■ **In this country a search for science talent has been started but no serious appreciation of exceptional ability in mathematics has been shown with equal interest so far when real scientists and philosophers often come from the mathematically gifted.**

EDUCATION FOR MATHEMATICALLY GIFTED

I believe that, scattered round the surface of the globe, there should be a few special boarding-schools for young people who show exceptionally high ability in mathematics. I am not suggesting that there should be many; for example, I believe one would suffice for an area with a population the size of Great Britain's.

I pick on exceptional ability in mathematics rather than in others, partly because mathematics, like ballet, is a subject in which exceptionally high ability does develop very young and can be recognized at a very early age. I use the words 'exceptionally high ability' to mean what is possessed by not one in five but one in 500 people, of whom at most a tenth would have this exceptional ability specifically in mathematics.

So I have in mind selecting about one in 5,000 from each age group for these special mathematical schools. But I want to avoid staking exaggerated claims for the importance of mathematics. Scientists too often make exaggerated c l a i m s for science, usually to get a lot of money. But since the sum of money needed for a single new school in a country the size of Great Britain is hardly exorbitant, g r a n d i o s e claims for the importance of mathematics are not necessary to justify it. The pleading as I would put in for mathematics is based on two circumstances only.

First, the subject is a structure, each part of which rests logically and necessarily on the parts that precede it (you cannot do fractions till you have done whole numbers) and, secondly, the sub-

ject has been under intensive development, stage by stage, for 2,500 years. In that time the structure has grown to a phenomenal extent, till it has become a formidable task to become acquainted with even one major part of it, and therefore special education for those with a chance of achieving this aim may be desirable.

Admittedly this continual growth in complexity is from time to time reversed by some flash of insight, which shows how a great complex of steps can be simplified and reduced and unified and given clarity. But only by utilizing to the full the exceptionally able can we ensure the occurrence of these flashes of insight, that show the way ahead again when it seemed dark and cloudy.

Naturally enough, I am not advocating a curriculum for such a school that would aim exclusively at the production of pure mathematicians. It is well known that much of the finest mathematics today is going on in theoretical physics and in other fields of application of mathematics. Because the majority of these are at least founded upon physics, it can be argued that physics might play a specially important role in the syllabus. Without doubt, however, many other subjects should be included, so that people able to apply mathematics in many different fields would emerge from such schools, as well as a number of pure mathematicians.

I certainly do not propose an exceptionally large fraction of the teaching time for mathematics itself. The aim, rather, would be mathematics teaching of high quality, that goes along at the pace which these exceptional pupils can take, unimpeded by others with different kinds of mind (who, I hasten to add, can of course in their different ways be just as valuable to the community or more so). Furthermore, the same material would be appropriate to those with inclinations towards pure or towards applied mathematics, inclinations which in any case are not usually finalized at school age.

But I have no wish to put excessive emphasis on curricula. A much more important topic is the benefit that

these children would receive just from living with large numbers of their own kind. It seems likely that contact with their peers on this scale would sharpen their wits, bring out their abilities, and give them ideas, more effectively than any syllabus.

So far I have argued in quite general terms. However, what I have said has been influenced by the fact that I know one part of the world, with a population close to that of Great Britain, where a school similar to what I have been describing has been in existence now for four years.

The part of the world where, it appears, the first school of this kind, selecting from a large population, came into being, happens to be Siberia. This might seem strange to anyone except those lucky enough to know Mikhail Alekseevich Lavrentiev, the very remarkable man who for ten years has been President of the Siberian Department of the U.S.S.R. Academy of Sciences. Academician Lavrentiev is one of the great figures of our time in science and the organization of science, and he has managed to bring about during the past ten years a great flowering of science in Siberia.

It is in the headquarters of the Siberian Department, that is, in the famous academic town Akademgorodok, near Novosibirsk, that the special school was set up, an event which without doubt owes more than anything else to Lavrentiev's devotion to the cause of pure and applied mathematics, and to his conviction that, in the new town he was building, advanced mathematical and scientific education must be given not only at the graduate-research and undergraduate levels but also at the pre-university level. As a matter of fact the Siberian developments have been followed by three boarding schools being set up in European Russia with some similarity of aim.

I have emphasized Mikhail Alekseevich's personal contribution to this because it is rather important to realize that developments of this kind have nothing to do with politics. Such a boarding-school to cater for special needs could equally well

flourish under communism, under socialism, under liberalism, or under conservatism, as is shown by the parallel developments in the case of ballet. In mathematics a man with exceptional gifts who has chosen to devote himself to the cause of science in Siberia has, as it happens, succeeded in bringing about there the first realization of the aim I am describing.

In this realization, the arguments that I indicated earlier, for physics playing a role of special importance, were found convincing, and the Novosibirsk school is called 'physical and mathematical school', or *fizmatshkola* for short. While I am on names, which perhaps are important, I cannot resist explaining the name given to the pupils of this school. The Russian language has a special declension for the young animals, with singular in *-onok* and plural in *-ata*, so that a young goose is gus-*yonok* and a young mouse is mysh-*onok*, with plurals gus-*yata* (goslings) and mysh-*ata* (baby mice). This generated a rather attractive name for a young pupil at the *fizmatshkola*. He or she is called fymyshonok, and therefore of course the student body becomes the *fymyshata*.

There are just 600 *fymyshata*, and no intention to let the school grow longer. Their ages are between fifteen and seventeen. They are selected from the whole of Siberia and central Asia, so that the school draws on a population of about 50,000,000. A *fymyshonok* will spend three years, two years, or one year at the school, and go on to higher education at the age of seventeen.

The selection for the school is based in the first instance on a method of testing known as the Olympiads, and consisting of an examination essentially without time-limit. The questions are published annually in the youth magazines that are read in all Siberian schools. Actually, a different set of about thirty questions is given for each age group, but the general characteristics of them all are the same. They are puzzling out the answer will tell as much as possible about the child's

real ability rather than about his teachers'. To pick two examples at random, fourteen-year-olds were asked to prove that the first fifty odd numbers multiplied together come to less than one tenth as much as do the first fifty even numbers; and, again, to show that, in a country where the distance between each pair of airports was different, if an aeroplane took off from each and flew to the nearest airport, not more than five of them would land on same runway.

But, as I hinted earlier, educationists are generally in agreement that high mathematical ability can be identified at an early age. The Olympiads are the particular method used to do this in Siberia, although only for the purpose of initial selection. They could not be used for final selection because of the possibility of collaboration, but in practice, where everybody knows that further screening will follow, they are found to be a most valuable method of identifying those with really keen mathematical inclinations. I should mention, therefore, that similar Olympiad tests are now being held in many parts of the world, including Britain, although at present purely for the fun of competition rather than for selection purpose.

About 2,000 of those who send in good answers to the Siberian Olympiad questions are brought to the university of Novosibirsk during the summer vacation, so that they can stay in the university dormitories (while the regular students are away) for a few weeks' so-called summer school. There they are subjected to an intensive programme, including lectures on mathematical and physical subjects by distinguished scientists, and more problem-solving work. Finally, only about 200-odd, those who really stand up well to this exacting environment, are selected for entry to the boarding school itself, and become *fymyshata*.

Boys and girls are equally eligible, but, at any rate in particular conditions of Siberia and central Asia, only one-tenth of those successful in these tests are in fact girls. It is stated that their presence in the boarding-school naturally in separate dormi-

tories, causes no outstanding difficulties.

At the school itself rather over half the teaching is in mathematics and physics, including high-grade courses of lectures by prominent members of the academic town's fifteen research institutes and of the University of Novosibirsk. A large amount of problem-solving is featured in the course. The other subjects studied are chemistry, biology, history, geography, Russian literature, and the English language (mainly for reading purposes only, I am afraid). There are, in addition, various optional specialist courses. A regular staff meeting is held with the aim of improving compatibility among the courses.

On Thursdays there is no work, but there is compulsory exercise, including especially skiing in the winter and swimming in the lake in the summer. Sundays, on the other hand, are completely free for the *fymyshata* to do what they like. The evenings in the *fizmatshkola* are stated to be periods of intense activity: over thirty societies, devoted to all kinds of different pursuits, meet, and members of the research institutes participate in these meetings also. Some of the societies are devoted to exciting branches of science like astronomy or meteorology that can capture the pupil's imagination, some to musical and artistic topics, and some to games and hobbies. Certainly the teachers regard this free time as of great educational value, because of the way the pupils make each other think, as it were, in a vast variety of discussion and similar activities.

No claim is made that the selection methods are of great efficiency. In fact, between ten and fifteen per cent of the *fymyshata* fail to complete the course, and are relegated to ordinary schools on the basis of half-yearly examinations. Those who do complete it almost all go on to higher education, but it is only claimed that about half of those leaving appear really promising in mathematics and physics. However, this is perhaps not too bad a result at an early stage of such a development. — *By M. J. Lighthill, F.R.S. condensed from The Listener, October,* 1966.