**Will Chinese Teaching Methods help us improve UK performance in Mathematics?**

David Tall

This article was written for *Prospect* Magazine May, 2014 to respond to the announcement that 60 Chinese teachers were to come to England from Shanghai to demonstrate their methods which had produced performances on the international PISA tests where Shanghai children scored far higher than English children. It was featured on the cover page under the teaser title 'How Britain can get better at maths' and was printed, lightly edited, under the title 'Why are the British so bad at maths?'. The title is an editorial addition that I only saw after publication.

# Will Chinese Teaching Methods help us improve UK performance in Mathematics?

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Following the UK's 'average' performance in international mathematics tests run by the OECD, the Government has taken the decision to bring sixty mathematics teachers from Shanghai to introduce Chinese teaching methods in Britain. Will this improve performance? Time will tell.

A major factor relates to whether the comparison between the high level of success in Shanghai and the average performance of the United Kingdom is comparing like with like. Not only are there major cultural differences involved, the learning of mathematics in Chinese is significantly different from learning in English and some of the differences may not be easily transferable.

For example, number names in Chinese clearly relate directly to place value. Where we count 'eight, nine, ten, eleven, twelve, …' in English, the Chinese equivalent translates into 'eight, nine, ten, ten-one, ten-two, …'. While our words 'eleven' and 'twelve' relate to the ten fingers on our hands using the old English 'ei lief on' meaning 'one left over' and 'twe lief' (two left), few people know this or use it to support the meaning of place value. American research shows that English-speaking children learning early arithmetic are often a year or so behind those learning in Chinese.

A second difference relates to the length of the spoken words for 'one, two, three, …' which are inherently shorter in Mandarin Chinese than in English. Travelling around Taiwan speaking about learning mathematics, I used to challenge my translator to count to ten in Chinese as I counted in English. The audience was delighted to see me only reach around 'six' when my translator had already finished.

This difference affects our mental processing power. As we continuously process ideas in our mind, we have a two or three second 'phonological loop' that dynamically processes our thoughts and, because of the difference between word-length, while Westerners can remember about seven digits (plus or minus two), Chinese speakers can cope with around ten. As a consequence, mental arithmetic in Chinese is easier than in English, while arithmetic in other languages, such as Arabic or Hebrew with even longer number words is inherently even harder.

In the table ***, a few entries from the PISA 2012 results are selected, with the position in the list (from 1 to 65), the name of the economic area, the marks scored and the percentage of children with lower scores in the bottom third and higher scores in the top third of the assigned PISA levels.

The first seven entries are all Asian with Shanghai-China a clear leader. The highest European score comes eighth followed by Switzerland and the Netherlands, with Finland and Germany among the next, and the United Kingdom and France scoring at the OECD average. The USA score is just below average and other scores are lower, including selected countries from the Middle East and South America, with Peru scoring the least.

| | score | % low | % high |
|---|---|---|---|
| OECD average | 494 | 23.1 | 12.6 |
| 1 Shanghai-China | 613 | 3.8 | 55.4 |
| 2 Singapore | 573 | 8.3 | 40.0 |
| … | | | |
| 7 Japan | 536 | 11.1 | 23.7 |
| 8 Liechtenstein | 535 | 14.1 | 24.8 |
| 9 Switzerland | 531 | 12.4 | 21.4 |
| 10 Netherlands | 523 | 14.8 | 19.3 |
| 12 Finland | 519 | 12.3 | 15.3 |
| 16 Germany | 514 | 17.7 | 17.5 |
| 25 France | 495 | 22.4 | 12.9 |
| 26 United Kingdom | 494 | 21.8 | 11.8 |
| 36 United States | 481 | 25.8 | 8.8 |
| 41 Israel | 466 | 33.5 | 9.4 |
| 48 United Arab Emirates | 434 | 46.3 | 3.5 |
| 51 Chile | 423 | 51.5 | 1.6 |
| 58 Brazil | 391 | 67.1 | 0.8 |
| 63 Qatar | 376 | 69.6 | 2.0 |
| 65 Peru | 368 | 74.6 | 0.6 |

Of course there are a wide range of other factors that affect these scores. For example, the Shanghai sample excludes a significant percentage of migrant workers of lower social status, which exaggerates their high score compared with others. But even this does not explain the wide differences. It has long been observed that Asian 'tiger economies' make huge demands on their children's learning with extended practice on arithmetic which leads not only to increased scores on standard tests but also to pressures that cause anxiety and limited flexibility in solving problems.

In recent years, Asian countries have sought to improve problem-solving ability, for example, the Japanese have a long-established technique called 'Lesson Study' that uses carefully designed lessons to encourage children to work together to make sense of an intriguing problem and to refine their ideas through a carefully organized class discussion. This involves not only making lessons stimulating so that the children enjoy them, but also very careful design of lesson sequences to build to a significant idea, teaching lessons with a number of observers to study what happens to different individuals in the classroom and discussing the experience immediately afterwards to refine the lessons in ways that can be used more widely by other teachers.

Of the top seven Asian economies, only in Singapore is mathematics taught in English. So why is it that Singapore scores so highly compared with the UK? Since the 1980s, in Singapore the goals of education have changed dramatically from the highly efficient learning of necessary skills typical of Asian mathematics to the development of creative thinking at all levels, be they academic, technical or vocational. The Singaporeans use ideas that they have gleaned from around the world, including the translation of Japanese Lesson Study books into English. In primary schools the curriculum is designed to encourage children to focus on deep understanding of a smaller number of fundamental ideas as a sound foundation for future development. Secondary education separates into academic, technical and vocational schools according to the skills of the children, recognising that a forward-looking economy needs to value and develop all relevant skills to thrive in an ever-changing world.

To achieve higher standards at all levels, the curriculum is not overloaded with detail, leaving space for innovative experiences that encourage the children to make sense of mathematics and develop their creativity. Such developments require innovative curriculum changes that focus on encouraging children to both make sense of new ideas and also to develop fluency in carrying out mathematical operations.

Such innovations may be impeded when rigid curriculum requirements cause teaching to focus on immediate specified goals. In the Netherlands, which scores higher than the UK in the PISA tests, there is a perception that students starting higher education are not achieving the desired levels of fluency in mathematics. In a project introducing Lesson Study in the Netherlands, for which I acted as an advisor, we found that teachers were so fixed on the need to satisfy immediate curriculum requirements that it was very difficult for them to find the space to encourage flexible thinking. There were also cultural differences where the Dutch participants were very keen to be good teachers themselves and took time to learn to work together, as distinct from Asian teachers who were more attuned to being part of a team.

In Britain the government's concern is not only on the mathematical limitations of the more able who drive new ideas to advance the economy, but also on the general lack of mathematical competency in the adult population. The PISA study highlights the varying levels of performance of 15-year-olds in different countries together with data about student experiences and attitudes. However, this information is mainly used to seek statistical correlations. Understanding the mathematical disaffection in a wide swathe of our population requires more than statistical correlation, it involves the *causes* of that disaffection.

It is not simply that some people 'don't like' mathematics. My book *How Humans Learn to Think Mathematically* studies the long-term development from the new-born child, through primary and secondary school and on to university and later developments in research. Successive shifts in meaning, say from whole number arithmetic to fractions, or introducing negative numbers, or moving from arithmetic to algebra, or using mathematics to model different kinds of problem, all involve subtle changes in meaning. Pleasure comes from making sense of ideas and fitting them together in meaningful ways. Anxiety develops if the learner's current knowledge cannot cope with increasingly sophisticated ideas. The consequence is a growing division between those who build ideas coherently, developing a resilience to tackle new problems based on previous success, and those who attempt to learn a collection of diverse procedures that become increasingly complicated to handle in more sophisticated problems. To improve the quality of teaching and learning in mathematics requires us also to consider these more fundamental issues.

Over recent years the performance in mathematics in the UK in the PISA tests has not changed. Evolving long-term improvement is not helped by the swings and roundabouts in government policies as successive parties in power seek to make changes that require a significant improvement to encourage re-election within five years. To improve the learning of mathematics over the longer term requires a fundamental grasp of how learners make sense of mathematics so that everyone can make the best of their talents. This includes stretching the high achievers who will lead our economy and supporting the wider population, so that fewer people become anxious because they are put under too much pressure and more people get pleasure and resilience from success.

The government are making movements in this direction, by shifting the criterion for success from children achieving grades A-C which causes resources to be focused on that borderline to a more comprehensive improvement at all levels. There is also a desire to encourage the performance of higher attainers.

As in the Singaporean story, clues for improvement may come from many sources. We should welcome teachers from Shanghai to introduce their methods in a few of our schools so that some of our teachers and policy makers can gain a grasp of how they encourage better performance in their own context. However, we also need to seek a better understanding of the underlying mechanisms involved in mathematical learning to be able to distinguish between advantages in Chinese mathematics that cannot be incorporated into our ways of working and those that may be of more lasting value.