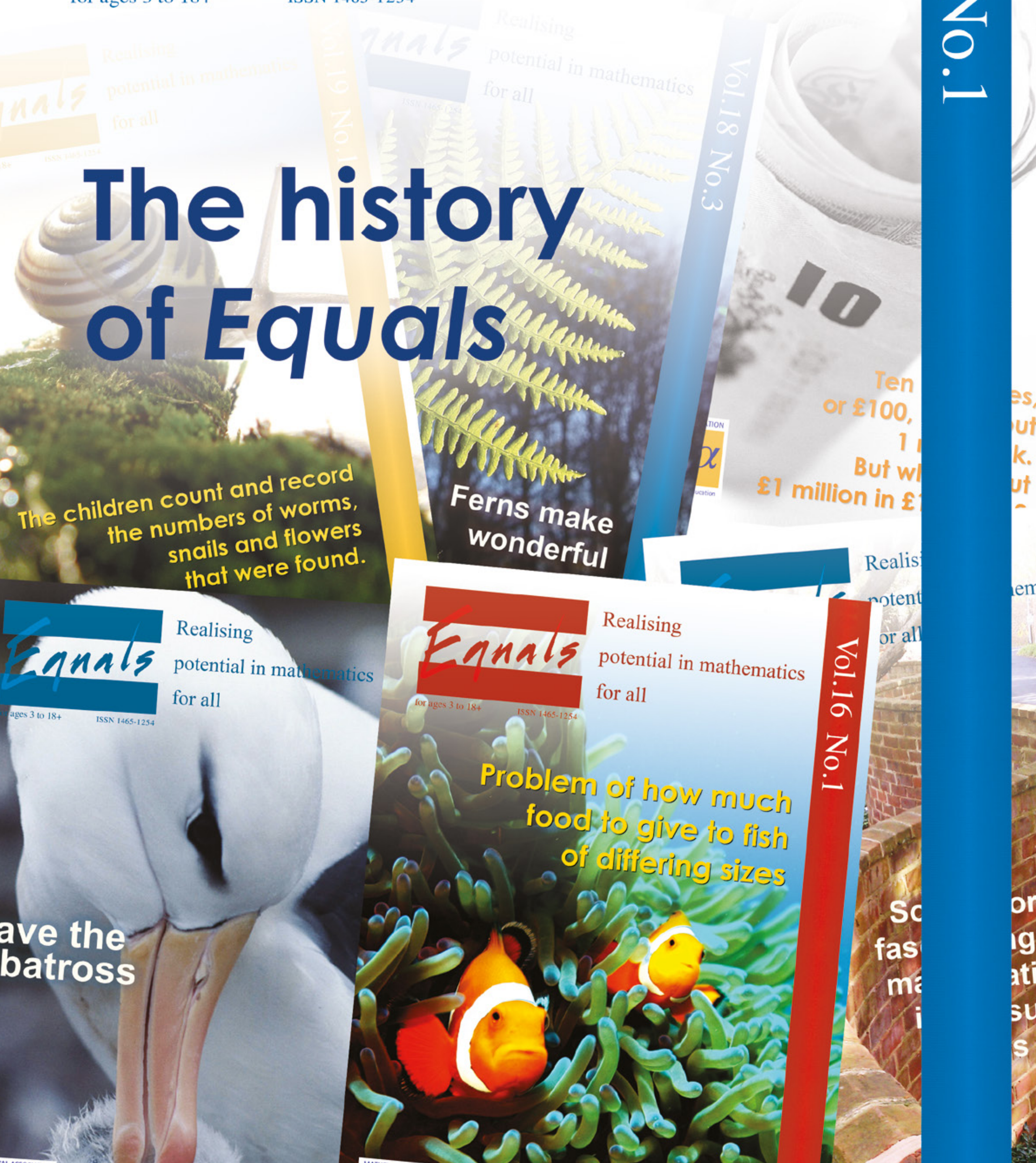
Equals

Realising potential in mathematics for all

for ages 3 to 18+ ISSN 1465-1254

Vol.20 No.1

The history of *Equals*



Realising
potential in mathematics
for all

Letters and other material for the attention of the Editorial Team to be sent by email to: edmiston01@btinternet.com

Published by the Mathematical Association, 259 London Road, Leicester LE2 3BE
Tel: 0116 221 0013
Fax: 0116 212 2835
(All publishing and subscription enquiries to be addressed here.)

Designed by Nicole Lane

Editors' Page

There are a range of articles included in this edition of *Equals* but two stand out for me: The history of *Equals* by Paul Harris and Thanks to Rachel Gibbons' by Mary Clark. Both of these highlight the role that Ray Gibbons has played in the development of a publication that has such a wide following. Ray has a real passion for all children but her skills were put to best use in supporting those who struggle to make progress in mathematics. To many of us these children are simply data we put on our seating plans or lesson plans during an inspection. But to her they were individuals in their own right and ones that deserved equal access to mathematics.

Pete Jarret brings his experience to bear in a number of pieces on two important areas of mathematics: dyslexia and discalculia. The latter has always interested me, especially since meeting Brian Butterworth, one of the most well known advocates for this misunderstood condition. In my piece on Hooke's Law I take the time to reflect upon the development of graphical understanding at the start of secondary education, something that hit me very powerfully during a science lesson in Year 7 earlier this year.

Equals, first and foremost has been a platform for sharing ideas and as such it would not work without your support and involvement. Please get in touch if you have any ideas of suggestions for the future work and direction of *Equals*. As a writer there is nothing more satisfying that a colleague picking up and developing your ideas and then sharing the outcome – it was this experience that kept me writing for *Equals* in a range of forms over the years. I do hope you will continue to interact with us at the classroom level. We always welcome suggestions for activities that might work to support and develop mathematical thinking in all pupils whatever their age or level.

You will notice lots of changes over the coming editions and we hope you will let us know what you think. During this time it is the legacy of Ray Gibbons that is uppermost in our minds and we aim to build upon that in a way that enable *Equals* to support the next generation of teachers and their pupils.

Meet the team

We have a new Editorial team at *Equals*. The four people below are the ones whose names you will see most often and so we felt you should get an idea of where we are coming from in terms of our backgrounds and current areas of interest.

Lucy Cameron

Is the mathematics coordinator in a special needs school for pupils from 2-19 with severe and profound and multiple learning difficulties based in Newcastle. She has taught primary and secondary aged pupils but currently teaches primary pupils in an autistic specific class. She is also currently completing my Masters course at Birmingham University in severe and profound and multiple learning difficulties.

Mary Clark

Following teaching and leading mathematics in a number of Inner London schools, Mary Clark moved into advisory work in two contrasting local authorities, one urban and one large shire county, focusing on teaching and learning mathematics in primary and secondary schools. As Adviser for Mathematics she was involved in improving mathematics education in a wide range of educational establishments from early years settings to adult colleges. She was also involved in Ofsted inspections. In the advisory roles she worked on professional development with serving teachers as well as teacher training for a number of SCITT courses, both primary and secondary. She also has wide experience of contributing to publications about mathematics education both for organisations employing her and more widely, including the Times Educational Supplement, The Mathematical Association and Association of Teachers of Mathematics, and BBC Education. Her work has also been published in an Open University publication. She has been a member of the *Equals* editorial team for many years.

Alan Edmiston

Alan has written for *Equals* for several years and has agreed to take on the role of Editor for the next year or so. His background is in secondary science education but following involvement with Mundher Adhami and the Thinking Mathematics or CAME approach he has spent more and more time in mathematics classrooms. Following spells working in two primary schools Alan spent one year teaching mathematics in an Academy before moving back into consultancy work supporting primary and secondary schools.

Peter Jarrett

Pete has been involved in training and education for most of his working life. Having spent the last 10 years working in a large FE College teaching mathematics and supporting students with specific learning difficulties, Pete now runs a tutoring and assessment business that specialises in working with students who have difficulties with learning mathematics. Pete is a specialist teacher and assessor holding AMBDA status. He is a member of the British Dyslexia Association Dyscalculia and Mathematics Learning Difficulties Committee. Pete is dyslexic and dyspraxic and often walks into stationary things, which is apparently funnier than a Statistics for Social Scientists module.

We also have a number of others who have agreed to support *Equals* such as Carole Buxton and Jenny Penfold. We are grateful to all of those who got in touch following various appeals over the last few months. If you would like to support *Equals* in any capacity and feel like putting pen to paper for us them please let me know: edmiston01@btinternet.com

From the 2015 World Championships in Beijing

The winning jump in the triple jump was 8cm behind the world record set by Jonathan Edwards 20 years ago in the World Championships in Gothenburg at 18.29m.

Usain Bolt ran the 10th fastest 200m of all time and the 34th fastest time in the 100m. His 100m time was over 0.2 s slower than his world record set in Berlin seven years ago. He has equalled this time twice since then!

Thanks to Rachel Gibbons

Mary Clark pays tribute to Rachel Gibbons, who was the driving force behind the genesis of *Equals*.

It is thanks in no small part to Rachel Gibbons (Ray) for her enthusiasm and determination that *Struggle*, more recently known as *Equals*, has flourished during the last 40 years or so.

In her role as one of the team of Inner London Education Authority (ILEA), Ray took on the leadership of the Struggle editorial team at the start of the journal's existence because a colleague inspector for mathematics in the Inner London Education Authority, who had initiated the production of *Struggle*, moved on from his post before the first edition had been published.

As a passionate believer in the rights of all learners to have access to mathematics, she has encouraged many educators to be a part of the creation of editions of *Equals*, whether through membership of the editorial team or by writing about all sorts of aspects of mathematics education for learners who find the subject more challenging. Thus contributors from schools, both mainstream and special, colleges, universities and other national organisations with special educational needs or mathematics education focuses, as well as from the wider community, have shared their reflections and strategies for teaching mathematics to a wide spectrum of learners through the pages of *Struggle* and then *Equals*.

The process of development whereby schools are encouraged to improve through sharing practice with other schools has been at the heart of *Equals*. Ray has promoted this approach by getting those involved in teaching mathematics to those who find learning challenging to write about their experiences and strategies. This process is clearly not such a modern one as some might currently present it!

Also in the spirit of sharing practice and collaborating to develop strategies to enable as many as possible to become more mathematically confident, Ray led the team in establishing some very thought-provoking 'Struggle on Saturday' workshop events.

Not only did Ray involve educators in *Equals* in all sorts of ways but children were not forgotten. The achievements of children have been celebrated through the annual award of the Harry Hewitt Memorial prize and children and young adults have also contributed through writing about their experiences of learning providing a different thought provoking perspective to *Equals* readers.

We wish Ray well as she stands down from the leadership of the editorial team and thank her for her massive contribution to the life of *Equals* up to now, and in looking towards its future.

Mary BJ Clark

A brief history of *Equals*

In the late 1970s, the journal, under the name of Struggle, was the creation of Peter Kaner, then an inspector in the Inner London Education Authority (ILEA). Peter was determined that the whole population should be given some facility with mathematics. Knowing that many strugglers in mathematics were taught by non-mathematicians - often fearful of the subject themselves - *Struggle* was founded to support teachers of pupils with special educational needs. In 1978 the first edition of *Struggle* was produced and published. By 1986 it was no longer an ILEA journal but was jointly published by the Mathematical Association and the National Association for Remedial Education. Thus it became a national journal, subsequently taken on by the Mathematical Association In 1995 the format of the journal was updated and, at the same time, the journal was renamed as *Equals* with its first edition published in the Spring of that year. Since then, three editions of the journal have been published annually, although in some years editions have been missed due to unforeseen circumstances.

Many articles are written by practising teachers who give examples of lessons which have been successful in engaging their students.

Originally *Equals* was published as a paper journal that was available to all members of the Mathematical Association. Starting with Volume 10, the journal was made freely available to anyone to download from the Association's website. In 2010 financial situation at the Association meant that *Equals* could only be published online to save money, and hence the change of name to *Equals Online*. Although the financial situation of the Association has improved, it has generally been felt that the freely available online format was the best format for this journal.

Equals has always published a wide range of articles. Some articles discuss the latest developments and government initiatives in education, and how they will impact on pupils with special educational needs, whilst others give practical advice on teaching and learning strategies for such pupils. In addition, many articles are written by practising teachers who give examples of lessons which have been successful in engaging their pupils. It is this wide range of articles that has made *Equals* such a successful journal.

Both *Struggle* and then *Equals* have been produced by a dedicated editorial team and whilst the members of the team have changed over the years, the one person who has done more for *Equals* than anyone else is Ray Gibbons, and the Mathematical Association acknowledges and thanks her for all her work on the journal.

Dr Paul Harris

MA Editor-In-Chief 2012-2017

Did you know that when an international team of researchers repeated 100 experiments published in top psychology journals they could only reproduce 36% of them!

Source: *The Guardian*, Friday 28th August.

I saw them change their minds

Time in a science lesson caused **Alan Edmiston** to reassess the teaching of graphs in Year 7.

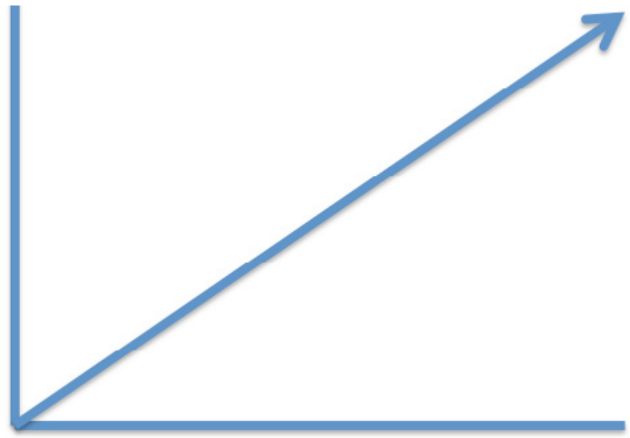
Simply allowing pupils to see and discuss each other's work on a problem is enough to move their thinking. Working to use graphs to express relationships, here they move from the familiar bar graphs to the more appropriate line graphs.

Something powerful happened to me this week. I witnessed a teaching episode that took me by surprise and prompted me to collect my thoughts and put pen to paper. After several years of teaching mathematics my work has recently seen me return to my first love – science. Currently I am both teaching science part-time and project managing a EEF funded research project 'Let's Think Secondary Science (see EEF website for more details: http://educationendowmentfoundation.org.uk/projects/P15) that is seeking to enhance student thinking and external examination success.

The incident in question occurred during a school visit to observe a Year 7 science class in a technology college in the north of England. The activity in question aims to challenge pupils to see that graphs are more than simple lines on paper but rather they can be viewed as a picture illustrating a relationship derived from two interacting variables. In this specific lesson the pupils are required to:

a) Collect results from a simple Hooke's Law experiment. They add 100g masses to a force meter and measure the force in Newtons required to lift each one.

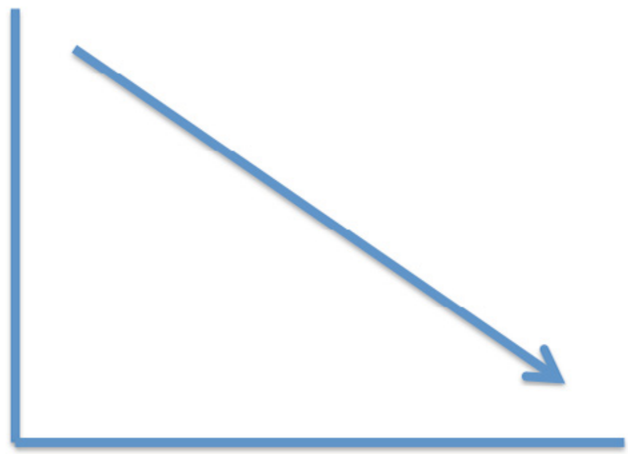
They then draw a graph of their results.



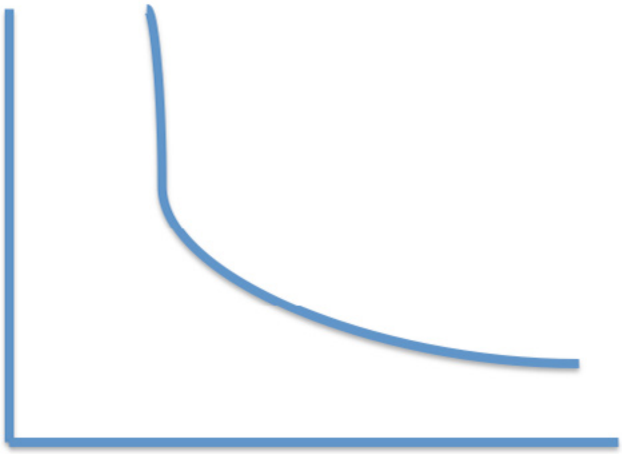
b) Watch a demonstration activity where washing up liquid of differing temperatures is poured through a glass funnel and timed. Initially only the first (cold) and final (warm) results are collected. The pupils can then draw a graph of what they think the other results will be.

The outcome of this is a twofold challenge:

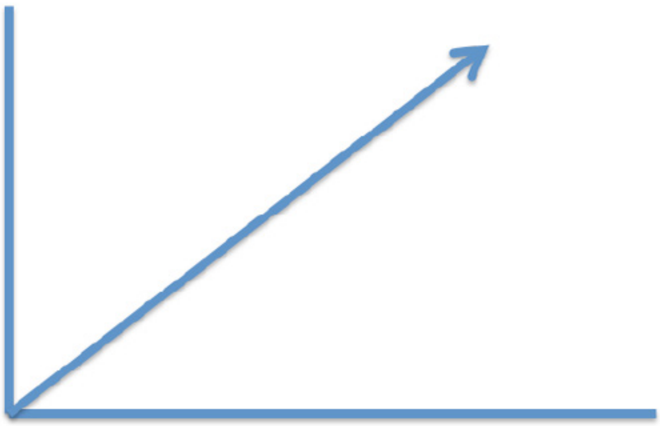
1. The pupils are challenged with their initial graph as compared with the actual one when more data is added:

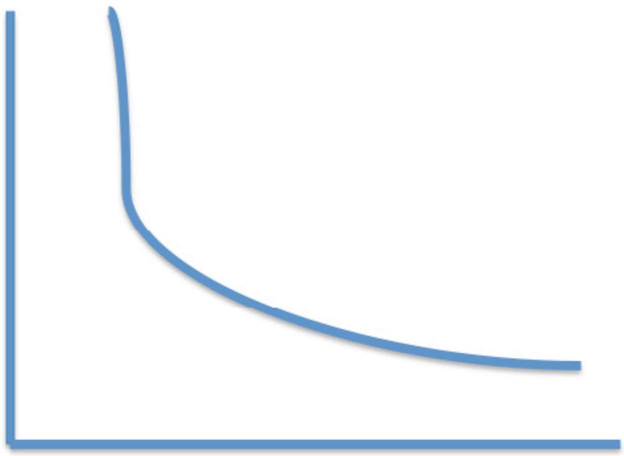


Compared to the actual:



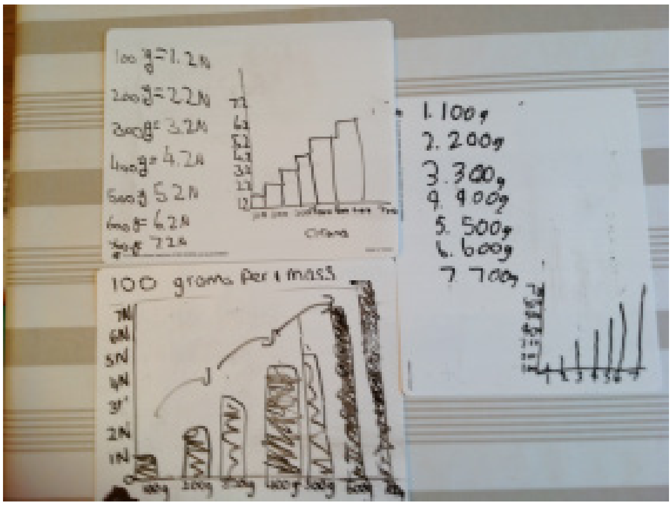
2. The pupils are then challenged to compare the two graphs and to explain why they look so very different:

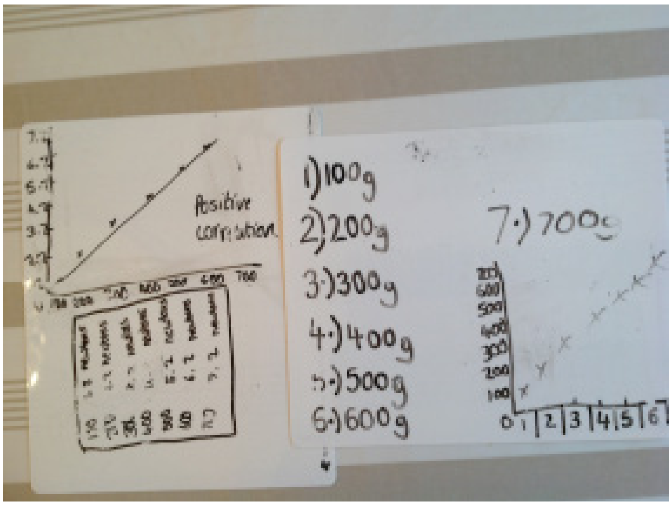




For me the significant thinking episode occurred just before the pupils were required to draw their neat graphs showing the first relationship. Many secondary science teachers are constantly frustrated by their pupils failure to draw line graphs from derived data and for many students the default position is to always draw a bar graph. They seem to find it very hard to move away from the safety of the bars that can be coloured and at times no amount of telling or showing will shift their natural response in this situation.

I was therefore not surprised with this groups first response to the 'Draw a graph on your whiteboards', instruction from their teacher. The two photographs below show the range of responses from this class.





Walking round the whole group I estimated that only about a quarter of the pupils had opted to draw a line graph. 'Here we go again' I thought as I began to think about how we could get the pupils to see the importance of line graphs when plotting continuous data. Sharing my thoughts about this with Karen, the teacher, together we formulated a plan of action.

We stopped the class and asked them to silently walk around the whole room for 5 minutes looking at all the different graphs that had been produced. They duly sat down and were allowed to talk about what they had seen before drawing the graph that would best show the relationship in question.

This strategy worked for scanning the room we noticed that more and more pupils were plotting line graphs, in fact only a quarter persisted in drawing bar charts. Without prompting they began to talk animatedly about what the lines were showing them about the relationship between the load and the force required to lift it.

For me this lesson was very rich in mathematical thinking and sadly I do not have time to discuss another misconception that arose, at this point, from the most able students in the class. On seeing the straight line one group chose to refer to it as a positive correlation – for they like many others view any straight line on a graph as a 'correlation'. Well before they have encountered scatter graphs, where they need to derive a line of best fit, I feel they have learned that this term pleases mathematics teachers and so they continue to use it whenever they see a straight line. This is similar to the way many pupils call a straight line at 45 degrees to the horizontal 'y = x' regardless of what the axes are telling them about the ratios involved.

The lesson ended as planned with the students sharing their views on why the two graphs looked so different. Yet for me my mind kept returning to the time half way through the lesson where we chose not to speak but rather allowed the pupils themselves to support each other to see the benefits of line graphs and their advantages over bar charts in this context.

Alan Edmiston

The assessment of self efficacy

Peter Jarrett asks how important is self efficacy in mathematics and/or learning in determining success in the mathematics classroom?

We tend not to worry too much about how learners feel about glaciated valleys or the Russian Revolution, but we know there are certain times of the year were we become tuned in to the heightened emotional reactions of our mathematics students, especially the strugglers, as we cheerfully wade in to algebra, or division or 'functional skills' questions. Mathematics appears to have its own unique social-cultural position, engendering feelings of anxiety, dislike and division (Ashcraft, 2002, Chinn, 2006, Evans, 2002, 2006), the Marmite of school subjects. A student once told me that mathematics is "like getting chewing gum stuck in your hair". Meaning, he didn't want it to be there, it was a nuisance when it was there, and it is very hard to get rid of it. There is a common bar room discussion on why we say we can't do mathematics but we feel it is socially inappropriate to say we don't do writing or spelling (for example: Sherwell, 2009). Mathematics seems to be intrinsically tied to feelings and an emotional reaction in a much more fundamental way than many other academic subjects.

Klinger (2011), in discussing the pervasiveness of mathematics anxiety in tertiary and pre-tertiary education suggests many learners:

> *-will bring to their mathematics/numeracy studies a strong affective load of negative preconceptions, both of mathematics and their own capabilities. That is, they have only a vague concept of what mathematics is really about, lack confidence in their own abilities, and often fail to appreciate the extent to which they actively and routinely engage in essentially mathematical thinking as they go about their daily activities.*

they have only a vague concept of what mathematics is really about

So, can we identify any differences between self-efficacy in mathematics and self-efficacy in the learning environment? If we can understand and assess a Replace with 'learner's approach to a classroom and the effect that this may have on how they expect to perform we can adjust our style of teaching to begin to adjust their expected performance. Perhaps poor self-efficacy, and potentially 'mathematics anxiety', are more bound to the situation in which the person finds themselves in than in mathematics. Naturally, there will be exceptions to this argument, a learner with a specific Learning Difficulty that affects their learning of mathematics will feel constrained by their mathematics ability in any context; that is, of course, the nature of a learning difficulty. It is accepted that the prevalence of moderate Learning Difficulties is between 5 and 7% (Butterworth, et all, 2011, Geary and Hoard, 2002). A similar figure of 5-8% has been quoted (Chinn, 2009) for levels of significant mathematics anxiety amongst secondary school learners in the UK. There continues to be a wide ranging debate relating to students continuing with mathematics beyond compulsory education, and their preparedness to continue with a mathematics education (Pampaka, et al. 2011, and Williams, 2011, for example). Wilson (2011) suggests that little attention has been given to the factors that influence the degree of an individual's engagement with mathematical activity. He goes on to list a number of factors, including self-efficacy amongst others such as attitude, motivation, beliefs and values. Pampaka, et al. (2011) observe "the importance of considering student's self-efficacy beliefs, in addition to test scores, is stressed in recent research findings mainly because of its positive impact on academic choices".

Bandura (1997) argues that people have influence over what they do, which he describes as human agency, that is, "acts done intentionally". He argues that beliefs of personal efficacy constitute the key factor of human agency and contribute to the regulation of aspirations, effort and behavioural courses. In short:

> *Much human endeavour, which is purposive, is regulated by forethought embodying cognized goals. Personal goal setting is influenced by self-appraisal of capabilities.* (Bandura, 1993)

A sound definition of self-efficacy could be considered to be:

> *Beliefs in one's capabilities to organise and execute the courses of action required to*

produce given attainments (Bandura, 1997)

The discourse of the classroom does seem to suggest that self-efficacy, and therefore anxiety, may well be situational. That it is the mathematics classroom that lies at the root of the problem. Klinger (2011) exemplifies this is discussion how the term 'basic' is applied in the mathematics classroom:

> *The word 'basic' is often applied to the everyday arithmetic of addition, subtraction, multiplication, division, fractions, decimals, and percentages. There is a tendency for those that 'can do' to use the word in a dismissive or belittling fashion with those who 'can't do' – "you should be able to do that [at least]...it's just basic arithmetic". Math-averse learners have heard statements like this throughout their mathematics learning history and in the workforce, often accompanied by expressions of disparagement, derision, frustration or anger..*

Learner 'Sam' identifies some of their concerns thus:

> *The worst thing about mathematics lesson at school was the teacher spent too much time lecturing the class and I would always switch off after 5 minutes no matter how much I tried to concentrate. I felt stupid asking her to stop and explain something. There was no discussion in class and it was not an open, friendly setting where students spoke up or contributed in any way.*

Learner 'Terry' on the best and worst aspects of maths lessons at school:

> *Best: - They were rewarding. - Directly applicable to everyday life. (Mostly) Worst: Mathematics teachers were usually very authoritarian. (In my case) - Negative attitudes toward math in class caused a lot of disruption and impeded learning. - Teachers never really made the value and importance of mathematics clear; so people didn't try as hard.*

And, learner 'Andrea':

> *Worst thing was being divided up into higher and lower classes, I thought I was reasonably good at it until I was put in the lower group*

If it is the case that the environment in which maths is done can have a significant effect on efficacy then there is a possibility that we would be able to identify efficacy of classroom tasks as being distinct from efficacy in completing mathematics tasks.

In order to test whether people approach mathematics differently depending on situation we have had to create three situations and two attitudinal perspectives or constructs. Because we hope to measure how people feel that they are able to function in a situation rather than a situation itself it is felt that there is an element of personal construct in the situation. The three situations are:

1. Mathematics and numeracy in real life
2. Mathematics as encountered in the educational environment
3. Mathematics classroom related learning activities

I have made an attempt to draw out three situations in which people's efficacy is different. Mathematics and numeracy in real life relate to the kind of tasks that have to be addressed on a regular basis. The individual items are not all overtly mathematical, and the construct hopes to draw out a greater level of self-efficacy because individuals find strategies to allow them to address problems. Some of the items require different skills sets in addition to the mathematical element. Mathematics related items relate to specific mathematical skills that are often encountered in educational settings, and these tasks are all overtly mathematical. The final construct relates to situations that are perceived to be a requirement of the mathematics classroom, but are not unique to mathematics. In addition to these situational constructs there is a differentiation based on a level of academic engagement with mathematics that suggests stereotypical self-efficacy levels. The boundary here is between learners who have chosen to pursue mathematics beyond compulsory education, arbitrarily at level 3 and above, and those who have at best achieved a level 2 qualification. Rather arbitrarily, this is used to differentiate between those that feel they can do mathematics and those that feel they can't.

What we are not attempting to measure is any form of trait, either personal or ability, simply defined by Cooper (2010) as "useful descriptions of how people behave". Bandura (2005) identifies that efficacy measures are not measuring the ability to do something, or the anxiousness of the person doing the thing. They are measuring whether the person considers that they can do the aforementioned thing at that particular moment in time. This suggest that it is possible to take a snapshot of an individual's efficacy as it relates to a number of tasks at a particular time, and that this information can be collected using a quantifiable scale. It will however, only be a snapshot, and will not present a universal truth of people's collective efficacy in situations or relating to specific tasks. What will be gained will be an insight into collective efficacy in certain contexts or situations, but even if apparent causal relationships may be the result of statistical analysis, they should not be seen as evidence of causality.

Methodology

A 20 item likert style questionnaire was used. Respondents were asked to score on an eleven point scale how certain they could complete the relevant task right now. The scale ranged from 'can't do at all' to 'highly certain can do'. Individual items were placed in one of three competences, Functional Numeracy, Mathematics, and Mathematics Classroom, and distributed randomly through the questionnaire. There were 8 items in the Functional Numeracy set (Items 1, 2, 4, 8, 13, 15, 18, 20), five in the Mathematics set (items 3, 5, 6, 11, 12), and seven items in the Mathematics Classroom set (7, 9, 10, 14, 16, 17, 19). Respondents were also asked three free response questions; these were a voluntary component of the questionnaire:

1. What were the best and worst things about mathematics at school?
2. Do you use mathematics in your job or studies? If so perhaps you could give an idea of the mathematics you use, and how confident you feel using it.
3. Do you think the mathematics you learnt in school prepared you for adult life?

In addition, data on the respondent's age, location, occupation and highest level of mathematics qualification were asked for.

Data was sorted into two groups, those with qualifications at level 2 or below, and those with qualifications at level 3 or above. Each group was analysed separately, and as a complete data set. Principle Component Analysis was used to identify linear components within the data, and as a by-product descriptive statistics and an r-matrix of correlations. Sampling adequacy was tested using the Kaiser-Mayer-Olkin measure due to the small size of the sample. Field (2009, pg. 647) suggests that values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb. Once components were extracted they were then rotated. "Factor rotation changes the position of the factors relative to the variables so that the solution obtained is easier to interpret" (Cooper, 2011). VARIMAX rotation was used and factors below 0.5 were excluded.

Results

130 people completed an online questionnaire based on likert type responses recording their self-efficacy in completing mathematically or numerically based tasks in a range of contexts. No differentiation was used in terms of gender, or attainment in subjects other than mathematics. Students were asked whether their highest level of mathematical attainment was up and to and including level 2, or level 3 or above, in the UK National Qualifications Framework (QCA, 2006). These levels are considered to replicate the point at which a learner elects to pursue a mathematics education voluntarily. International equivalents were identified to situate learners from outside of the UK. In general, learners whose maximum levels of achievement were based within the same geographical region as the author, with the greatest proportion being based at the College of Further Education in which the author worked at the time of the data collection. Those whose highest level of achievement was level 3 or above tended to be more geographically dispersed. For the purposes of this study, and in order to get a large enough sample size, it is assumed that geographical location will have no impact on the self-efficacy of a respondent.

Respondents were invited to participate either through direct emailing or through the social networking sites Facebook and Twitter.

A comparison of mean item scores for the two groups is shown in Chart 1. The range of the two sets of mean scores is shown in Chart 2. It is clear from a cursory inspection of these straightforward statistical approaches that a number of trends appear to exist. Not surprisingly, those that elect to progress their mathematics education beyond the compulsory stage are far more efficacious than those who do not. Item 19, which asks respondents whether they can 'Begin a University Mathematics Course' purposely asks a question that should differentiate between the two groups of respondents, allowing post compulsory mathematicians to be relatively efficacious, but, expecting that those with a lower attainment to be largely lacking in efficacy in relation to this situation. As expected the mean score for the 'Level 3' group is at 8.54 (3sf) with a standard deviation (SD) of 2.30, whilst the mean for the 'Level 2' group is 2.70 with an SD of 2.91. Whilst the score for the 'Level 2' group is relatively low, the relatively high standard deviation is of concern. The raw data indicates that two respondents scored this item at 10; one scored it at 9 and a number at 7 and 8. Most of these respondents had good level 2 passes, and perhaps had gained further efficacy through work or other aspects of their life. Whilst this leads to supposition, it is not unreasonable to expect a number of people in this group to be highly efficacious in all mathematics situations. It questions the arbitrary nature of the cut-off between the two groups as much as it questions the reliability of the item. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy for both the complete set of data (.942) and the Level 2 group (.885) is acceptable to excellent, although it is low for the Level 3 group (.632), however, it would be prudent to suggest that the sample sizes are relatively low, and whilst superficially the data seems to have significance, this must be handled with care. At this stage it would suggest that the data set indicates that further investigation is required to be absolutely able to evidence what is being searched for.

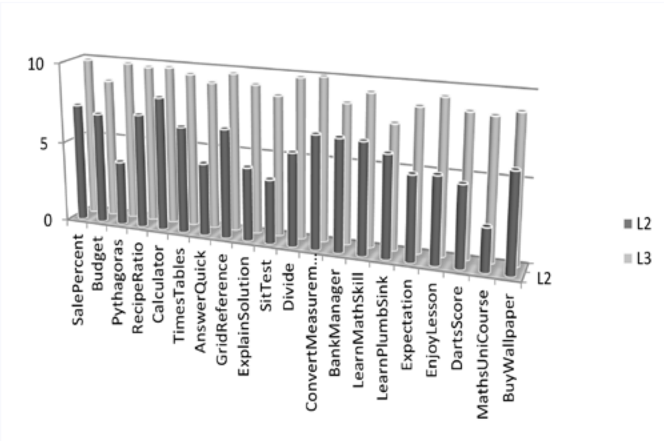


Chart 1. Comparison of mean scores for ‘up to level 2’ respondents and ‘Level 3 and above’ respondents.

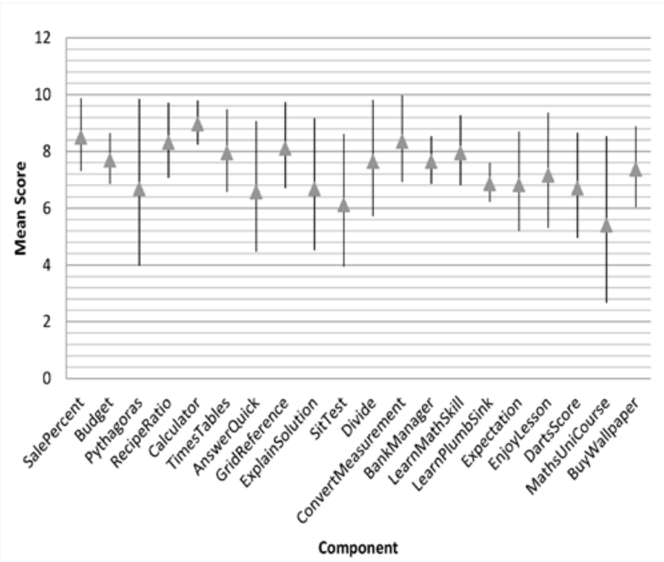


Chart 2. Range of mean scores for both sets of data.

Item correlations for all data where the correlations are significant (>0.7 at 0.01 significance using Pearsons correlation) are shown in Table 1. This data seems to suggest that four items have a particularly strong correlation to each other and self-efficacy in general. These are ‘Solve a problem using Pythagoras’ Theory’; ‘Answer a question quickly in a mathematics lesson’; ‘Explain the solution to a mathematics problem in a lesson’; and, ‘Divide 156 by 12’. Strong correlations also exist involving ‘Sit a mathematics test tomorrow’; ‘Live up to what a mathematics teacher expects of me’; and ‘Enjoy a mathematics lesson’.

	Sale	Pyth	Recipe	Answer	Explain	Test	Divide	Learn	Expect	Enjoy	Darts	Uni	Wallpaper
SalePercent	1												
Pythagoras	0.62	1											
RecipeRatio	0.77	0.65	1										
AnswerQuick	0.64	0.81	0.66	1									
ExplainSolution	0.65	0.85	0.64	0.89	1								
SitTest	0.65	0.82	0.65	0.85	0.87	1							
Divide	0.73	0.76	0.71	0.74	0.74	0.72	1						
LearnMathsSkill	0.56	0.63	0.58	0.66	0.65	0.67	0.57	1					
Expectations	0.54	0.67	0.58	0.76	0.75	0.72	0.66	0.7	1				
EnjoyLesson	0.46	0.73	0.51	0.76	0.74	0.68	0.59	0.63	0.75	1			
DartsScore	0.51	0.65	0.54	0.71	0.68	0.69	0.6	0.54	0.68	0.65	1		
MathsUniCourse	0.57	0.79	0.59	0.73	0.78	0.81	0.64	0.6	0.67	0.69	0.63	1	
BuyWallpaper	0.65	0.67	0.74	0.64	0.67	0.66	0.69	0.66	0.63	0.54	0.66	0.64	1

Table 1. Correlation matrix showing significant correlations (>0.7) of ‘all data’ set values for each Component

Rotated Component Matrix[a]

	Component		
	1	2	3
SalePercent		.513	.563
Budget			.668
Pythagoras	.689		
RecipeRatio		.551	
Calculator			.760
TimesTables	.517		
AnswerQuick	.778		
GridReference		.640	
ExplainSolution	.788		
SitTest	.791		
Divide	.501		.504
ConvertMeasurement		.719	
BankManager			.574
LearnMathsSkill	.603		
LearnPlumbSink		.825	
Expectation	.847		
EnjoyLesson	.862		
DartsScore	.678		
MathsUniCourse	.719		
BuyWallpaper		.501	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Table 2. Rotated Component matrix for ‘up to Level 2’ data

Three components are identified. Items are clustered on components, and these clusters help to explain the nature of that component. Components two and three seem to represent a measure of functional mathematics and a mixture of functional and classroom mathematics respectively. Component one identifies a mix of mathematical competences and mathematics learning competences. There is no clear differentiation between the two factors here, and therefore the results are somewhat inconclusive. There does seem to be evidence of identifiable factors for mathematics in school and mathematics in the real world. It is possible that this indicates that learners at this level of achievement see all aspects of mathematics in the school environment as a similar construct, although at this stage, this hypothesis is very speculative.

Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
SalePercent		.602			
Budget			.594		
Pythagoras	.937				
RecipeRatio			.732		
Calculator				.824	
TimesTables				.805	
AnswerQuick	.718				
GridReference					.808
ExplainSolution	.778				
SitTest		.737			
Divide				.628	
ConvertMeasurements	.908				
BankManager			.622		
LearnMathsSkill		.691			
LearnPlumbSink			.574		
Expectations		.718			
EnjoyLesson	.759				
DartsScore			.534		
MathsUniCourse		.586			
BuyWallpaper			.744		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Table 3. Rotated component matrix for ‘Level 3 and above’ data

Five components have been identified and they are less distinct than other data sets. As the KMO value of .632 for this data set is low it would seem that this data set does not yield satisfactory factors. The Bartlett’s test of sphericity has a significance p<0.001 at 0.00 which suggest that the data is suitable for PCA (Field, 2009). Component 3 appears to sit within the functional mathematics factor; so again, this appears to be the factor that is most readily distinguishable from other factors. Components 1 and 2 hint at the existence of the mathematics classroom factor, but this interpretation is unconvincing.

Rotated Component Matrix[a]

	Component		
	1	2	3
SalePercent		.594	
Budget		.714	
Pythagoras	.795		
RecipeRatio		.538	.504
Calculator		.698	
TimesTables	.591	.522	
AnswerQuick	.818		
GridReference			.584
ExplainSolution	.829		
SitTest	.818		
Divide	.583	.534	
ConvertMeasures			.638
BankManager		.592	
LearnMathsSkill	.594		
LearnPlumbSink			.846
Expectations	.796		
EnjoyLesson	.854		
DartsScore	.711		
MathsUniCourse	.804		
BuyWallpaper			

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 4. Rotated Component matrix for ‘all data’.

The principle component analysis was conducted on all 20 items with orthogonal variation (VARIMAX). Values below 0.5 were excluded from the table (7). The Kaiser-Mayer-Olkin measure verified the sampling adequacy for the analysis, KMO = .942 (‘superb’ according to Field, 2009). Bartlett’s test of sphericity $\chi2$ (190) = 2267.353, $p<.001$, indicated that correlations between items were sufficiently large for PCA. An initial analysis was run to obtain eigenvalues for each component in the data. Three components had eigenvalues over Kaisers criterion of 1 (Field, 2009) and in combination explained 65.362% of the variance. Table 7 shows the factors after rotation. Again there is little clear definition in each component, but we do see components 2 and 3 move towards identifying a functional component. Again there does seem to be evidence that those competences that appear to be mathematics classroom competences, and those mathematics competences that are perhaps traditionally considered to be more difficult end up in the same component. This hints at a suggestion that the learning environment in which mathematics is taught is intrinsically linked to the mathematical processes being taught whilst some mathematical tasks that are considered either to be life skills or more functional appear to form a separate, or group of separate components.

Evaluation

The inference is that there is an identifiable factor that seems to include mathematics classroom situations and some of the more apparently complex and pure aspects of mathematics, but also some skills that are taught in ways that sometimes do not enhance understanding. For example, division is a skill that is often taught as an algorithm with little understanding of the concept behind it (Swan, 2005). However, it appears that the greatest difference between individual items seems to concern the general grouping of mathematics classroom activities and competences and those that might be considered to be more functional.

It is clear that situations in the mathematics classroom have an effect on efficacy, and therefore, mathematics teaching must be considered to be a factor in determining the education of the individual. Having to explain how they arrived at a solution for fear of getting it wrong; having to answer quickly in class because that appears to demonstrate retention of knowledge; testing that identifies weaknesses; living up to the expectations of a teacher that has to justify their results; and, also to those algorithms often taught without conceptualisation, such as Pythagoras' theorem, and division, for which the memory of the process is held until the exam has been sat and then is unused for an open period of time.

A strong sense of self efficacy is a major contributor to skill development in mathematics, as Bandura (1993, pg 119) notes, irrespective of mathematical ability "children who believed strongly in their capabilities were quicker to discard faulty strategies. They chose to re-work more of the problems they failed and did so more accurately than did children of equal ability who were plagued by self-doubts".

Whilst the data supporting this argument cannot be considered conclusive it does led us towards some answers to the original premise. Firstly, efficacy, according to Bandura is evidence of mastery. Respondents that have demonstrated mastery in post compulsory mathematics education feel more efficacious, not only in their mathematics but also in their approach to the mathematics classroom. In looking at a range of competences that include both maths skills and learning competences we see that many of these learning competences display disparity between our two groups of learners equal to some of the mathematics competences that are seen as abstract to many learners. This perhaps suggests that learners who do well in mathematics not only have a predisposition to mathematics, but also to learning in the way that mathematics is often taught.

This then begs the question – what about the learners who have not attained in the same way – is it the mathematics, or the mathematics classroom that leads to reduced efficacy. The key here is the creating of methods that work, and, if they work, allow the user to feel efficacious about their use. Whilst the data did not identify three clear factors it did seem to suggest a real world efficacy balanced against a school lack of efficacy for many learners. In general, those learners with low efficacy tended to be in the level 2 or below group, but this is not a general rule.

It seems increasingly apparent that the nature of the mathematics classroom, and an awareness that certain approaches to the learning of mathematics suits some learners more than others, can lead to different efficacy states for different learners. It would also appear that some learners feel more efficacious in contexts outside of school and therefore it is a small logic leap towards suggesting that a more embedded real world approach to learning that encompasses peer discussion and the opportunity to make sense of situations in their own time may suit a significant number of learners. The pervasive nature of mathematics anxieties amongst low achieving learners (Ashcraft, 2002, Chinn, 2009) and the disaffection with mathematics that appears to be equally common (Evans, 2001, Allen, 2009) continue the deficit view that many people find mathematics to be a stress inducing subject and that it is an area of study that some people simply can't do. This, however, runs as counter-logic to the perception that functional numeracy is something that most people manage to feel comfortable attempting.

One needs to take note of the fact that the traditional style of learning mathematics serves a substantial population very well, including some of those with maths learning difficulties, and the baby should not be thrown out with the bath water. Writers such as Boaler (2009) have advocated the need to bring the real world in to the classroom for some time. It is clear that some learners learn effectively in a collaborative, problem solving, and contextualised manner. Conversely, it would appear that other learners thrive in an environment that other learners find particularly difficult. If, as Bandura suggests "Positive attitudes to mathematics (are) better predicted by perceived self-efficacy than by actual ability" (1993) does it not make sense that a learners efficacy in school mathematics and real world numeracy are assessed and their learning tuned to this. Perhaps setting could be based more of efficacies in certain learning environments than on tests of traditional mathematical ability.

References

Allen, B. (2009) What Pupils want: a Friendly Mathematics Classroom. In Mason, J and Houssart, J. Eds *Listening Figures. Listening to Learners of Mathematics at Secondary School and Above*. Stoke on Trent. Trentham Books.

Ashcraft, M (2002) Math Anxiety: Personal, Educational, and Cognitive Consequences. *Current Directions in Psychological Science. Vol.11, Number 5, October 2002*.

Bandura, A. (1993) Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist, 28(2), 117-148*.

Bandura, A (1997) *Self Efficacy: The Exercise of Control.* New York. W.H Freeman and Co.

Bandura, A. (2006) Guide for Constructing Self Efficacy

Scales. In Pajares, F. and Urdan, T.C. *Self Efficacy Beliefs of Adolescents.* Charlotte, NC. Information Age Publishing

Boaler, J (2009) *The Elephant in The Classroom. Helping Children Learn and Love Maths*. London. Souvenir Press

Burrell, G. and Morgan, G. (1979) *Sociological Paradigms and Organisational Analysis*. London. Heinemann Educational

Butterworth, B. (2002) *Screening for Dyscalculia: A New Approach*. SEN Presentation Summary. Mathematical Difficulties: Psychology, Neuroscience and Interventions. September 2002 Accessed online: 9th Feb 2011 www.mathematicalbrain.com/pdf/

Butterworth, B. Varma, S. and Laurillard, D. (2011) Dyscalculia: From Brain to Education. *Science. Vol 332. 27th May 2011. 1049-1053*

Chinn, S. (2006) *The Trouble With Maths. A practical guide to helping learners with numeracy difficulties.* Routledge Farmer. London.

Chinn, S. (2009) Mathematics Anxiety in Secondary Students in England. *Dyslexia. 15: 61-68. October 2008*.

Claxton, G. (2008) *What's The Point Of School. Rediscovering The Heart Of Education.* One World. Oxford.

Cohen, L. Manion, L. And Morrison, K. (2007) *Research Methods in Education*. Sixth edition. London. Routledge.

Coolican, H. (2009) *Research Methods and Statistics is Psychology*. London. Hodder Education.

Cooper, C. (2010) *Individual Differences and Personality. Third Edition*. Hodder Education. London.

Cronbach, L.J. and Meehl, P.E. (1955) *Construct validity in Psychological Tests. Psychological Bulletin. 52: 281-302. 1955*

Ecclestone, K. (2007) Resisting images of the 'diminished self': the implications of emotional well-being and emotional engagement in education policy. *Journal of Education Policy. Vol. 22, No.4, July 2007, 455-470*

Evans, J. (2001) *Adults Mathematical Thinking and Emotions.* Routledge Farmer. London.

Evans, J., Morgan, C., And Tsatsaroni, A., (2006) Discursive Positioning and Emotion in School Mathematics Practices. *Educational Studies in Mathematics 63: 209-226. 2006*

Excellence Gateway (n/d) *Ofsted Good Practice Database: Initial Assessment.* Available online (Accessed: 25/09/2011): http://www.excellencegateway.org.uk/page.aspx?o=108146

Hoffman, B. (2010) "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem-solving efficiency. L*earning and Individual Differences. 20, 2010 pp276-283*

Howard-Jones, P. (2010) *Introducing Neuroeducational Research. Neuroscience, education and the brain from contexts to practice.* Routledge. London.

Facebook (online forum) *I can't do math to save my life....* Accessed online: 9th Feb 2011. www.facebook.com/pages/I-cant-do-math-to-save-my-life/273784857464

Field, A. (2009) *Discovering Statistics Using SPSS. Third Edition*. London. Sage.

Geary, D and Hoard, M (2002) Learning Disabilities in Basic Mathematics: Deficits in Memory and cognition. In. Royer, J. (Ed) *Mathematical Cognition* (pp. 93-115) Information Age Publishing. Greenwich, CT.

Gergen, K, J. (1985) The Social Constructionist Movement in Modern Psychology. *American Psychologist, Vol.40, number 3, March 1985, pp 266-275*

Jain, S. and Dowson, M. (2009) Mathematics anxiety as a function of multidimensional self regulation and self efficacy. *Contempory Educational Psychology 34 (2009) 240-249*

Klinger, C.M. (2011) Connectivism – A new paradigm for the maths anxiety challenge? *Adults Learning Mathematics: An International Journal, 6(1), Feb 2011, pp7-19*

Liang, X. (2010) Assessment use, self efficacy and mathematics achievement: comparative analysis of PISA 2003 date of Finland, Canada and the USA. *Evaluation and Research in Education. Vol 23, no.3, September 2010, 213-229*

Lucas, B. And Claxton, G (2010) *New Kinds of Smart. How the science of learnable intelligence is changing education.* Open University Press. Maidenhead.

Morgan, G. And Smircich, L. (1980) The Case for Qualitative Research. *Academy of Management Review.* 1980. Vol. 5, no.4, pg 491-500

Move on (n/d) *Welcome to move on.* Available online (accessed 25/09/2011) : http://www.move-on.org.uk/

My Guide (n/d) *Skills for Life Screener.* Available on line (accessed 25/09/2011): http://www.myguide.gov.uk/myguide/RunCourse.do?submitAction=viewVisitorCourseDescription&key=/html/learning/learning/visitorcoursedescriptions/skillsforlifescreenera.html

Pajares, F. (1997) Current Directions in Self-efficacy Research In M. Maehr & P. R. Pintrich (Eds.). *Advances in motivation and achievement.* Volume 10, (pp. 1-49). Greenwich, CT: JAI Press.

Pampaka, M. Kleanthous, I. Hutcheson, G.D. and Wake, G. (2011) Measuring Mathematics Self Efficacy as a Learning Outcome. *Research in Mathematics Education. Vol 13. No. 2. July 2011, 169-190*

Pratt, N (2010) *Resined: Beginning Research.* Accessed online (21st February 2011) http://www.edu.plymouth.ac.uk/RESINED/beginning/begresed.htm#Paradigms

Qualifications and Curriculum Authority (2006) *The National Qualifications Framework. Helping learners Make Informed Decisions.* QCA/06/2298. QCA. London

Ramachandran, V.S. and Hirstein, W. (1997) Three Laws of Qualia: What neurology tells us about the Biological functions of Consciousness, Qualia and the Self. *Journal of Consciousness Studies. 4, No. 5-6, 1997, pp 429-458.*

Sherwell, P. (2009) Prince Harry admits he struggles with mathematics during pilot training. *Daily Telegraph, 1st June 2009.* Accessed online: 9th Feb 2011. www.telegraph.co.uk/news/newstopics/theroyalfamily/5417542/prince-harry-admits-he-struggles-with-maths-during-pilot-training.html

Swan, M. (2005) *Improving Learning in Mathematics: Challenges and Strategies.* London. Department for Education and Skills Standards Unit.

Usher, E. And Pajares, F. (2009) Sources of Self efficacy in mathematics: A validation Study. *Contempory Educational Psychology 34* (2009) 89-101

Williams, J. (2011) Looking Back, Looking Forward: Valuing Post-compulsory Mathematics Education. *Research in Mathematics Education. Vol 13. No.2. July 2011. 213-221*

Wilson, P. (2011) Disposition towards engagement in mathematics. In, Smith, C. (Ed.) *Proceedings of the British Society for Research into Learning Mathematics 31(2) June 2011.*

Broadening the curriculum

As the end of term approaches the thoughts of **Lucy Cameron** turn to the recent changes within KS1.

At the end of every term you will always find the staffroom buzzing with conversations about progress: which children have embedded that crucial bit of learning; which children still haven't quite mastered that mathematical concept; and then there are those who have totally blown us away and exceeded all our expectations – the mathematics teachers of the future perhaps?

This year has been very different, especially for our Key Stage 1 colleagues. In September 2014 our school made the decision to teach the new mathematics curriculum but at the same time we still planned to assess using the old national curriculum levels. Lots of ideas about assessment were being thrown around in bulletins and on courses yet we weren't quite ready to commit to something unknown and untested when children, parents and all staff were aware of what the national curriculum levels meant and what good progress based on these s should look like. By doing this, in December 2014, the staff room was filled with the faces of frustrated teachers.

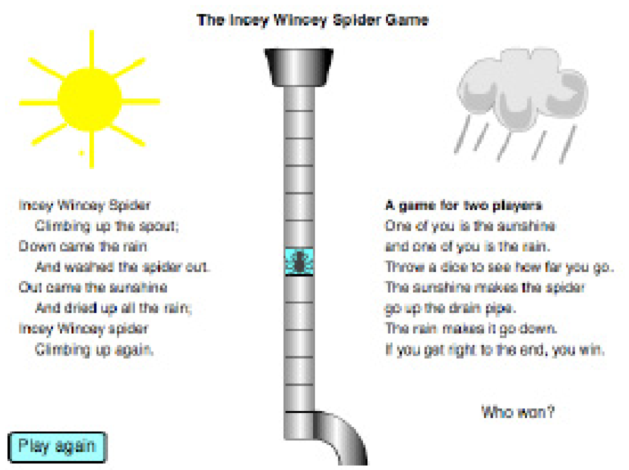
Through discussion with the Year 1 team the following issue was thrown up:

> The Year 1 program of study requires children to 'add and subtract one-digit and two-digit numbers to 20, including 0'.

Historically, once children could work confidently within 20 we would move them on to work with larger numbers, repeating the same methods working with numbers beyond 20. This would help pupils in Year 1 move into Level 2 of the National Curriculum. However working with the new curriculum wouldn't allow this. We had to change our thinking and take on the latest buzzword around primary schools: broaden our curriculum. We were all understandably dubious. Why change what was already working for us? But through conversations with the Upper Key Stage 2 team we began to see the potential benefits. Teachers are often claiming that the basics are not embedded. Place value comes up as a regular issue - children not fully understanding what the digits they are using represent in number problems.

One of the best ideas that came up was 'Investigation Friday'. Every Friday children across all Year groups are required to complete an investigative activity related to their learning from that week. There is no expectation of detailed recording and for children in all classes the use of thought bubbles are encouraged to record thoughts, ideas and discussions. The buzz of teaching mathematics came flooding back to the staffroom and the approach felt new and exciting. All children within a class were to be given the same task regardless of ability and they were encouraged to complete it at their own level.

In one Year 1 class children were given an Nrich problem where they were required to travel up and down the water spout by adding numbers. All of the children were instantly engaged with the 'play' aspect of the activity and whilst some of the more able pupils grew frustrated with the task, never reaching the sun, it was a pupil who normally finds mathematics challenging who claimed, 'I'll win if I roll bigger numbers than him'. This led to further discussion about how the theory could be tested and manipulation of the rules to see if the child was right. The opportunities throughout the lesson to keep altering the activity, using different valued dice, and building on discussion, made the activity easily fill the slot and the children continued to talk about it into the afternoon.



The activities continue to be exciting and challenging further up the school, suggestions that were shared included:

> 'Find **three numbers** that have **exactly 3** factors. What is **special** about these numbers?'

Here there is opportunity for children to explore mathematical vocabulary and in addition there is the ambiguity of the word 'special'. Children are able to make this word mean what they need it to mean, they may use it to apply to the mathematical elements of the numbers at any level they choose. All children are included and all children are able to access the learning.

In conclusion the experience of broadening the curriculum has been beneficial to all children from those who find mathematics challenging to those who already have a good understanding of number. The children are now required to demonstrate their understanding in multiple ways and through various methods: - mental, written and concrete.

The search for patterns

In this piece our outgoing Editor **Rachel Gibbons** challenges us all to think deeply about the purpose of mathematics teaching.

Oh dear, it has happened again! A member of the social services was here asking questions and, on learning that I had taught mathematics, she described her early life telling me how at the age of 6 she had removed from Venezuela to Germany and found her new class mates doing long multiplication and long division when she did not even know what division was - expressing a fear of numbers and a sense that they are what mathematics is all about. Of course it is important to give all our pupils some facility with numbers but of even more importance, surely, is that we give them a deeper appreciation of pattern. One of the greatest teachers of mathematics, W.W. Sawyer, entitled one of his books on the nature of the subject *The Search for Pattern*: indeed,' all study, surely, is a search for pattern, an attempt at classification? Botany is concerned with the classification of plants, the study of the shapes of leaves, colours of flowers, patterns of growth; history is an attempt to find pattern in the events of the past, and so on, mathematics being the study of pattern itself.

This year is the 150th anniversary of the year of publication of *Alice's Adventures in Wonderland* where we find Charles Dodgson's wonderful examples of a mathematician's logic devised for the delight of children. So that a study of mathematical reasoning, as found in that book - and in *Through the Looking Glass* - should equip our young people to find their way to reasonable points of view concerning their place in the world and even protect them from extremism. Maybe where it is not doing so we should question the effectiveness of our mathematics teaching? That sense of logic, order, pattern and symmetry should affect all our everyday actions - even down to how we stack the pots and pans, the crockery and cutlery, on the draining board when washing up.

Rachel Gibbons is a retired ILEA inspector

Review - **Peter Jarrett**

Peter Jarrett has taken the time to identify a resource that is a must for those who wish to understand the learning difficulty dyscalculia. Readers who have found similar useful resources are encouraged to submit their own reviews, please contact Alan if you have anything that deserves a wider audience.

Book review
The Routledge International Handbook of Dyscalculia and Mathematical Learning Difficulties.
Edited by Steve Chinn.
Routledge. Abingdon.
ISBN: 978-0-415-82285-5
£125

If you have a rich benefactor, or a large lump left in your departmental budget then I urge you to get a copy of this book. This is a once in a generation work that provides an opportunity to take stock of what we know about, and how we manage, developmental dyscalculia (DD) and mathematics learning difficulties. Containing 31 papers from the leading practitioners in neuroscience, psychology and teaching and learning, the book is essential reading for anyone wishing to understand these complex conditions.

In tying the book together, Steve Chinn poses 16 key questions about difficulties in learning mathematics. These include "What is dyscalculia/mathematics learning disabilities?"; "What about co-occurrence with other difficulties and disabilities?"; "How should we teach mathematics?"; and "Why are fractions and division universally perceived as 'difficult'?". Each of these key questions is addressed by at least one chapter, and in many cases new insights are offered. However, as one would expect when research is moved forward, there are not always clear answers, and, indeed, further questions are asked.

From the outset Stephanie Bugden and Daniel Ansari make it clear that "researchers are struggling with the fundamental question of what constitutes the core deficits of DD and what causes them" (Pg. 19). It would appear that DD is heterogeneous and, therefore, "it is probable that various cognitive and neural mechanisms may contribute to different behaviour profiles of DD". This moves us on from the hypothesis of DD being a pure deficit of numerosity, although, as the authors point out, there is still much to learn.

Annemie Desoete contributes a very useful chapter, 'Predictive indicators for mathematical learning disabilities/dyscalculia in kindergarten children'. Here she identifies four areas that can be considered of indicators of difficulties; logical thinking abilities and counting knowledge; language abilities; number representation and working memory. This could, in time, become a very useful framework for the assessment of difficulties.

Karin Landerl identifies that co-morbidity with other conditions is "the rule rather than the exception". She notes that "children with good attentional and verbal skills, adequate working memory, and executive control generally show better arithmetic performance than those who have problems in these domains". Once again, the usefulness of measuring literacy, attention and working memory are identified as aiding an understanding of DD. However, it is stressed that there is convincing evidence that difficulties in numerical processing constitute a core deficit, citing studies that look at co-morbid and single deficits both identify a specific and unique difficulty around number processing.

In other chapters, Jane Emerson considers what to look for in an assessment including some suggestions on standardised testing and non-standardised diagnostic tools, that, used together can inform appropriate interventions. On a similar vein, Robert B. Ashlock encourages us to ask that underused question, "why?" as we dig below the misunderstanding of a concept or procedure. Anne Dowker and Peter Morris and Giannis N. Karagiannakis and Anny Coorman look at two perspectives on intervention.

In every chapter of the book there are new insights and fresh perspectives, and speaking personally, it will take some time to absorb this and reflect on the implications for our classroom practice. There is no doubt that a core deficit in the processing of number exists and that this is domain specific even when co-morbidity exists. I now feel that we also have a far greater understanding of the risk indicators of DD and this may move us towards a more structured diagnostic framework, in turn allowing for more targeted/focussed interventions, and we may also be moving closer to a working definition of dyscalculia that meets the needs of researchers, assessors and teachers alike.

As a parting shot, for those at the chalkface who meet learners with difficulties every day of our working lives, I feel that Judy Hornigold has summed everything up perfectly – “we owe it to our young students to teach mathematics in the way that they learn it so that they can enter adulthood as numerate adults, with an appreciation and enjoyment of this rich and fascinating subject”.

Policy, research, identification and intervention for mathematics
Learning difficulties and dyscalculia

One of the Editorial team Peter Jarrett has put together an invaluable list of publications and references for those who wish to support their pupils, from SENCOs to those who simply want to better understand the needs of their pupils.

This resource guide is not exhaustive but is intended to offer a wide range of resources and perspectives, largely because the British Dyslexia Association Dyscalculia and Maths Learning Difficulties Committee recognises that no one resource or approach suits every learner.

The Committee wishes to stress that inclusion on this list does not infer endorsement of any resource, product, service or viewpoint.

The section on keystone research contains enough to inform on current thinking without becoming too long. Omission from this list does not suggest that the Committee does not value the work, only that we wish to provide an accessible start point for individuals to conduct their own research.

There are a couple of general principles that have been applied to the preparation of this list. Firstly, we have focussed on resources that are intended particularly for the use of learners with dyscalculia and mathematics learning difficulties. For this reason, many general mathematics resources, however useful, have not been included in this list. Secondly, we have avoided inclusion of ‘concrete’, multisensory resources, largely because there are a great number of very similar products available and we wanted to avoid either repetition or having to not include some products. We all believe that multisensory approaches are an integral part of any teaching and learning programme and we feel that the advice and guidance given in many of the included books and resources will guide readers in the right direction with regard to the use of multisensory materials.

This is a living document and will be regularly updated. If you have a resource that should be included in this list please contact Pete Jarrett (pete@tutorum.co.uk) in the first instance. Once the Committee has approved inclusion your resource will then be added.

Policy and Government guidance on mathematics teaching and learning

Coben, D., et al. (2007). *Effective Teaching and Learning. Numeracy.* NRDC. London.

Department for Education (2013). *Subject Content GCSE Mathematics.*
Available online: https://www.gov.uk/government/publications/gcse-mathematics-subject-content-andassessment-objectives Accessed 20/1/15

Department for Education (2013). *Statutory guidance: National curriculum in England: mathematics programmes of study*.
Available online: https://www.gov.uk/government/publications/national-curriculum-in-englandmath-ematics-
programmes-of-study Accessed 20/1/15

Department for Education (2014). *SEND Code of Practice.*
Available online: https://www.gov.uk/government/publications/send-code-of-practice-0-to-25
Accessed 20/1/15

Dowker, A. (2009). *What works for children with Mathematical Difficulties. National Numeracy Strategies: Primary.* Department of Children, Schools Families. Nottingham.
You can download this publication and obtain further information at:
www.standards.dcsf.gov.uk

PISA (2010). *Mathematics Teaching and Learning Strategies in PISA.* OECD Publishing. Paris.

OFSTED (2012). *Mathematics: Made to Measure.*
Available online: http://www.slideshare.net/Ofstednews/mathematics-made-to-measure
Accessed 20/1/15

OFSTED (2013). *Effective Numeracy Support that makes a Difference. Case Study: New College, Durham.*
Available online: https://www.gov.uk/government/publications/effective-numeracy-support-that-makes-adifference Accessed 20/1/15

Swan, M. (2005). *Standards Unit. Improving Learning in Mathematics. Challenges and Strategies.*
Available online: http://tlp.excellencegateway.org.uk/pdf/Improving_learning_in_maths.pdf Accessed 20/1/15

Keystone research

Boaler, J. (2011). *The Elephant in the classroom: Helping children learn and love maths.* Souvenir Press. London.

Bransford, JD, Brown, AL and Cocking, RR (2000). *How People Learn.* Washington DC, Academy Press

Butterworth, B (1999). *The Mathematical Brain.* MacMillan. London.

Butterworth, B. Varma, S. and Laurillard, D. (2011). Dyscalculia: From Brain to Education. *Science. Vol 332. 27th May 2011. 1049-1053*

Chinn, S. (2009). Mathematics Anxiety in Secondary Students in England. *Dyslexia. 15: 61- 68. October 2008*

Chinn, S. Ed. (2015). *The Routledge International*

Handbook of Dyscalculia and Mathematical Learning Difficulties. Routledge. London.

Dehaenes, S. (2011). *Number Sense. How the mind creates mathematics, revised and updated edition.* OUP USA. Boston.

Desoete, A and Stock, P (2011). *Can we Predict Mathematical Disabilities from Abilities in Kindergarten?* New York, Nova Science Publishers

Gathercole, S.E. and Packiam Alloway, T. (2008). *Working Memory and Learning. A practical guide for Teachers.* Sage. London.

Geary, D. (2010). Mathematical Disabilities: Reflections on cognitive, neuropsychological, and genetic components. *Learning and individual Differences 20 (2010). 130-133.*

Geary, D. C. (2010). Mathematical learning disabilities. In J. Holmes (Ed.), *Advances in Child Development and Behavior (Vol. 38, pp. 45-77).* San Diego, CA: Academic Press.

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five year prospective study. *Journal of Educational Psychology, 104, 206–223.*

Gelman, R. and Gallistel, C.R. (1986). *The Childs Understanding of Number.* Harvard University Press. Cambridge, Mass.

Gillum, J. (2012). Dyscalculia: Issues for practice in educational psychology. *Educational Psychology in Practice: theory, research and practice in educational psychology. 28:3. 287-297.*

Gillum, J. (2014). Assessment with Children who experience difficulty in mathematics. *Support for Learning. 29:3. 275-291.*

Hattie, J. and Yates, G. (2014). *Visible Learning and The Science of How We Learn.* Routledge. Abingdon.

Hunt, T.E., Clark-Carter, D. and Sheffield, D. (2011). The Development and Part Validation for a UK Scale for Mathematics Anxiety. *Journal of Psychoeducational Assessment. Vol 29. 2011. 455-466*

Kaufmann, L. and von Aster, M (2012). The Diagnosis and Management of dyscalculia. *Deutsches Ärzteblatt International 2012. 109:45. 767-778.*

Mareschal, D. Butterworth, B. and Tolmie, A. Eds. (2014). *Educational Neuroscience.* Wiley Blackwell. Chichester, West Sussex.

Mazzocco, MMM and Berch, DB (2007). *Why is Maths so Hard for Some Children?* Baltimore, Paul H Brookes

Shalev, R. and Gross-Tsur, V. (2000). Developmental Dyscalculia. *Paediatric Neurology. 2000. Vol.24. No.5.*

Usher, E. and Pajares, F. (2009). Sources of Self efficacy in mathematics: A validation Study. *Contempory Educational Psychology 34 (2009) 89-101*

Yeo, D. (2003). *Dyslexia, Dyspraxia and Mathematics.* Whurr Publishers. London.

Young, C.B., Wu, S.S. and Menon, V. (2012). The Neurodevelopmental Basis of Math Anxiety. *Psychological Science.* Pub. Online: 20 March 2012.

Available at: http://pss.sagepub.com/content/early/2012/03/23/0956797611429134 Accessed: 26th March 2012

Screening and Assessment Dyscalculia specific

Butterworth, B. (2003). *The Dyscalculia Screener.* GL Assessment. London. **(Ages 6-14+)**

Chinn, S. (2012). *More Trouble with Maths. A complete guide to identifying and diagnosing mathematical difficulties.* Routledge. Abingdon. **(Ages 7-adult)**

Emerson, J. and Babtie, P. (2010). *The Dyscalculia Assessment.* Continuum Publishing. **(Primary, Secondary)**

Francis, T., Smith, G., Wareham, J. and Wood, H. (2013). *Dyscalc*
Available online: http://www.educational-psychologist.co.uk/screening/dyscalculic/
Accessed 15/1/15 **(age 14+)**

Dynamo Maths (online). *Dynamo Profiler.*
Available online: http://dynamoprofiler.co.uk/.
Accessed 11/1/15. **(Ages 6-9)**

The Dyscalculia Centre (Online). *The Dyscalculia Test.*
Available online: http://www.dyscalculia.me.uk/testing.html Accessed 11/1/15 **(No age given)**

Trott, C. /Tribal (online). *DysCalculium Screener.* Available online: https://dyscalculia.advancelearningzone.com/index.php?option=com_content&view=article&id=2&Itemid=2 Accessed 12/10/13 **(Ages 16+ to adult)**

Other useful 'open' assessment tools for SENCo's and specialist teachers/ assessors

Arnold, C., Bowden, P., Talents, M., and Waldon, R. ( ). *Sandwell Early Numeracy Test – Revised – SENT-R.* Sandwell Inclusion Support Service. Sandwell.

Clausen-May, T and Vappula, H. (2006, 2009). *Progress in Mathematics. PiM.* GL Assessment. London.

Gillham, B. Hesse, K. and McCarty, C. (2012). *Basic Number Screening Test. 4th Edition.* Hodder Education. Abingdon.

Gillham, B. and Knight, C. (2001). *Basic Number Diagnostic. 3rd Edition.* Hodder Education. Abingdon.

GL Assessment (2012). *Cognitive Abilities Test. CAT4.* GL Assessment. London.

Glutting, J. Adams, W. And Sheslow, D. (2000). *WRIT: Wide range intelligence test.* Wilmington, DE. Wide Range Inc.

McCarty, C. and Cooke, C. (2014). *Progress in Understanding Mathematics Assessment.* Hodder Education. Abingdon.

Reynolds, C.R. and Voress, J.K. (2007). *Test of Memory and Learning. Second edition.* Pro-ed. Austin, Texas.

Smith, A. (1982). *Symbol Digits Modalities Test.*

Western Psychological Services, Los Angeles.

Wilkinson, G.S. and Robertson, G.J. (2006). *Wide Range Achievement Test 4.* Lutz, FL. Psychological Assessment Resources, Inc.

Williams, J. (2005). *Mathematics Assessment for Learning and Teaching.* Hodder Education. Abingdon.

Vernon, P. Miller, K. and Izard, J. (1995). *Mathematics Competency Test.* Hodder Education. Abingdon.

Vernon, P. and Miller, K. (1998). *Graded Arithmetic Mathematics Test. 4th Edition.* Hodder Education. Abingdon.

Other useful assessment tools for Educational Psychologists

Elliot, C.D., Smith, P. (2012). *British Abilities Scale 3. BAS3.* GL Assessment. London.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale–Fourth Edition. WISC-IV* Pearson. San Antonio, TX.

Teacher training for specialist teachers of dyscalculia and mathematics learning difficulties.

The criteria for courses leading to Approved Teacher Status (ATS) for teachers specialising in dyscalculia and mathematics learning difficulties has now been set out by the British Dyslexia Association. Institutions that currently run appropriate courses, or intend to run appropriate courses are listed below:

Bath Spa University - PG Cert TT7369 – Identifying and Overcoming Maths Difficulties

Edge Hill University - PG Cert SpLD (Dyscalculia) – to run from September 2015

Teaching learners with mathematics difficulties – resources and books

Adlam, F. (2012). *Dyscalculia Matters. Effective ways of working with children who struggle with maths.* Essential Resources. Invercargill.

ADSHE (Online). *Numeracy Resources for students with SpLD's.*
Available online: http://adshe.org.uk/resources-from-liz-ahrends-award/2009/ Accessed 12/2/15

Ashlock, R.B. (2010). *Error Patterns in Computation. Using error patterns to help each student learn. Tenth Edition.* Allyn and Bacon. Boston.

Attwood, T (2012). *Dyscalculia Practice Activities.* First and Best in Education. Corby.

Bird, R. (2007). *The Dyscalculia Toolkit: Supporting Learning Difficulties in Maths.* Sage. London.

Bird, R. (2009). *Overcoming Difficulties with Number: Supporting Dyscalculia and Students Who Struggle With Maths.* Sage. London

Bird, R. (2011). *The Dyscalculia Resource Book. Games and Puzzles for Ages 7 to 17.* Sage. London.

Butterworth, B and Yeo, D (2004). *Dyscalculia Guidance.* London: nferNelson.

Butterworth, B. (online). *Dyscalculia – Numberphile.* Video.

Available online: https://www.youtube.com/watch?v=p Hqdqe84Uc Accessed 12/2/15.

Chinn, S. (2006). *The Trouble With Maths. A practical guide to helping learners with numeracy difficulties.* Routledge Farmer. London.

Chinn, S. (2009). *What to do when you can't …. (Series).* Egon. Wakefield.

Chinn, S. and Jarrett, P. (2012). Dyscalculia Lesson Checklist. In: Cochrane, K. and Saunders, K. *Dyslexia Friendly Schools Good Practice Guide.* British Dyslexia Association. Bracknell.

Chinn, S and Ashcroft, R (2007). *Mathematics for Dyslexics, Including Dyscalculia.* Chichester. 3rd edn. Wiley

Clausen-May, T. (2013). *Teaching Mathematics Visually and Actively 2nd Edition.* Sage. London.

Cochrane, K. and Saunders, K. (2012). *Dyslexia Friendly Schools Good Practice Guide.* British Dyslexia Association. Bracknell.

Emerson, J. and Babtie, P. (2014). *The Dyscalculia Solution.* Bloomsbury. London.

Hannell, G. (2012). *Dyscalculia – Action Plans for Successful Learning in Mathematics.* Routledge. London.

Hansen, A. Ed. (2014). *Children's Errors in Mathematics. 3rd Edition.* Leaning Matters. London.

Henderson, A. (2012). *Dyslexia, Dyscalculia and Mathematics: A Practical Guide.* Routledge. London.

Hornigold, J. (). *Dyscalculia Lesson Plans: Comprehensive Exercises to Support Mathematics Learning Difficulties.* Special Direct.com. Kirkby-in-Ashfield.

OUP (Online). Numicon. Primary Maths Resources. Available Online: https://global.oup.com/education/content/primary/series/numicon/;jsessionid=FB36594C43A118F2310CFE62498D1460?region=uk Accessed: 11/1/15

Power of two (Online). *Power of Two resources.* Available online: http://www.powerof2.co.uk/ Accessed: 11/1/15

TES Connect (online). Dyscalculia Resource Treasure Collection.
Available online: https://www.tes.co.uk/teaching-resource/Dyscalculia-Resource-Treasure-Collection-6302884 Accessed 11/1/15

Information and guidance for dyscalculics and their parents or carers

Chinn, S (2011). *The Fear of Maths. How to Overcome it. Sum Hope^3.* Souvenir Press. London.

Moorcraft, P. (2014). *It Just Doesn't Add Up. Explaining Dyscalculia and Overcoming Number Problems for Children and Adults.* Filament Publishing Ltd. Croydon.

Software and online interventions/ programmes

Addacus LTD (online). *Beat Dyscalculia.*
Available online: http://beatdyscalculia.com/

Accessed 11/1/15

CatchUp.org (online). *CatchUpNumeracy.* Available online: http://www.catchup.org/CatchUpNumeracy/CatchUpNumeracy.aspx Accessed 1/2/15

Chinn, S. (Online). *Maths Explained.* Available online: https://www.mathsexplained.co.uk/ Accessed 1/2/15

Dybuster (Online). *Dybuster Calcularis.* Available online: http://www.calcularis.ch/int Accessed 11/1/15

Dynamo Maths (Online). *Dynamo Maths*. Available online: http://www.dynamomaths.co.uk/ Accessed 11/1/15

IXL Learning (online). *IXL* Available online: http://uk.ixl.com/math Accessed: 11/1/15

Laurillard, D and Baajour, H. (Online). *Numbersense.* Available online: http://numbersense.co.uk/index.html Accessed 11/1/15

Nessy (online). *Nessy Numbers.* Available online: http://www.nessy.com/uk/product/nessy-numbers/ Accessed 11/1/15

NumberGym (Online). *NumberGym*. Available online: www.numbergym.co.uk Accessed 1/2/15

Pearson (Online). *Rapid Maths*. Available online: http://www.pearsonschoolsandfecolleges.co.uk/Primary/Mathematics/AllMathematicsresources/RapidMaths/RapidMaths.aspx Accessed 1/2/15

Renlearn (Online). *Accelerated Maths.* Available online: http://www.renlearn.co.uk/accelerated-maths/ Accessed 1/2/15

Scholastic (online). *FASTT Maths.* Available Online: http://www.scholastic.com/fasttmath/index.htm Accessed 1/2/15

Whitespace (Online). *Numbershark*. Available online: http://www.wordshark.co.uk/numbershark.aspx Accessed 11/1/15

Schools and Specialist Private Tutors

Council for the Registration of Schools Teaching Dyslexic Pupils (CReSTeD): http://www.crested.org.uk/

Professional Association of Teachers of Students with Specific Learning Difficulties – Tutor/Assessor Index: https://www.patossdyslexia.org/SupportAdvice/TutorAssessorIndex/

This list was compiled by Pete Jarrett (www.tutorum.co.uk) a member of the BDA's dyscalculia committee, with contributions from Dr James Gillum and the other members of the committee, Dr Steve Chinn (Chair) Prof Brian Butterworth, Clare Trott, Jill, Higginson and Kate Saunders.

In Numbers:

- There are estimated to be 5,000 displaced people at Calais. At least 9 have died since June attempting to reach Britain.
- It is estimated that 100,000 refugees reached EU borders in July – this took the total for the year to 340,000.

Source: *The Guardian*, Monday 31st August.