Tests for use in Assessments of Dyscalculia and Maths Difficulties

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SASC Guidance on assessment of Dyscalculia and Maths Difficulties within other Specific Learning Difficulties

Available at
https://sasc.org.uk/SASCDocuments/FINAL%20SASC%20Guidance%20on%20assessment%20of%20%20Dyscalculia%20%20November%202019.pdf

(Downloads page of SASC website)

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Domain-general cognitive skills (eg)

- Visual-spatial perception
- Language
- Processing speeds
- Rapid automatized naming
- Working memory
- Executive Function

ALL play a crucial role in learning and understanding numbers

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Growing evidence of a **domain specific ability** to perceive and manipulate *discrete quantities* (quantities that must be divided into units/numbers and are not continuous).

Distinct from other domain general cognitive abilities.

= ***sense of number*** or ***number sense***

(Henik et al 2017, Sharma 2015, Karagiannakis et al 2014., Kaufman et al 2013, Landerl et al 2013, Butterworth & Laurillard 2010).

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Dyscalculia is a specific and persistent difficulty in understanding numbers which can lead to a diverse range of difficulties with mathematics. It will be unexpected in relation to age, level of education and experience and occurs across all ages and abilities.

Mathematics difficulties are best thought of as a continuum, not a distinct category, and they have many causal factors. Dyscalculia falls at one end of the spectrum and will be distinguishable from other mathematics issues due to the severity of difficulties with number sense, including subitising, symbolic and non-symbolic magnitude comparison, and ordering. It can occur singly but can also co-occur with other specific learning difficulties, mathematics anxiety and medical conditions.

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What Is Sense Of Number?

Definitions vary

Potentially as many as **30** components of number sense

Berch (2005).

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4 areas are commonly listed as being crucial in identifying

a deficit in sense of number

as opposed to poor arithmetical skills.

All 4 areas are equally important within an assessment

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1. Subitising

The ability to rapidly and accurately recognise

the **number of objects**

in a **small** group

without having to mentally or physically count them.

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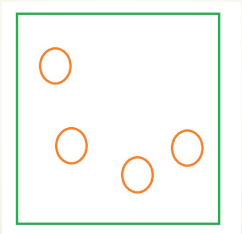
Ability to subitise is commonly assessed through **dot arrays.**



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2. Non-symbolic Magnitude Comparison

Ability to compare **objects** or **groups of objects**, to recognise **differences in size or quantity** and identify which is **greater or lesser**.

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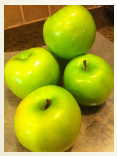
Non-symbolic magnitude comparison is commonly assessed using **dot arrays**, or **pictures of groups of objects**.



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3. Symbolic Magnitude Comparison

Ability to compare **symbols which represent quantities** (eg Arabic numerals) to recognise **differences in quantity** and identify which is **greater or lesser**.

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Can be

- **Single digit** numbers or
- Compositional numbers (multi-digit whole numbers, fractions, decimals).

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4. Ordering (Cardinality and Ordinality)

Cardinality - "**how many**" items there are in a set with similar properties (e.g. 5 applies and 4 pears, or 9 pieces of fruit)

Ordinality - position of an item or number relative to other items or numbers within a series

Gifford (2018).

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Relationship With Arithmetic

Subitising, non-symbolic and symbolic magnitude comparison, and ordering

form the basis on which arithmetic knowledge and strategies are then built.

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Rote Learning v Understanding

Can rote learn arithmetic without a sense of number

But sense of number makes it possible

- to **estimate** and
- to **transfer** knowledge, strategies and procedures from one situation/context to another.

Eg

6 x 5 = 30 30 = 6 ÷? 6 people each have £5, how much money do they have altogether?

So Number Sense contributes to **efficiency** in mathematical procedures

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An individual who remains dependent upon counting in ones is unlikely to have developed number sense and will have great difficulty with any type of estimation task

Chinn (2017).

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Measuring/Evaluating Sense of Number

What **knowledge** and **skills** will you need?

What **tools** will you need?

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TOOLS

- Tests that are designed to evaluate sense of number (as opposed to arithmetic and other mathematical skills)
- Concrete materials (depending on the tests that you select).

Comparison of Tests of Sense of Number

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Test	What it measures:	Strengths	Limitations
Basic Number Screening Test (forms A and B) New edition Age Range: 6:0 – 12:11. Could be used qualitatively with older students/adults Type of Test: Pencil and Paper Admin Time: Average 20 to 30 minutes Country where developed: UK Publisher, Date: Hodder Education 2017 Cost: Around £50	Untimed test of basic understanding of the number system and number operations. Includes object counting, counting on, single and double digit addition and subtraction, visual and written fractions, addition of decimals, recognising number sequences, understanding of place value, single and double digit multiplication and division. 4 page answer form. Instructions for each question are spoken by the assessor. Designed to assess National Curriculum from Years 1 to 5. Designed to be an 'informal "special needs indicator" . . . helps pinpoint children who are likely to require some degree of learning support.	• Quick and easy to administer • 2 Parallel forms - directly comparable – each contains the same calculation/ question but with different number/pictures used. • Scoring is easy and includes reference to the National Curriculum levels. Identifies level that the individual is operating at within the curriculum (gives a Number age) as well as individual's age standard score. • Untimed test so it gives a measure of accuracy and understanding rather than efficiency. • Test is delivered orally to ensure that numeracy skills are being measured (rather than reading skills).	• Limited number of items which relate directly to sense of number. Greater part of test relates to number fact knowledge and application of the 4 operations. Would need to analyse errors and strategies to identify whether problems relate to understanding or knowledge. • Limited age range standardised – although can use qualitatively with older students/adults

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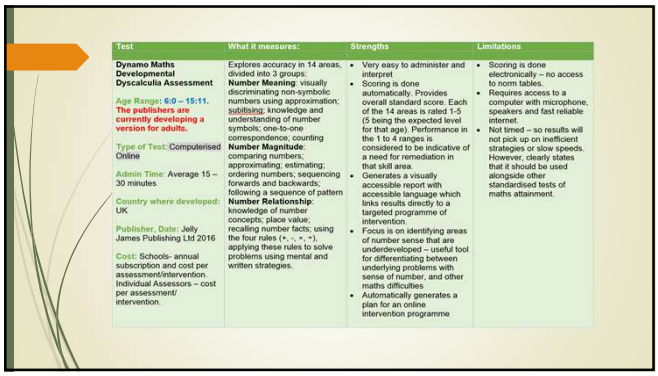

Test	What it measures:	Strengths	Limitations
Dynamo Maths Developmental Dyscalculia Assessment Age Range: 6:0 – 15:11. The publishers are currently developing a version for adults. Type of Test: Computerised Online Admin Time: Average 15 – 30 minutes Country where developed: UK Publisher, Date: Jelly James Publishing Ltd 2016 Cost: Schools- annual subscription and cost per assessment/intervention. Individual Assessors – cost per assessment/ intervention.	Explores accuracy in 14 areas, divided into 3 groups: **Number Meaning**: visually discriminating non-symbolic numbers using approximation; subitising; knowledge and understanding of number symbols; one-to-one correspondence; counting **Number Magnitude**: comparing numbers; approximating; estimating; ordering numbers; sequencing forwards and backwards; following a sequence of pattern **Number Relationship**: knowledge of number concepts; place value; recalling number facts; using the four rules (+ , -, ×, ÷), applying these rules to solve problems using mental and written strategies.	• Very easy to administer and interpret • Scoring is done automatically. Provides overall standard score. Each of the 14 areas is rated 1-5 (5 being the expected level for that age). Performance in the 1 to 4 ranges is considered to be indicative of a need for remediation in that skill area. • Generates a visually accessible report with accessible language which links results directly to a targeted programme of intervention. • Focus is on identifying areas of number sense that are underdeveloped – useful tool for differentiating between underlying problems with sense of number, and other maths difficulties • Automatically generates a plan for an online intervention programme	• Scoring is done electronically – no access to norm tables. • Requires access to a computer with microphone, speakers and fast reliable internet. • Not timed – so results will not pick up on inefficient strategies or slow speeds. However, clearly states that it should be used alongside other standardised tests of maths attainment.

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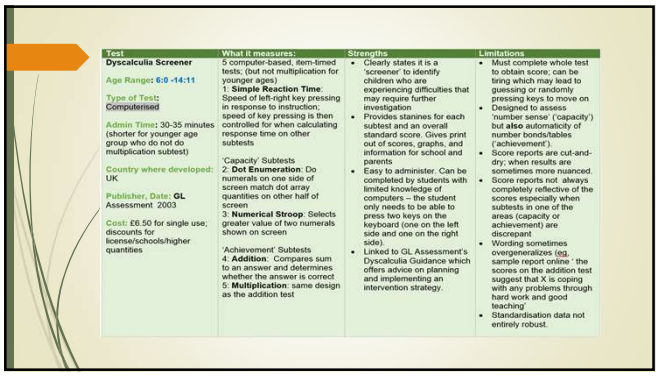

Test	What it measures:	Strengths	Limitations
Dyscalculia Screener Age Range: 6:0 -14:11 Type of Test: Computerised Admin Time: 30-35 minutes (shorter for younger age group who do not do multiplication subtest) Country where developed: UK Publisher, Date: **GL** Assessment 2003 Cost: £6.50 for single use; discounts for license/schools/higher quantities	5 computer-based, item-timed tests; (but not multiplication for younger ages) 1: **Simple Reaction Time**: Speed of left-right key pressing in response to instruction; speed of key pressing is then controlled for when calculating response time on other subtests 'Capacity' Subtests 2: **Dot Enumeration**: Do numerals on one side of screen match dot array quantities on other half of screen 3: **Numerical Stroop**: Selects greater value of two numerals shown on screen 'Achievement' Subtests 4: **Addition**: Compares sum to an answer and determines whether the answer is correct 5: **Multiplication**: same design as the addition test	• Clearly states it is a 'screener' to identify children who are experiencing difficulties that may require further investigation • Provides stanines for each subtest and an overall standard score. Gives print out of scores, graphs, and information for school and parents • Easy to administer. Can be completed by students with limited knowledge of computers – the student only needs to be able to press two keys on the keyboard (one on the left side and one on the right side). • Linked to GL Assessment's Dyscalculia Guidance which offers advice on planning and implementing an intervention strategy.	• Must complete whole test to obtain score; can be tiring which may lead to guessing or randomly pressing keys to move on • Designed to assess 'number sense' ('capacity') but **also** automaticity of number bonds/tables ('achievement'). • Score reports are cut-and-dry; when results are sometimes more nuanced. • Score reports not always completely reflective of the scores especially when subtests in one of the areas (capacity or achievement) are discrepant • Wording sometimes overgeneralizes (eg, sample report online ' the scores on the addition test suggest that X is coping with any problems through hard work and good teaching' • Standardisation data not entirely robust.

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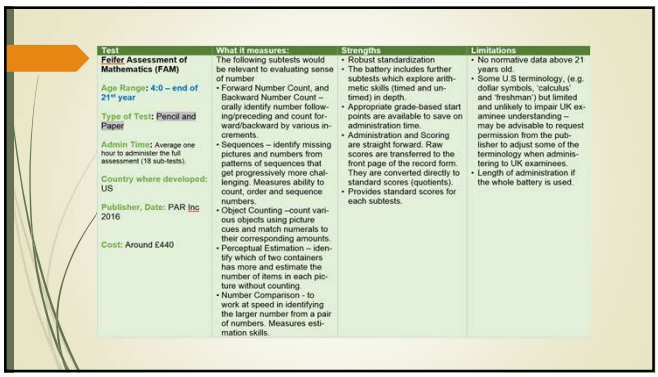

Test	What it measures:	Strengths	Limitations
Feifer Assessment of Mathematics (FAM) Age Range: 4:0 – end of 21st year Type of Test: Pencil and Paper Admin Time: Average one hour to administer the full assessment (18 sub-tests). Country where developed: US Publisher, Date: PAR Inc 2016 Cost: Around £440	The following subtests would be relevant to evaluating sense of number • Forward Number Count, and Backward Number Count – orally identify number following/preceding and count forward/backward by various increments. • Sequences – identify missing pictures and numbers from patterns of sequences that get progressively more challenging. Measures ability to count, order and sequence numbers. • Object Counting –count various objects using picture cues and match numerals to their corresponding amounts. • Perceptual Estimation – identify which of two containers has more and estimate the number of items in each picture without counting. • Number Comparison - to work at speed in identifying the larger number from a pair of numbers. Measures estimation skills.	• Robust standardization • The battery includes further subtests which explore arithmetic skills (timed and untimed) in depth. • Appropriate grade-based start points are available to save on administration time. • Administration and Scoring are straight forward. Raw scores are transferred to the front page of the record form. They are converted directly to standard scores (quotients). • Provides standard scores for each subtests.	• No normative data above 21 years old. • Some U.S terminology, (e.g. dollar symbols, 'calculus' and 'freshman') but limited and unlikely to impair UK examinee understanding – may be advisable to request permission from the publisher to adjust some of the terminology when administering to UK examinees. • Length of administration if the whole battery is used.

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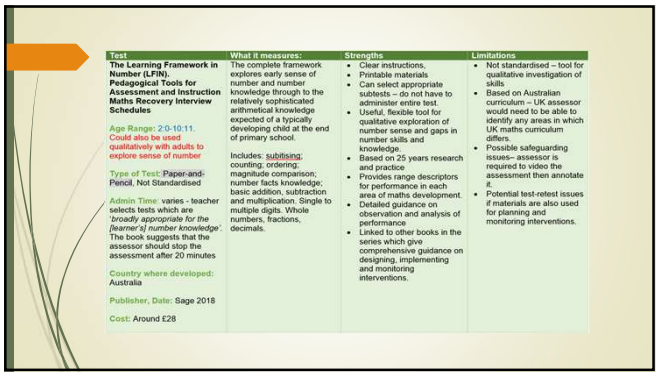

Test	What it measures:	Strengths	Limitations
The Learning Framework in Number (LFIN). Pedagogical Tools for Assessment and Instruction Maths Recovery Interview Schedules Age Range: 2:0-10:11. Could also be used qualitatively with adults to explore sense of number Type of Test: Paper-and-Pencil, Not Standardised Admin Time: varies - teacher selects tests which are *'broadly appropriate for the [learner's] number knowledge'*. The book suggests that the assessor should stop the assessment after 20 minutes Country where developed: Australia Publisher, Date: Sage 2018 Cost: Around £28	The complete framework explores early sense of number and number knowledge through to the relatively sophisticated arithmetical knowledge expected of a typically developing child at the end of primary school. Includes: subitising; counting; ordering; magnitude comparison; number facts knowledge; basic addition, subtraction and multiplication. Single to multiple digits. Whole numbers, fractions, decimals.	• Clear instructions. • Printable materials • Can select appropriate subtests – do not have to administer entire test. • Useful, flexible tool for qualitative exploration of number sense and gaps in number skills and knowledge. • Based on 25 years research and practice • Provides range descriptors for performance in each area of maths development. • Detailed guidance on observation and analysis of performance • Linked to other books in the series which give comprehensive guidance on designing, implementing and monitoring interventions.	• Not standardised – tool for qualitative investigation of skills • Based on Australian curriculum – UK assessor would need to be able to identify any areas in which UK maths curriculum differs. • Possible safeguarding issues– assessor is required to video the assessment then annotate it. • Potential test-retest issues if materials are also used for planning and monitoring interventions.

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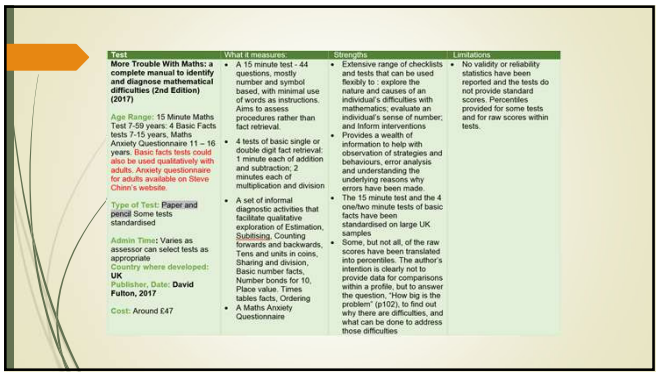

Test	What it measures:	Strengths	Limitations
More Trouble With Maths: a complete manual to identify and diagnose mathematical difficulties (2nd Edition) (2017) Age Range: 15 Minute Maths Test 7-59 years: 4 Basic Facts tests 7-15 years, Maths Anxiety Questionnaire 11 – 16 years. Basic facts tests could also be used qualitatively with adults. Anxiety questionnaire for adults available on Steve Chinn's website. Type of Test: Paper and pencil Some tests standardised Admin Time: Varies as assessor can select tests as appropriate Country where developed: UK Publisher, Date: David Fulton, 2017 Cost: Around £47	• A 15 minute test - 44 questions, mostly number and symbol based, with minimal use of words as instructions. Aims to assess procedures rather than fact retrieval. • 4 tests of basic single or double digit fact retrieval: 1 minute each of addition and subtraction; 2 minutes each of multiplication and division • A set of informal diagnostic activities that facilitate qualitative exploration of Estimation, Subitising, Counting forwards and backwards, Tens and units in coins, Sharing and division, Basic number facts, Number bonds for 10, Place value, Times tables facts, Ordering • A Maths Anxiety Questionnaire	• Extensive range of checklists and tests that can be used flexibly to : explore the nature and causes of an individual's difficulties with mathematics; evaluate an individual's sense of number; and Inform interventions • Provides a wealth of information to help with observation of strategies and behaviours, error analysis and understanding the underlying reasons why errors have been made. • The 15 minute test and the 4 one/two minute tests of basic facts have been standardised on large UK samples • Some, but not all, of the raw scores have been translated into percentiles. The author's intention is clearly not to provide data for comparisons within a profile, but to answer the question, "How big is the problem" (p102), to find out why there are difficulties, and what can be done to address those difficulties	• No validity or reliability statistics have been reported and the tests do not provide standard scores. Percentiles provided for some tests and for raw scores within tests.

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Test	What it measures:	Strengths	Limitations
Numeracy Screener Age Range: 6:0-9:11 Type of Test: Paper and Pencil with Online Scoring Standardised Admin Time: 4 minutes total for most age groups (2-minutes for each subtest) 8 minutes total for youngest age group Country where developed: Canada Publisher, Date: 2013 Cost: Free	2 subtests of 2-minutes each for Grades 1-3 and 4-minutes each for younger age groups) Cross out larger of two numbers presented in 56 pairs of • 1-digit numerals (symbolic) • dot-arrays (non-symbolic) Alternate Forms – yes, same questions in different order Measures efficiency of judging and comparing magnitudes for both symbolic (numerals) and non-symbolic (dot arrays); Pupils specifically instructed NOT to count the dots	• Can obtain percentile rank by inputting raw score • Simple, quick paper-and-pencil screening for two aspects of number sense (symbolic and non-symbolic magnitude comparison) using numerals and dot arrays • Downloadable. Scoring done online	• Small age range: 6-9 yrs only • Cannot view any actual norms tables due to computerised scoring – but this is often the case with screeners • Canadian norms may differ from UK norms as UK curriculum may have more emphasis on speed than Canada.

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Knowledge and **Skills**

- Knowledge of which questions are evaluating sense of number, and which ones evaluate arithmetic or other aspects of mathematics
- Knowledge of typical types of error
- Ability to analyse the individual's pattern of errors
- Knowledge of the range of available strategies, and typical use of strategies at the relevant age/stage of education
- Ability to observe/question and analyse strategies used
- Ability to observe attitudinal/executive function factors: motivation, determination, perseverance, impulse inhibition, attention, and which tasks were avoided
- Ability to use data from tests, error analysis and observations **to differentiate between understanding, accuracy** and **speed/efficiency.**

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What Else Do We Need to Include in an Assessment of Maths Difficulties

Diagnostic assessment of difficulties in mathematics should form part of a holistic assessment designed to explore the full range of SpLDs and cognitive, medical and environmental factors that may be contributing to difficulties with learning. As such they should include the following:

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- A framework for a thorough and appropriate **history taking** which covers mathematics, literacy and wider barriers to learning.
- Tests of **verbal, visual and visual-spatial reasoning** and **cognitive processing** (such as memory, phonological processing, processing speed and accuracy, visual spatial sequential skills) in order to identify domain general strengths and weaknesses within the cognitive profile.
- Tests of **literacy** and **mathematics skills** in order to identify strengths and weaknesses within the attainment profile.
- Informal, qualitative tests of **understanding of number** that use subitising, symbolic and non-symbolic magnitude comparison, ordering and concrete tools to explore concept of number. This could include screeners designed to explore number sense.

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Standardised measures of

- **Arithmetic** (+, -, x, ÷). Timed and untimed to establish what difference time pressure makes upon performance,
- **Mathematics reasoning** and **problem solving**, including **word problems** to explore whether the difficulties are related to number, or mathematical terminology, or language more generally.

Qualitative analysis of performance within these tests:

- Analysis of the individual's **pattern of errors**,
- Observation and questioning about **strategies used**,
- Observation of motivation, determination, perseverance, impulse inhibition, attention, and which tasks were avoided, conceptual understanding of any standard procedures used

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Standardised Tests of Mathematics

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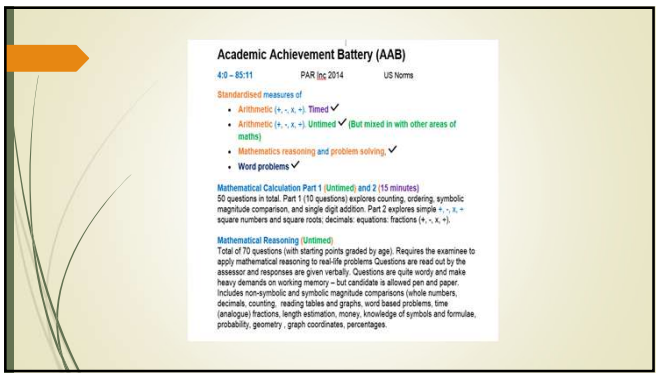
Academic Achievement Battery (AAB)
4:0 – 85:11
PAR Inc 2014
US Norms
Standardised measures of
Arithmetic (+, -, x, ÷). Timed ✓
Arithmetic (+, -, x, ÷). Untimed ✓ (But mixed in with other areas of maths)
Mathematics reasoning and problem solving. ✓
Word problems ✓
Mathematical Calculation Part 1 (Untimed) and 2 (15 minutes)
50 questions in total. Part 1 (10 questions) explores counting, ordering, symbolic magnitude comparison, and single digit addition. Part 2 explores simple +, -, x, ÷ square numbers and square roots; decimals: equations: fractions (+, -, x, ÷).
Mathematical Reasoning (Untimed)
Total of 70 questions (with starting points graded by age). Requires the examinee to apply mathematical reasoning to real-life problems Questions are read out by the assessor and responses are given verbally. Questions are quite wordy and make heavy demands on working memory – but candidate is allowed pen and paper. Includes non-symbolic and symbolic magnitude comparisons (whole numbers, decimals, counting, reading tables and graphs, word based problems, time (analogue) fractions, length estimation, money, knowledge of symbols and formulae, probability, geometry , graph coordinates, percentages.

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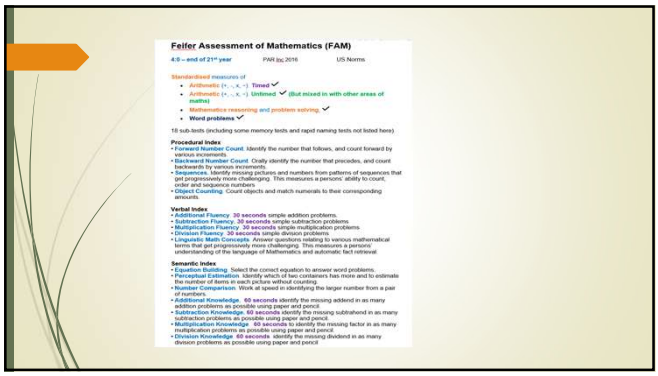
Feifer Assessment of Mathematics (FAM)
4:0 – end of 21st year
PAR Inc 2016
US Norms
Standardised measures of
Arithmetic (+, -, x, ÷). Timed ✓
Arithmetic (+, -, x, ÷). Untimed ✓ (But mixed in with other areas of maths)
Mathematics reasoning and problem solving. ✓
Word problems ✓
18 sub-tests (including some memory tests and rapid naming tests not listed here)
Procedural Index
• Forward Number Count. Identify the number that follows, and count forward by various increments.
• Backward Number Count. Orally identify the number that precedes, and count backwards by various increments.
• Sequences. Identify missing pictures and numbers from patterns of sequences that progressively more challenging. This measures a persons' ability to count, order and sequence numbers.
• Object Counting. Count objects and match numerals to their corresponding amounts.
Verbal Index
• Additional Fluency. 30 seconds simple addition problems.
• Subtraction Fluency. 30 seconds simple subtraction problems.
• Multiplication Fluency. 30 seconds simple multiplication problems
• Division Fluency. 30 seconds simple division problems.
• Linguistic Math Concepts. Answer questions relating to various mathematical terms that get progressively more challenging. This measures a persons' understanding of the language of Mathematics and automatic fact retrieval
Semantic Index
• Equation Building. Select the correct equation to answer word problems.
• Perceptual Estimation. Identify which of two containers has more and to estimate the number of items in each picture without counting.
• Number Comparison. Work at speed in identifying the larger number from a pair of numbers.
• Additional Knowledge. 60 seconds identify the missing addend in as many addition problems as possible using paper and pencil.
• Subtraction Knowledge. 60 seconds identify the missing subtrahend in as many subtraction problems as possible using paper and pencil.
• Multiplication Knowledge. 60 seconds to identify the missing factor in as many multiplication problems as possible using paper and pencil.
• Division Knowledge. 60 seconds identify the missing dividend in as many division problems as possible using paper and pencil

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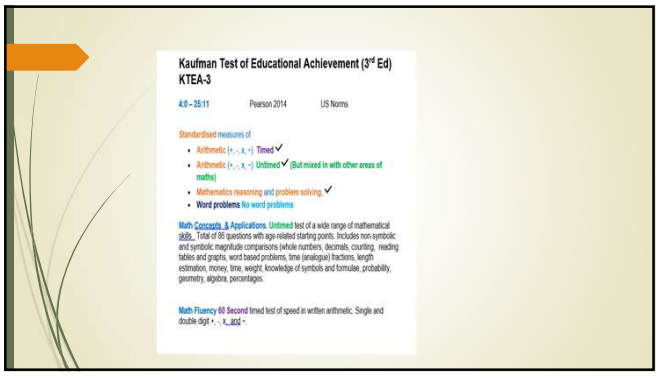
Kaufman Test of Educational Achievement (3rd Ed)
KTEA-3
4:0 – 25:11
Pearson 2014
US Norms
Standardised measures of
Arithmetic (+, -, x, ÷). Timed ✓
Arithmetic (+, -, x, ÷). Untimed ✓ (But mixed in with other areas of maths)
Mathematics reasoning and problem solving. ✓
Word problems No word problems
Math Concepts & Applications. Untimed test of a wide range of mathematical skills. Total of 86 questions with age-related starting points. Includes non-symbolic and symbolic magnitude comparisons (whole numbers, decimals, counting, reading tables and graphs, word based problems, time (analogue) fractions, length estimation, money, time, weight, knowledge of symbols and formulae, probability, geometry, algebra, percentages.
Math Fluency 60 Second timed test of speed in written arithmetic. Single and double digit +, -, x, and ÷.

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KeyMath3
Pearson 2013
UK Norms
Standardised measures of
Arithmetic (+, -, x, ÷) Timed No part of the test is timed
Arithmetic (+, -, x, ÷) Untimed ✓
Mathematics reasoning and problem solving ✓
Word problems ✓
Basic Concepts
Numeracy examines early number awareness, place value and number sense, magnitude of numbers, fractions, decimals, percentages and exponents, integers, multiples and factors.
Algebra examines early algebraic awareness, algebraic uses of numbers and geometry, symbolic representation, ratio and proportion and coordinate grids.
Geometry examines early geometric awareness, two-dimensional shapes, three-dimensional shapes, lines and angles, formulae, grids and coordinate planes.
Measurement examines early awareness of measurement, standard units, time and money.
Data Analysis and Probability examines early awareness of data and probability, charts, tables and graphs, graphical representation, statistics and probability.
Operations
Mental Computation and Estimation examines early awareness of mental computation, mental computation chains, mental computation with whole numbers, mental computation with rational numbers, estimation and whole numbers and estimation and rational numbers.
Addition and Subtraction addition & subtraction of whole numbers, rational numbers, integers and algebra.
Multiplication and Division multiplication and division of whole numbers, rational numbers, integers and algebra.
Applications
Foundations of Problem Solving measures an individual's ability to identify the necessary elements, operations, and strategies required to solve maths problems. It places emphasis on the individual's ability to explore the procedural elements that facilitate solutions.
Applied Problem Solving measures an individual's ability to interpret problems and determine the mathematical (numeracy, measurement and data analysis and probability) set in a context and then apply computational skills and conceptual knowledge to produce a solution.

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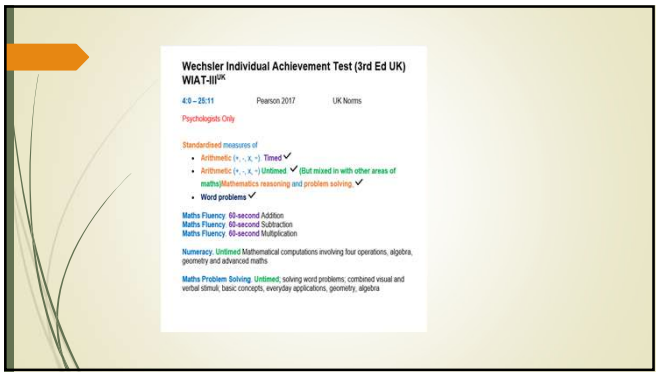
Wechsler Individual Achievement Test (3rd Ed UK) WIAT-III^UK
4:0 – 25:11
Pearson 2017
UK Norms
Psychologists Only
Standardised measures of
Arithmetic (+, -, X, ÷) Timed ✓
Arithmetic (+, -, X, ÷) Untimed ✓ (But mixed in with other areas of maths)Mathematics reasoning and problem solving. ✓
Word problems ✓
Maths Fluency. 60-second Addition
Maths Fluency. 60-second Subtraction
Maths Fluency. 60-second Multiplication
Numeracy. Untimed Mathematical computations involving four operations, algebra, geometry and advanced maths
Maths Problem Solving. Untimed, solving word problems; combined visual and verbal stimuli; basic concepts, everyday applications, geometry, algebra

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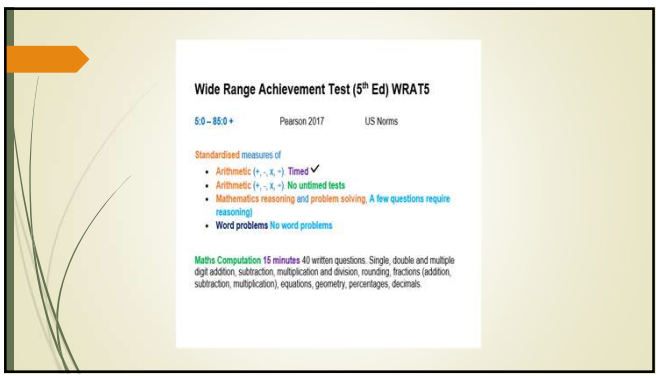
Wide Range Achievement Test (5th Ed) WRAT5
5:0 – 85:0 +
Pearson 2017
US Norms
Standardised measures of
Arithmetic (+, -, X, ÷) Timed ✓
Arithmetic (+, -, X, ÷) No untimed tests
Mathematics reasoning and problem solving, A few questions require reasoning)
Word problems No word problems
Maths Computation 15 minutes 40 written questions. Single, double and multiple digit addition, subtraction, multiplication and division, rounding, fractions (addition, subtraction, multiplication), equations, geometry, percentages, decimals.

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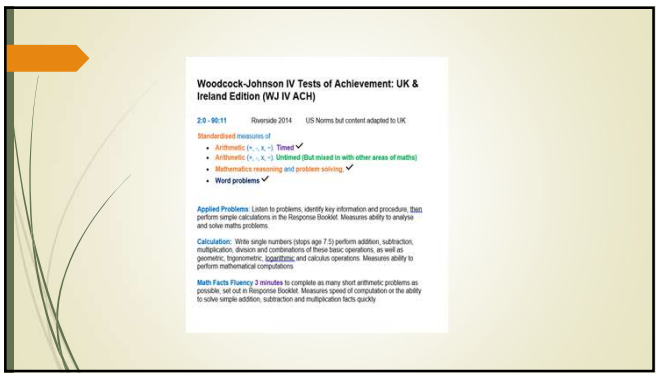

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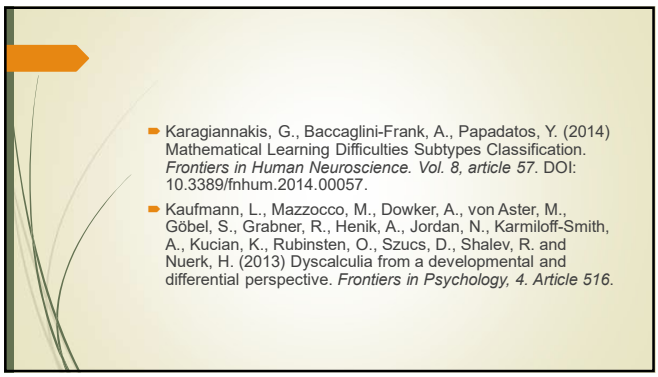
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