

What Works in Teaching Maths? Report Summary

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Abstract

This is a summary of two reports that evaluate research on the achievement outcomes of alternative approaches for teaching maths in primary and secondary schools. The reports looked at teaching strategies, ICT and mathematics curricula.

Study inclusion criteria included the use of randomised or well-matched control groups, study duration of at least 12 weeks (preferably a year or more), and the use of valid measures independent of treatments. In total, nearly 200 studies met the inclusion criteria across the two reports.

The key findings were that:

- The most successful mathematics programmes focus on changing daily teaching practices, particularly the use of co-operative learning methods, classroom management, and motivation programmes.
- The most successful mathematics programmes encourage pupil interaction.

Full reports

This review is adapted from:

- Slavin, R.E., & Lake, C. (2008), Effective programs for elementary mathematics: A best evidence synthesis. *Review of Educational Research*, 78 (3), 427-515
- Slavin, R.E., Lake, C., & Groff, C. (2009), Effective programs in middle and high school mathematics: A best evidence synthesis. *Review of Educational Research*, 79 (2), 839 – 911

The full reports are available at www.bestevidence.org.uk.

This summary was prepared by Jonathan Haslam and Jeannette Bollen-McCarthy at the Institute for Effective Education, University of York.



Background

In the UK during the last two decades mathematics teaching and learning has been shaped by national standards and testing. In 1989 the National Curriculum was introduced in England and Wales to standardise content and the time spent on each subject. However, the introduction of national testing in the early 1990s for 7-, 11- and 14-year-olds revealed that too many pupils were failing to reach the intended targets in key subjects. Indeed, only around half of KS2 children (age 7 to 11) were reaching the level expected for their age in mathematics.¹

In 1999 the *National Numeracy Strategy* was introduced in primary schools in an effort to raise standards in mathematics. Based on the National Curriculum, it included a daily Numeracy Hour which comprised oral work and/or mental calculation, a direct teaching session on a particular aspect of maths which children then practised, and a summary of the session. In 2003 the *National Numeracy Strategy* was combined with the *National Literacy Strategy* to form the *National Primary Strategy*.

The results of these initiatives have been mixed. Although the past decade has seen an impressive rise in maths attainment for pupils of all ages, the government's targets have not been achieved. At KS2 the target set was that 85% of 11-year-olds should achieve Level 4 or above in mathematics in 2006, with this level of performance sustained to 2008.² In 2008 79% of pupils reached this level.³ This is a significant improvement on the results from the mid 1990s, but falls short of the target figure. Moreover, 21% of children are still failing to reach Level 4. The target for GCSE was that 60% of pupils should achieve five or more A*-C GCSEs or equivalent by 2008,⁴ but the actual figure was 47.6%, including English and maths.⁵

The OFSTED report, *Mathematics: Understanding the score* (2008), is based on evidence from inspections of mathematics from April 2005 to December 2007⁶ and offers a broader assessment than exam scores alone. Again, though, the picture is mixed. The report praises the upward trend in test results at KS2, KS3 and GCSE, and the range of strategies that have been used by schools to achieve these. However, OFSTED also outlined a number of concerns. These largely reflect the way in which the subject was taught rather than the curriculum, which was considered age-appropriate in most cases.

The report's concerns included the fact that too much teaching concentrates on the skills needed to pass exams, but that assessment for learning continues to be weak. The report said that teaching was better at primary level because of teachers' attention to pupils' individual needs, and as many secondary schools struggled to recruit suitably qualified staff. Indeed, the report found that schemes of work in secondary schools were frequently poor, and inadequate to support

¹ 53.2% of pupils nationally achieved the government's target of Level 4 or above in mathematics in 1996 (the first year that the statistics are available). Source DCSF (NB Average for England shown on each local authority table) http://www.dcsf.gov.uk/cgi-bin/performance/tables/archives/shleap_96?lea=815&type=p

² Source: DCSF <http://www.standards.dfes.gov.uk/ts/informationcentre/nattar/>

³ Source: DCSF (NB Average for England shown on each local authority table) http://www.dcsf.gov.uk/cgi-bin/performance/tables/group_08.pl?Mode=Z&Type=LA&Begin=b&No=816&Base=p&F=1&L=50&Year=08&Phase=p

⁴ Source: DCSF <http://www.standards.dfes.gov.uk/ts/informationcentre/nattar/>

⁵ Source: DCSF (NB Average for England shown on each local authority table) http://www.dcsf.gov.uk/cgi-bin/performance/tables/group_08.pl?Mode=Z&Type=LA&Begin=b&No=816&Base=g&Phase=1&F=1&L=50&Year=08

⁶ Evidence for the report was collected in 192 schools in England, 84 primary and 108 secondary.



recently qualified or non-specialist teachers. The report identified that the best teaching was enthusiastic, knowledgeable, developed pupils' understanding of key concepts, and encouraged mathematical independence. Overall, mathematics teaching was rated good or better in just over half the lessons seen and satisfactory in around two in five. It was better in primary than secondary schools.

2009 saw a major shift in policy. Although more than £2 billion has been spent on the combined mathematics and literacy strategies, it was announced that from 2011 schools will no longer have to implement them. They will instead be encouraged to work together to find local solutions to improve their pupils' basic skills. This is an opportunity for schools, but in they need to have access to relevant and reliable information in order to make informed choices.

Aims

It has been difficult for educators to access clear information about the evidence supporting alternative teaching strategies, and in particular it has been difficult to make comparisons between different programmes of practice. However, as individual schools become increasingly responsible for choosing and implementing effective teaching methods, the evidence base for alternative approaches takes on even greater importance.

For this reason, this review seeks to summarise evidence of effectiveness of alternative approaches to teaching mathematics, and uses a common set of procedures to evaluate and summarise the evidence. We ask what tools are available to improve the outcomes of pupils, and which textbooks, computer programmes and professional development techniques are most effective in the teaching and learning of maths?

Research methods

An exhaustive search for potentially relevant research considered hundreds of published and unpublished articles. The two reports included studies from all countries that were available in English and met the following criteria:

- Schools or classrooms using each programme had to be compared to randomly assigned or well-matched control groups.
- Measures had to be fair to all groups (and not, for example, be a test inherent to the programme).
- Programmes had to be evaluated for at least 12 weeks, and preferably a year or more.
- Outcome measures had to be assessments of the mathematics being taught in all classes.

Outcomes of individual studies are expressed as effect sizes, the proportion of a standard deviation by which the experimental group out performed the control group (after adjusting for any pretest differences). Effect sizes of +0.20 or more are generally considered educationally significant.



Key findings

A total of 189 studies met the inclusion criteria across the two reports. The key findings were that:

- The most successful maths programmes focus on changing daily teaching practices, particularly the use of co-operative learning methods, classroom management, and motivation programmes.
- The most successful maths programmes encourage pupil interaction.

Findings by category

We grouped mathematics interventions into three categories: teaching strategies, ICT, and mathematics curricula.

Maths curricula

A number of studies measured impact on achievement for a number of different curricula. These fell into three categories:

- Innovative strategies that focus on problem-solving, alternative solutions and conceptual understanding
- Traditional commercial textbooks
- A back-to-basics textbook that emphasises a step-by-step approach.

Our reports assessed 13 studies of primary mathematics curricula, and 40 of secondary mathematics curricula. There was very little evidence that it mattered which curriculum was used, as none of them showed any strong evidence of effectiveness. Although it might be suggested that the standardised tests used to measure performance would not detect some of the more sophisticated skills taught by some innovative curricula, there didn't seem to be any evidence of this in the studies we looked at.

ICT approaches

In primary schools, technology has typically been used as a supplement to classroom teaching, often used only a few times a week. These programmes can help to identify children's strengths and weaknesses and then give them self-taught exercises designed to fill in any gaps.

Across the 38 studies that qualified for our reports, we found that most studies found positive effects, and none significantly favoured a control group. There was not enough high quality evidence to recommend one programme over another. We also found that the outcomes were stronger for computations than for concepts of problem solving. This is not surprising, as ICT particularly helps children with their computation skills.



In secondary schools, technology is used in three ways in the teaching of maths:

- Supplemental programmes, used to fill gaps in children's knowledge
- Core programmes, where the computer largely replaces the teacher
- Computer-managed learning systems, which use a computer to assess pupils and provide teachers with feedback for use in lessons

In the 40 qualifying studies that looked at these various programmes, there was little evidence of effectiveness. No programme stood out as having large and replicated effects, and computer-managed learning systems were particularly ineffective.

One limitation of our reviews is that many of these studies, both in primary and secondary schools, looked at programmes that are no longer available. This is a rapidly developing area, and ICT programmes are becoming ever more sophisticated. There is definitely a need for further research into effectiveness of these programmes.

Professional development

A number of studies have looked at the impact of using extensive professional development to help teachers use effective teaching strategies. These studies keep the textbooks, content and objectives the same, but change the teaching methods.

There were 36 qualifying studies in primary schools and 22 in secondary schools. Professional development programmes had the strongest evidence of effectiveness. Co-operative learning was particularly strong. In co-operative learning pupils work in pairs or small groups to help each other. It increases learning if the groups have a common goal that they can only achieve if all group members do well on independent learning. In other words, pupils have to teach each other, because their own success depends on it.

In primary schools, programmes that focused on classroom management and motivation also had strong evidence of effectiveness.

Implications for policy

1. Teachers can significantly enhance mathematics learning by adopting **co-operative learning**.
2. Teachers can also change their **classroom management and motivation strategies** to improve pupils' outcomes.
3. **Professional development** works.
4. The evidence does not support the idea that **different curricula** give different outcomes in terms of mathematics achievement.
5. There is limited evidence in primary schools and even less in secondary schools that maths **ICT programmes** are effective.



Conclusions

There are a number of important conclusions to be taken from this research. There is no evidence that different curricula give different outcomes in terms of achievement. Clearly this has important implications for the policy behind teaching maths. There is also limited evidence that technology is effective, although more research on newer programmes would help to improve our knowledge. However, there is good evidence that using effective teaching strategies can make a real difference. Changing the way that children work together, and classroom management and motivation, can improve mathematics outcomes for all pupils.

It is clear that more high-quality studies are needed on the effectiveness of the curricula, textbooks, computer programmes and teaching strategies being used in UK schools today. Most studies were done in the US, and need to be replicated in the UK. The evidence reviewed was of variable quality, and more work should be done to further investigate these findings. Nevertheless, there are a number of proven strategies that teachers can utilise to improve mathematics teaching and learning in their classes.

The full reports, together with an educator's summary, can be found on the Best Evidence Encyclopaedia UK, www.bestevidence.org.uk.

Glossary

Effect size

The effect size shows how much difference a programme/intervention makes. It is the difference between the mean of the *experimental group* and the mean of the *control group*, divided by the *standard deviation* of the control group.

The important point is that the larger the effect size, the greater the difference the programme/intervention has made. An effect size of more than +0.20 is considered educationally significant.

References

OFSTED, (2008), *Mathematics: Understanding the score*
<http://www.ofsted.gov.uk/Ofsted-home/Publications-and-research/Browse-all-by/Documents-by-type/Thematic-reports/Mathematics-understanding-the-score>

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