

Inaugural Conference

Dyscalculia and Maths Learning Difficulties



Conference Chair: Steve Chinn

19th June 2009

Holiday Inn, Bloomsbury (nr. Euston Station)
London

For all teachers of numeracy and maths, SENCOs and Learning Support teachers,
LA inclusion and numeracy support teams and Educational Psychologists



www.dyscalculia-maths-difficulties.org.uk



Dyscalculia: Causes, identification, intervention and recognition

Brian Butterworth

Institute of Cognitive Neuroscience, UCL
&
Centre for Educational Neuroscience



Programme

- MD is bad for you
- Behavioural indications of MD and *dyscalculia*
 - Neural and genetic basis of MD
- Identification and Assessment of dyscalculia and other types of MD
 - Theoretical models
 - Screening tools
- Interventions for dyscalculia and MD and implications for school practices
 - Training teachers and teaching assistants
 - Specialized software
- Political issues
 - Recognition

Mathematics disability and dyscalculia

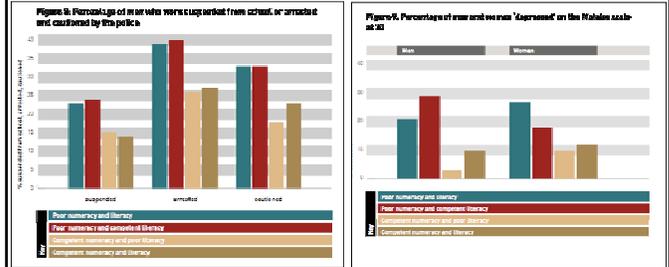
- UK government identifies 10% with MD
 - Leave primary school (11years) with age-equivalence of a 7 year old
- Poor adult functional numeracy affects 20+% (National Research and Development Centre)
 - 26% of 30 year olds were below Entry Level 2 - knowledge of whole numbers and common fractions
- Dyscalculia affects 3.6 - 6.5%
 - Data from UK, Israel, Cuba, Belgium, US

Mathematics disabilities are bad for you

MD is bad for you: it affects life chances

- More of a handicap in the workplace than poor literacy (Bynner & Parsons, 1997, *Does Numeracy Matter?*)
- Low numeracy leads to lower lifetime earnings by about £110,000 in UK (*Foresight Report*)
- Higher rate of unemployment
- Poor functional numeracy affects about 20% of the UK population
- This will include dyscalculics. Best prevalence estimates between 3.6 and 6.8%

Social consequences of low numeracy



Bynner & Parsons, 2005, *Does Numeracy Matter More?*

6

MD makes learners very unhappy

Focus group study in schools in London by Bevan & Butterworth, 2007

[Low attaining children]

I feel like screaming and saying 'why are you doing this, why are you doing this?' and I feel like punching the teachers...

... I'm not good, and I don't like it when my mum says that - that's why I don't like times tables at all.

7

Focus group study in schools in London by Bevan & Butterworth, 2007

- Child 5: *It makes me feel left out, sometimes.*
 Child 2: *Yeah.*
 Child 5: *When I like - when I don't know something, I wish that I was like a clever person and I blame it on myself*
 —
 Child 4: *I would cry and I wish I was at home with my mum and it would be - I won't have to do any maths -*

MD lowers self-esteem

Focus group study in schools in London by Bevan & Butterworth, 2007

Moderator: *How does it make people feel in a maths lesson when they lose track?*

Child 1: *Horrible.*

Moderator: *Horrible? Why's that?*

Child 1: *I don't know.*

Child 3 (whispers): *He does know.*

Moderator: *Just a guess.*

Child 1: *You feel stupid.*

Stigmatization and teasing

Focus group study in schools in London by Bevan & Butterworth, 2007

[Low attaining group]

He just comes up to us and says "ha ha - you don't know anything - you are so dumb" and then he asks me, like, questions like "thousand times thousand" which he knows and I don't know ...which is very hard for us

[High attaining child about a low attaining child]

Yeah, and then she goes hide in the corner - nobody knows where she is and she's crying there

10

MD makes teachers unhappy too

Interview study in schools in London by Bevan & Butterworth, 2007

MLI: ...when they're in the introduction for maths they're not - they're just sitting there basically."

KD: ...if they forget really basic things from the beginning, then there's no way you can use those further down the line, so if they're really struggling with taking away, and knowing it's the difference or whatever, you can't do exchanging or whatever because it's - they can't even do the basics.

MM: The gap will get bigger and bigger unless they give them a chance to catch up, and there's not - So I think for them, I would prefer them not to have the Numeracy Hour, but just to focus on those basic skills.

CP: I think a child who's struggling is either likely to be disruptive or to be - or to opt out.

JL: ...lots of times they're trying to cover it up. And sometimes they'll cover it up - they'd rather be told off for being naughty than being told off that they're thick.

MLI: They - in a class of thirty I've got six. You've got a lot of problems. And when I'm on my own, I don't - I really feel very guilty that I'm not giving them the attention they need.

Behavioural indications of MD and dyscalculia

Signs of maths disability and dyscalculia

- Being slow or unable to recognise numerosities under five without counting them.
- Poor sense of number size
 - in number comparison tasks where they are asked to select the larger of two numbers their reaction time compared to controls is significantly longer.
- Reliance on laborious strategies for arithmetic
 - counting on their fingers and other immature strategies.
- Poor memory for arithmetical facts
- Inability to grasp and remember mathematical concepts, rules, formulas, sequence (order of operations), and basic addition, subtraction, multiplication and division facts. Their results are often inconsistent.
- Arithmetical laws (such $a + b = b + a$) have to be learned by rote and not in an intuitive way.
- Difficulty with time and direction. May be chronically late..
- Poor with money and credit. Cannot do financial planning or budgeting. They may have fear of money and cash transactions. May be unable to mentally figure change due back, the amounts to pay for tips, taxes, etc.

What it's like to be dyscalculic

Dyscalculic addition

14

Case study: JB

- 9years 7 months old, Right Handed male. Normal in all school subjects except maths, which he finds impossible. Not dyslexic. Counts up to 20 slowly.
- Knows that 4 is the next number after 3 (has a sense of ordinality)
- Believes that $3+1$ is 5
- Dot enumeration: 1-3 accurate. Guesses larger numbers
- Cannot say which of two numbers is bigger

Persistence: Case BD

(f 23 yrs, at Ivy league uni)

Experimenter: *Can you please tell me the result of nine times four?*

BD: *Yes, well, looks difficult.*

[Thinks and repeats aloud the problem for a couple of minutes]

Now, I am very uncertain between fifty-two and forty-five... I really cannot decide: it could be the first but could be the second as well.

Experimenter: *Make a guess then.*

BD: *Okay... uhm... I'll say forty-seven.*

Experimenter: *Good, I'll write down forty-seven. But you can still change your answer, if you want. For example, how about changing it with thirty-six?*

BD: *Bah, no... it does not seem a better guess than forty-seven, does it? I'll keep forty-seven.*

Identification

Definitions of dyscalculia

Discrepancy: DSM-IV

Mathematics disability. The child must substantially underachieve on a standardized test relative to the level expected given age, education, and intelligence and must experience disruption to academic achievement or daily living

ICD 10

Specific disorder of arithmetical skills. A specific impairment in arithmetical skills that is not solely explicable on the basis of general mental retardation or of inadequate schooling. The deficit concerns mastery of basic computational skills of addition, subtraction, multiplication, and division rather than of the more abstract mathematical skills involved in algebra, trigonometry, geometry, or calculus. (WHO *International Classification of Diseases 10*)

Criterion: DFES

Dyscalculia. A condition that affects the ability to acquire arithmetical skills. Dyscalculic learners may have difficulty understanding simple number concepts, lack an intuitive grasp of numbers, and have problems learning number facts and procedures. Even if they produce a correct answer or use a correct method, they may do so mechanically and without confidence

Theories

- MD is due to poor cognitive capacity
 - There is a correlation between IQ and maths performance
- MD is due to poor working memory
 - There seems to be no relationship between span and maths
- MD is due to poor long-term memory
 - Is this why MD is associated with poor memory for arithmetical facts?
- MD is due poor language skills
 - There is a “language of maths”
 - Arithmetical facts, according some, are stored in a verbal form
 - Co-morbidity with dyslexia
- One form of MD is due to a selective core deficit
 - In number sense

Operational criteria

- If maths difficulties are *only* the consequence of general cognitive factors, then
 - Low cognitive ability or poor working memory will be *sufficient* for MD
- If MD solely the result of inappropriate teaching, then
 - Poor education will be *sufficient* for MD
- Problem is to find test that doesn't reflect
 - Intelligence
 - Education
- A test for
 - understanding simple number concepts
 - And an intuitive grasp of numbers

Core deficit theory

Numerosities

Fundamental to understanding arithmetic

Early learners base the beginnings of arithmetic on what number terms mean as sets
sets combined with sets
and how sets are ordered
sets within sets

Number bonds and tables make no sense unless you know what the numbers mean

22

22

Tests for understanding numerosities

Object enumeration: e.g. how many dots?

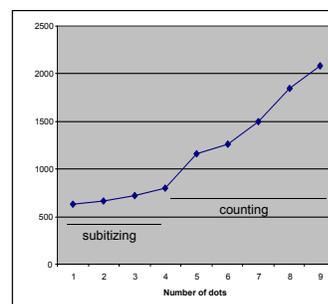


Numerosity ordering: which is more/which is the larger number?

3 7

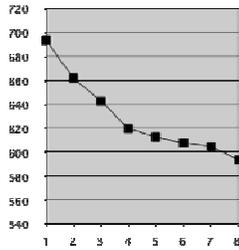


Relation between reaction time and number



Data from Butterworth et al, 1999

Numerical distance and reaction time



Data from Butterworth et al, 1999

First Harrow study

Landerl, Bevan, & Butterworth, 2004

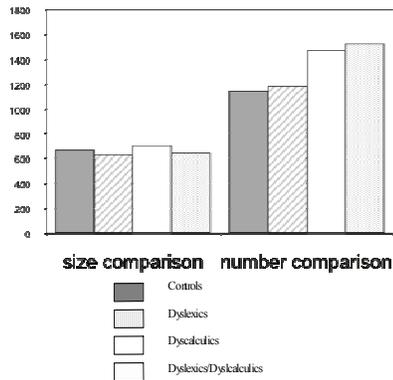
- Criterion - three SDs worse than matched controls on timed addition
- Reasoning, Memory and Language: Matched controls on IQ, digit span, reading and vocabulary
- Plus one group of dyslexics, and one group with a double deficit
- Children with reading deficits as well as dyscalculic performed the same on number tasks
- What about basic number concepts - how many and more?

Number and size comparison

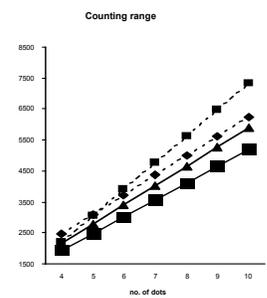
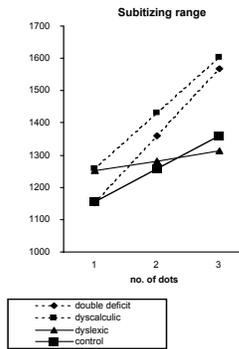
Which is larger?

3 **7**

Correct answers:
 Number comparison 7
 Size comparison 3



Estimation in dyscalculics



Conclusions from Harrow study

- You can be dyscalculic, even if you are intelligent, a good reader and with a good vocabulary and a good memory
- Dyscalculics have a core deficit – they are bad at numerosity - how many and number ordering

29

29

Melbourne Longitudinal study

Reeve, Thomas, Reynolds, Humberstone, & Butterworth (in prep)

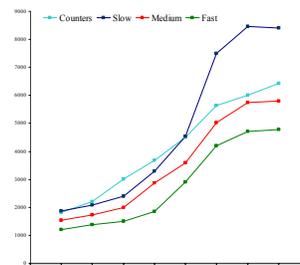
N= 261 at age 5-6yrs

Two stage cluster analysis reveals three clusters

- Slow
- Medium
- Fast

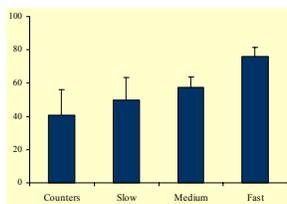
Video analysis distinguishes

- Slow
- Counters

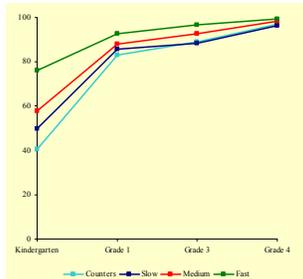


Dot enumeration predicts SDA

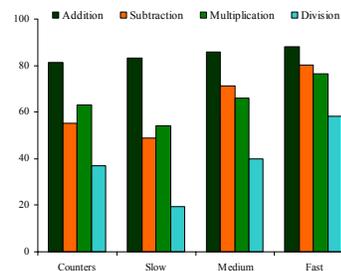
Single digit addition at 6yrs



Single digit addition from 6 to 11



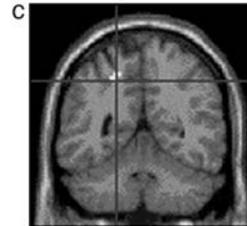
Arithmetical operations predicted at Grade 4 by initial clusters



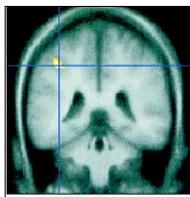
Neurobiological basis for core deficit

Brain area for processing numerosities

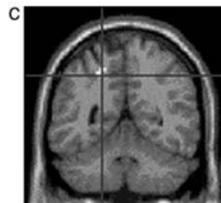
Castelli et al, 2006



Reduced grey matter in dyscalculics



ISAACS et al 2001
VLBW adolescents
Low WOND vs VLBW
controls



NEUROTYPICAL

Dyscalculia is heritable

Twin studies

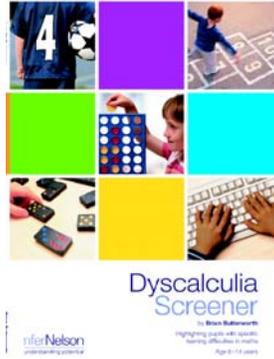
- If one twin has dyscalculia, then 58% of monozygotic co-twins and 39% of dizygotic co-twins also Dyscalculic (Alarcon et al, 1997)
- Third of genetic variance in 7 year olds specific to mathematics (Kovas et al, 2007)

Family study

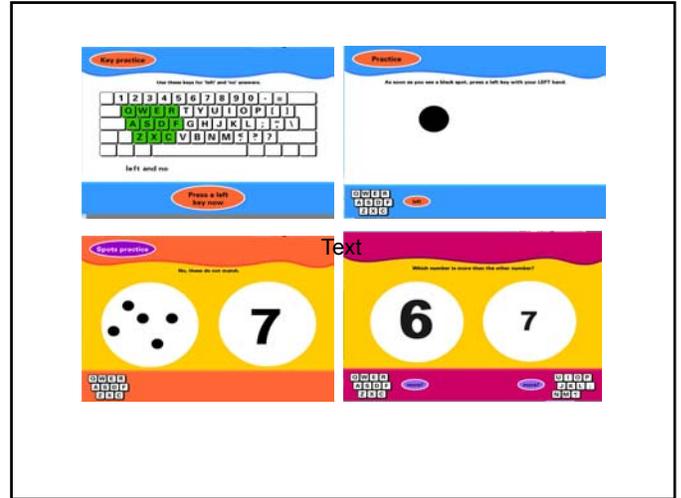
- Nearly half of siblings of dyscalculics are also dyscalculic (5 to 10 times greater risk than controls) (Shalev et al)

Screening tool in UK classrooms

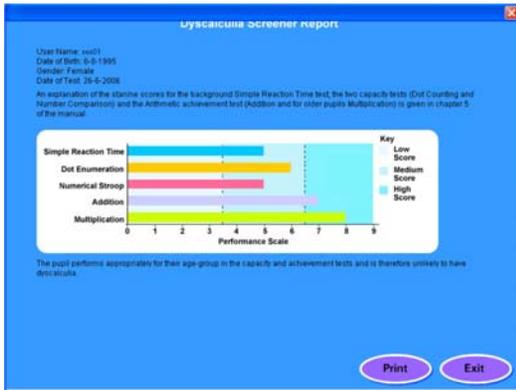
- **Two capacity tasks**
 - Number Comparison
 - Dot estimation
 - (Simple reaction time)
- **One attainment task**
 - Item-timed arithmetic
- Software for your PC
- Results given as standard scores and automatically calculated by computer in a printable form
- Critical Diagnoses:
 - lowest 5% on capacity measures
 - Number comparison and Dot estimation
 - Low performance on attainment but not on the other tests: poor learning/teaching



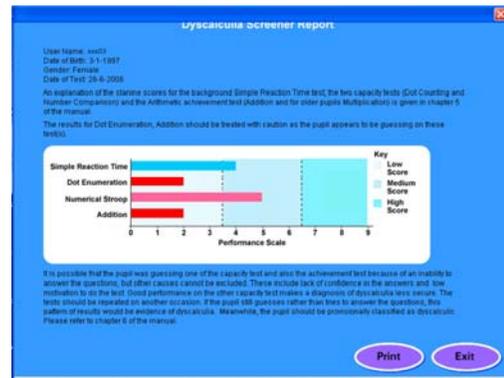
41



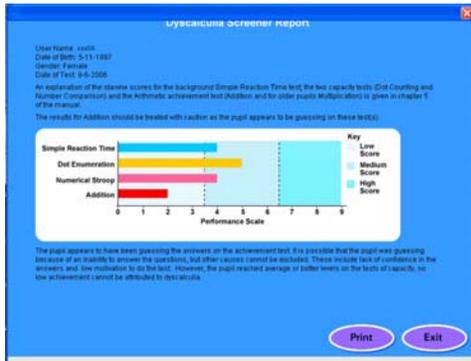
NORMAL PERFORMANCE



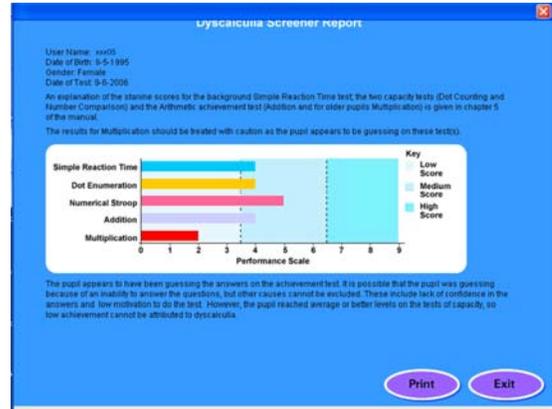
DYSCALCULIA



POOR ARITHMETIC WITHOUT DYSCALCULIA



POOR UNDERSTANDING OF MULTIPLICATION FACTS



Normal Fingers' representation

Classroom version of enumeration test

Unusually rapid responses

How many are dyscalculic?

- Lewis et al (1994) Lancashire, England, about 3.6%
- Shalev (2007), Tel Aviv, Israel, about 6.5%
- Reigosa et al (in prep) Havana, Cuba, 4.9-6.8%
- Reeve et al (in prep) Melbourne, Australia, about 10%

Intervention

Principles of intervention

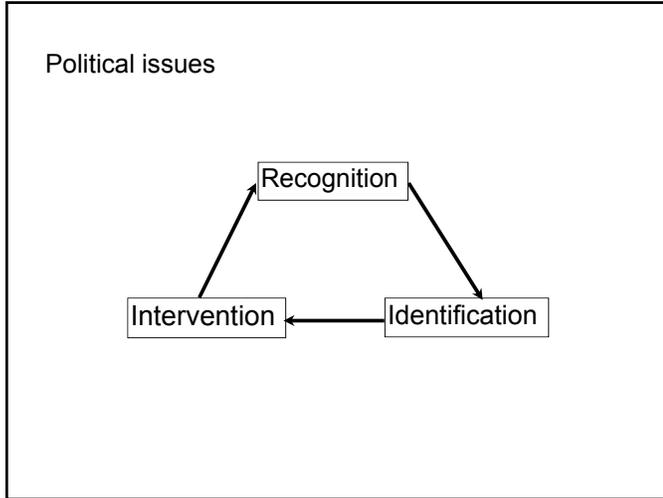
- Strengthen simple number concepts
- Start with manipulables and number words
- Only when learner reliably understands relationship between number words and concrete exemplars, progress to numeral symbols
- Structured teaching programme designed for each learner

Training teachers in one London Borough

- Focussing on identification of dyscalculia and strengthening basic number concepts
- INSET plus ongoing support and networking, with 31 primary teachers and TAs, and 11 SENCOs
- In its third year, supported by John Lyon's Charity
- Teachers, TAs & SENCOs trained to identify dyscalculic learners with the *Dyscalculia Screener*, with additional assessments to see what each child needs
- 85 learners in the study, mostly years 2 to 5

Software for intervention

- Software has advantages that can help the teacher
 - Can keep accurate record of individual learner's performance
 - Can adapt the tasks to reflect current level of performance
 - Learners can use software in private
- But the relationship between identifying a deficit and providing an intervention is not deterministic
 - Software should be modifiable by the teacher
 - Teachers should have a way to share best practice
- Interface should clear and simple
 - Focus on task, no irrelevancies on screen
 - Rewards should be intrinsic
- Tasks should be constructive
 - Learner should see *how* response is right or wrong
 - And how to construct the right answer



- Recognition of dyscalculia
- Teachers
 - recognise dyslexia
 - Parents
 - No parents groups or charities (unlike dyslexia)
 - Government
 - The Williams Mathematics Review does not recognise it
 - Every Child Counts (and DCSF) does not recognise
- 58 58

“Dyscalculia’ ... is the subject of cognitive research using sophisticated clinical investigative tools such as Magnetic Resonance Imaging ... Were the conclusions of these studies to suggest beyond doubt the existence of such a condition as ‘Dyscalculia’, there could clearly be far reaching implications for the teaching of mathematics to the affected group. **It is important to maintain an open mind on the possible outcomes of this research.**”

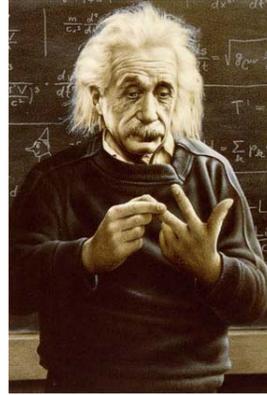
Williams Mathematics Review - Interim report May 2008

- Recognition of dyscalculia
- Teachers
 - recognise dyslexia
 - Parents
 - No parents groups or charities (unlike dyslexia)
 - Government
 - The Williams Mathematics Review does not recognise it?
 - Foresight Report on Mental Capital recognises it
- 60 60

UK Chief Scientific Officer

Professor John Beddington:

“developmental dyscalculia is currently the poor relation of dyslexia, with a much lower public profile. But the consequences of dyscalculia are at least as severe as those for dyslexia.” (Beddington et al., 2008)



The end

For quality and excellent value...

- INSET
- Training events
- CPD courses
- Publications
- Consultancy
- Pupil challenge events



Learning works when it is...



- Relevant
- Active
- Co-operative
- Celebrated
- and... FUN!

Every school is different and we work very hard to tailor our events to suit the context, pupils and particular needs of staff.

To discuss your ideas and/or book your professional training or pupil challenge event please ring Dominique on:

+44 (0)1672 512914

or email Fil directly:

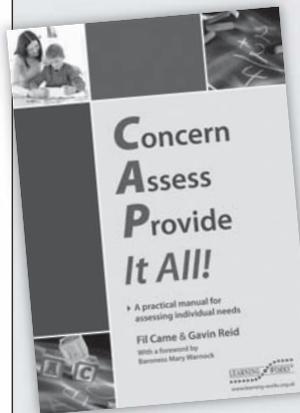
fil.came@learning-works.org.uk

www.learning-works.org.uk

CAP It All!

A practical manual for assessing individual needs

By Fil Came and Gavin Reid



"A book for everyone's departmental bookshelf – appropriate for all no matter what key stage you teach."

Ruth Newbury,
Special Needs Practitioner,
Speaker and Writer

"Those working with pupils with SEN in all phases will find this a brilliant resource."

Phil Smart,
Special Needs Information
Press (SNIP)

COURSE PROGRAMME AND APPLICATION FORM



STEVE CHINN'S UNIQUE FOUR-DAY COURSE

Incorporating

University of Worcester's Advanced Certificate in 'Overcoming barriers to learning in Mathematics'

The Trouble with Maths

A pragmatic course for helping learners who have difficulties in Maths

- ▶ 11 & 12 November 2009
- ▶ 3 & 4 March 2010

Venue: Uplands, High Wycombe
Buckinghamshire, HP15 6LB

www.learning-works.org.uk

COURSE PROGRAMME AND APPLICATION FORM



SPECIFICALLY DESIGNED FOR TEACHERS WORKING IN INDEPENDENT SCHOOLS

University Advanced Certificate in

Managing the Role of the SENCO

Module 1:
Managing Policy and Practice

- ▶ 19 & 20 October 2009
- ▶ 16 & 17 March 2010

Venue: Uplands Conference Centre, High Wycombe,
Buckinghamshire, HP15 6LB

www.learning-works.org.uk