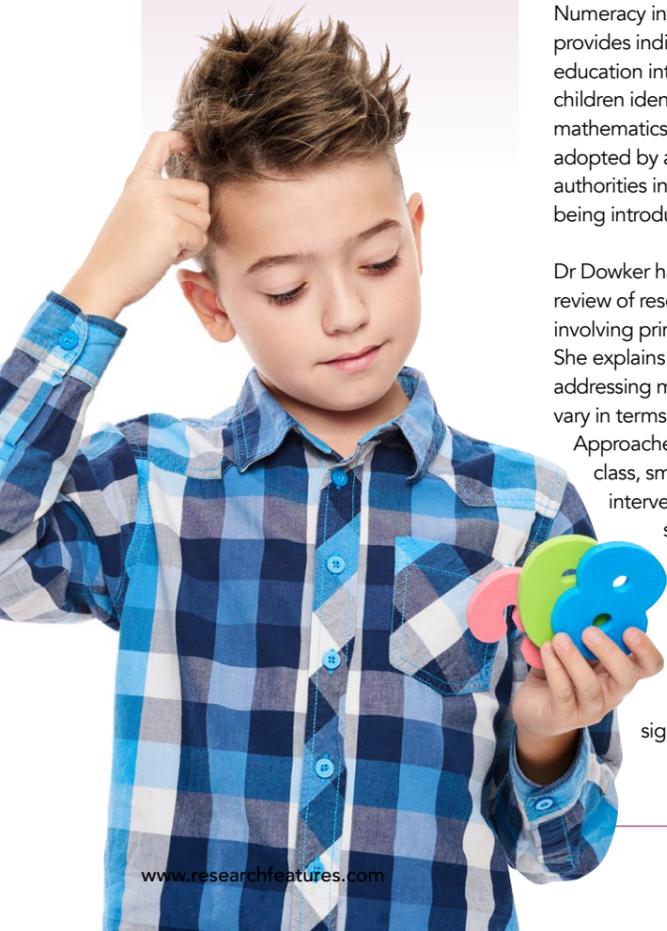


# Mathematical Difficulties

## Contributory factors and interventions

*Mathematical difficulties are common, yet they have usually received less attention than other areas of development, such as difficulties with language and literacy. Dr Ann Dowker, a University Research Lecturer at the Department of Experimental Psychology, University of Oxford, is redressing this disparity as she applies psychology research to education. In collaboration with the not-for-profit charity Catch Up, she has developed the Catch Up Numeracy program of interventions for children with mathematical difficulties.*



Around 22% of the UK adult population have numeracy difficulties that significantly impact their daily lives. Difficulty with mathematics, particularly arithmetic, is common yet this has received much less attention than other areas of development, such as issues with language and literacy.

Dr Ann Dowker, a University Research Lecturer at the Department of Experimental Psychology, University of Oxford, is redressing this disparity. She is applying psychology research to education in order to develop intervention programs for children with mathematical difficulties. Dr Dowker is the lead researcher on the Catch Up Numeracy intervention project, which provides individualised numeracy education interventions for primary school children identified as low achievers in mathematics. The program has been adopted by approximately 45 local authorities in the UK to date, and is now being introduced in Ireland.

Dr Dowker has carried out an extensive review of research into interventions involving primary school children. She explains how these interventions addressing mathematical difficulties vary in terms of their intensiveness.

Approaches can involve the whole class, small groups and/or individual interventions for children with significant problems.

### DYSCALCULIA AND DYSLEXIA

Difficulty with arithmetic is a common problem. Furthermore, there is a significant overlap between

difficulties in reading and mathematics. Researchers have observed diagnoses of both dyslexia and dyscalculia ranging from 20% to 60% in various studies. Evidence shows, however, that mathematics and reading difficulties can dissociate, so we cannot assume that mathematical difficulties result from dyslexia, language difficulties, or a generally low IQ.

### SOCIO-ECONOMIC DIFFERENCES

Dr Dowker describes how parental social class is an important predictor of children's academic performance in all subjects. Adults with severe numeracy difficulties are more likely to come from poor 'working class' backgrounds. Better off parents with a formal education make them more likely to be able to help their children learn. They can afford more educational resources for their children who tend to go to schools that are also better resourced. Moreover, the school culture is probably less alien to those children whose parents have more experience of formal education.

### MATHEMATICS ANXIETY

In addition to our abilities and the teaching we received, our mathematical development and performance depends on both emotions and attitudes. People's attitudes to mathematics range from extremely positive to the extremely negative. While the latter negative attitudes may result from dislike or boredom with the subject, for many people mathematics can cause severe anxiety or even fear. Mathematics anxiety has been defined as 'a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in [...] ordinary life and academic situations.' It



It has been shown that interventions that improve people's mathematical performance can also improve their attitudes to mathematics and reduce their anxiety.

is estimated that 17% of the population have high levels of mathematics anxiety. Sufferers can find managing their finances difficult and in severe cases they can experience difficulty and anxiety with day-to-day tasks such as reading train and bus timetables. Consequently, their choice of occupation is also limited. Nevertheless, it has been shown that interventions that improve people's mathematical performance can also improve their attitudes to mathematics and reduce their anxiety.

### INTERVENTION FOR MATHEMATICAL DIFFICULTIES

Although some intervention programs for children with mathematical difficulties have been available, particularly in the USA, since the beginning of the 20<sup>th</sup> century, large scale numeracy interventions are a relatively recent development.

It is important that we recognise that mathematical difficulties are diverse. Arithmetical cognition involves many components. Different people can show weakness in virtually any individual component, or combination of components, and no clear hierarchy of abilities is apparent. Research involving adults with acquired dyscalculia and the functional separability of different arithmetic components has revealed the need for interventions that assess and

target children's weaknesses, in particular numeracy components as opposed to a 'one size fits all' approach.

### PEER TUITION AND GROUP COLLABORATION

Encouraging children to teach one another offers schools a way to deal with

**We cannot assume that mathematical difficulties result from dyslexia, language difficulties, or a generally low IQ.**

their pupils' individual differences and can contribute to the success of some small-group interventions. The most common peer teaching approach is



Difficulty with mathematics is common yet has received much less attention than other areas of development, such as language and literacy.

collaborative group work with children working together as they attempt to solve a mathematical problem. This can have advantages such as increasing motivation while encouraging children to verbalise their mathematical ideas and to reflect on the strategies that they choose to employ, as well as sharing mathematical knowledge and ideas with one another. These benefits can depend on group dynamics. A dominant or 'clever' child can end out doing the majority of the work, while the others sit back and accept their decisions. Moreover, low achievers can be ignored and excluded from group discussions and decisions. Meta-analyses have revealed that peer tuition can be appropriate for children with moderate arithmetical weaknesses and no serious additional problems. Children with more severe difficulties are likely to require input from trained adults.

### BOARD AND COMPUTER GAMES

Games involving playing cards, dominoes and board games are often used in arithmetic teaching to improve children's arithmetic learning and performance both at home and at school. Many intervention programs use existing or bespoke games

for both individuals and groups of children to practice their arithmetical skills. Digital games specially developed for use by children

with mathematical difficulties, such as Dots2Track have received positive reviews from teachers. They have observed children to be more focused spending more time on individual tasks and complete more challenges with digital games than similar games involving physical cards.

### INDIVIDUALISED INTERVENTION

Individualised interventions, aimed at individual children's strengths and weaknesses, have only recently become widespread. The children's strengths and weaknesses are assessed in different components of mathematics and, where required, remedial activities are provided to address the assessed weaknesses. Many children are in need of targeted intervention, but not all require extremely intensive intervention. Relatively light-touch interventions delivered by teachers or teaching assistants within the school,

can be provided for small groups of children, with the option of individual intervention on a relatively infrequent basis. Researchers, both in the UK and USA have found that these interventions can considerably improve children's progress. They have also noted that level and nature of their effectiveness can depend on how these interventions are delivered.

#### CATCH UP NUMERACY

Some programs can be delivered to individual children by teaching assistants, rather than specialist teachers, and involves relatively small amounts of time. Catch Up Numeracy, a collaboration between Dr Dowker and the not-for-profit charity Catch Up, is an example of this type of program. Catch Up interventions was developed for children aged between 6 to 11 years, who have moderate difficulties with mathematics. The program has been extended and can now also be used with 11- to 14-year olds. It comprises two 15-minute sessions per week for approximately 30 weeks.

The Catch Up program involves individually assessing children on ten components of numeracy. A 'Catch Up Numeracy' learner profile is constructed for each pupil. This includes the entry level for each of the ten Catch Up Numeracy components that match the child's particular strengths and weaknesses. Mathematical games and activities are then provided for each child targeted to their individual levels in particular activities.

Dr Dowker's analysis of pre- and post-test results have revealed that "children make about twice as much



Many children are in need of targeted intervention, but not all require extremely intensive intervention.

**Children make about twice as much progress as would be expected from the passage of time alone.**

progress as would be expected from the passage of time alone and that they make significantly more progress than business-as-usual controls".

Some children, however, have severe mathematical difficulties that require more intensive interventions. These can involve daily one-to-one sessions with a teacher specialising in intervention techniques.

#### IMPROVING MATHEMATICS WITH GENERAL COGNITIVE SKILLS

The interventions discussed here are just a few of those that specifically involve mathematics. Research is ongoing into

improving children's mathematics by training them in more general cognitive skills. These include logical reasoning, planning and organisation, and reflection on one's own thinking processes. Training in working memory and other executive functions is showing promise, but still requires more research to establish whether it is an effective approach for improving mathematical skill.

#### RECOMMENDATIONS FOR FUTURE RESEARCH

More work is still required to develop and evaluate intervention programs. Dr Dowker recommends that long-term follow-up of programs are put in place to discover if programs impact on pupils' long-term mathematical performance. More comparisons between the various programs are required, particularly those that examine whether different programs have more success with different groups of pupils. In particular, Dr Dowker advises that whether the size and nature of the group affects the effectiveness of the programs being delivered should be explored to uncover, for example, the circumstances where individualised interventions are more effective than group interventions, or where small-group more effective than large-group interventions.

The Catch Up program involves individually assessing children on ten components of numeracy.



# Behind the Research

## Ann Dowker

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### Research Objectives

Ann Dowker's research interests include many aspects of developmental psychology and individual differences. She is especially interested in mathematical development and cognition.

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#### Bio

Ann Dowker is a University Research Lecturer at the Department of Experimental Psychology,

University of Oxford. She is the lead researcher on the Catch Up Numeracy intervention project. She is a member of the British Dyslexia Association Dyscalculia & Maths Learning Difficulties Committee. She has published numerous articles, edited or co-edited five books, and author of 'Individual Differences in Arithmetic: Implications for Psychology, Neuroscience and

Education' (Psychology Press, 2005; 2nd edition 2019).

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#### Collaborators

Dr Graham Sigley, Catch Up Trust

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### Personal Response

#### What initially sparked your interest in combining psychology research with education?

" I have always been interested in child development, and have noticed that children's lives can be significantly affected by difficulties in learning important aspects of the curriculum. Many of these involve individual differences in quite specific components of subjects like reading and mathematics, and if these individual differences are taken into account, this may help to prevent serious problems from arising. Mathematics seems to be a subject in which both underperformance and highly negative attitudes are particularly common. "

