Why We Lag Behind in Math

David Burghes

There has been much speculation about the poor performance of U.K. pupils in school mathematics—complaints have come from engineers, scientists and others in higher education, as well as from employers of school-leavers. Much of the evidence presented has been, at best, anecdotal.

To seek the truth behind their criticism, we started the Kassel Project, funded mainly by the Gatsby Charitable Foundation, in which secondary pupils (aged 13-plus) in 17 countries have been taking tests in math over two to three years. The countries involved include England, Scotland, Germany, Hungary, Poland, Singapore, Japan, Thailand, Norway, Greece, Holland and Finland.

Not only do we have data on attainment in math at a particular age, but we can also see how well pupils of similar ability in each country progress year by year. Our aim has been to find the factors that give rise to enhanced progress, and in consequence, to make recommendations for math teaching in the U.K.

Our results, which were presented at the second Gatsby mathematics education seminar in Birmingham, have tended to confirm the anecdotal evidence, although there are some topics in which England is doing reasonably well. More important, however, we have been able to identify a number of key factors in which countries making good progress differ from England and Scotland, so that there is every chance that we might redeem the situation.

It should be added that we are not blaming teachers—in the main they have been trying to implement, in difficult circumstances, the advice being given by educationists, administrators and government.

In our project, all pupils take the same tests (translated where necessary) in number, algebra, and shape and space. Table 1 shows the results and total progress over the first year (age 13-plus to 14-plus) for pupils in England, Scotland, Germany, Poland and Singapore. For each of these countries, Table 1 shows the average score (out of 50 marks for each test) for representative samples of about 1,000 pupils in each country. The final column shows progress made over the year.

Not only were England and Scotland well behind in total attainment on these core topics on the first testing, but the progress made during the year was less than in other countries. It should also be noted that Singapore is doing so well that it begins to become more difficult for many of the pupils to show any real progress so their increase of 16.8 over the year is an excellent result.

The trends in progress can be seen in the examples in Table 2 of responses to individual questions on the tests.

It is also interesting to note the performance of different groups of pupils. In Germany, there are three types of schools: *Gymnasium* (academic); *Realschule* (technical); *Hauptschule* (vocational). The attainment and progress made by pupils in these schools from Year 1 to Year 2 of the project and the equivalent data for pupils in England are shown in Table 3.

Table 3 shows that the *Gymnasium* students are catching up on our able pupils; the middle-ability students in both countries show similar performance, both in attainment and progress; while the *Hauptschule* pupils are progressing much faster than similar-ability pupils in England, and from a slightly higher attainment level.

In summary, we really do seem to be underperforming in comparison with both European and far eastern countries. Since math plays such a central role in technological developments, it is a real

Table 1. **Average Score Out of 50**

	Number		Algebra		Shape and Space		Totals		Progress
Age	**13+**	**14+**	**13+**	**14+**	**13+**	**14+**	**13+**	**14+**	
England	17.6	20.2	11.3	14.4	15.4	19.9	44.3	54.5	10.2
Scotland	18.2	21.6	9.6	13.0	14.1	18.4	41.9	53.0	11.1
Germany	23.5	26.9	12.5	17.6	11.3	17.3	47.3	61.8	14.5
Poland	24.0	29.2	16.6	24.9	13.6	22.4	54.2	76.5	22.3

Table 2. **How They Scored—% of Correct Answers**

Questions	Scotland		England		Germany		Poland		Singapore	
	13+	14+	13+	14+	13+	14+	13+	14+	13+	14+
$70 \times 0.3 =$	34	42	23	34	65	71	77	80	83	85
$2.4 \times 1\frac{1}{4} =$	3	7	5	11	20	26	42	54	63	70
Simplify $\frac{\sqrt{147}}{\sqrt{3}}$	0	2	1	5	2	4	12	33	16	33
Solve for x $3x - 4 = 11$	48	63	50	65	60	76	61	72	84	88
Multiply out $(x + 1)(x - 2)$	0	9	1	11	5	31	25	39	21	57

Answers
21 / 3 / 7 / 5 / $x^2 - x - 2$

concern for many that we are lagging so far behind our economic competitors.

So why are we underachieving? There is probably no single answer to this, but our observation of mathematics teaching in good schools in this country and abroad, particularly in Germany, Hungary and Poland, does, at least, give us some clues. Math teaching in these countries, and in other continental countries, is characterized by the teacher playing a central teaching role, not a management role as we see so often in the U.K. Whole-class interactive teaching is the norm, with teachers adept at bringing everyone into a discussion—often choosing the stragglers to work through exercises, or the homework, on the blackboard. In short, they keep all the pupils on task.

Math is always written and spoken clearly and precisely—again in contrast to the rather sloppy trends now seen in the U.K. Calculators are not used in primary schools and only allowed in secondary schools when pupils have gained that all-important feel for numbers and have learned to use them correctly. Homework plays a key role in the learning process, and mental and written tests are given regularly. Both homework and tests are marked before the next math lesson so that any common mistakes can be used as teaching points.

Table 3. **Rate of Progress Over Two Years**

	Germany		England	
	Yr 1	Yr 2	Yr 1	Yr 2
Gymnasium (higher ability)	62	+21	72	+15
Realschule (middle ability)	43	+11	41	+11
Hauptschule (lower ability)	25	+10	22	+5

Another key factor, apparent in Singapore, is that it is made absolutely clear what should be taught and when. There is only one series of texts and practice books, and it is these which in essence provide the vastly enhanced expectations, compared with the U.K.

These factors provide us with the basis for recommendations for math teaching in the U.K. Some may sound rather old-fashioned, but it is time to question our so-called "progressive" methods. A much more sensible approach is needed to teaching mathematics. For example, we must not be afraid to say a pupil's work is wrong, because it is so difficult to correct misconceptions introduced at an early age (as tutors in higher education are finding now).

Despite the many recent negative reports about mathematics teaching, let me finish with the really good news. Since outlining our recommendations, we have offered to support secondary schools in putting them into place. We already have 100 schools keen to take part in the demonstration project, the Mathematics Enhancement Program, which is again backed by The Gatsby Charitable Foundation and also by some leading companies including Esso, the Post Office and British Steel.

It has been heartening to find schools receptive to our recommendations and keen to be involved. It is time to stop the criticism and instead invest in and support our math teachers. We need to help our pupils reach their mathematical potential, which means enhancing teaching and learning. Our future prosperity depends on investment in education, and math is a key subject which should not be neglected.

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