best students of advanced classes are too often subjected to the "star disease". Among the other students one can sometimes find the symptoms of an inferiority complex as a sharp reaction to their low achievements in comparison with the results of the best ones. A lot of recipes were suggested to protect the children (the development of advanced mathematical schools of different levels, the broad spreading of streamlines with non-mathematical directions, the special orientation of non-mathematical courses and so on) but honestly, none of them provides complete recovery. Nevertheless, in spite of all the discussions about plusses and minuses of advanced mathematical schools, the students and parents in Russia choose such schools with enthusiasm.

Let me end this article with a true story. Some years ago I saw the reportage on Russian TV about the boarding school of Novosibirsk University. A part of the programme was discussion between two University professors about the usefulness and expediency of schools for gifted. The discussants were born in a small village in the mountains of Altay. They studied at the same rural school, became Novosibirsk University students in the same year and had very similar academic careers in Applied Physics. The difference was that one of them passed the selection procedure and spent his last school years at boarding school, whereas the other one did not pass the entrance examination to the boarding school and graduated from his local ordinary school. The second difference was that in the programme one of them was very enthusiastic about advanced schools and saw only the advantages in it, whereas the other one was very skeptical and saw only the negative sides. Could you solve a very simple psychological problem: which of these two professors was the skeptic and which was the enthusiast ?