

Unit 7: Acquiring Mathematics and Numeracy Skills

a) Basis of mathematical learning

Most children with Down syndrome encounter difficulties with mathematics and to date there is very little in the way of research in this area that identifies the reason for this. However, there is a collection of predictable contributory factors that will affect the maths attainment results in all children.

Research shows that the main neuro-developmental functions that are required when children think with numbers are: memory; language; attention; concentration span; temporal-sequential ordering; higher-order cognition and spatial ordering. These form the process in which children constantly introduce new concepts and skills as they solve maths problems.

The learning profile of children with Down syndrome identifies varying degrees of difficulties in all of these functions. Consequently, it is safe to say that most children are likely to experience difficulty with numeracy.

In order to undertake mathematical operations, children must attain a general developmental readiness. They acquire this during infancy and throughout the preschool years as a result of actively exploring by touch, handling and manipulating objects. It is at this time early numeracy and maths concepts as well as mathematical thinking are developed. This is a critical maths learning stage for all children.

This initial informal stage in mathematical learning is vital to the development of skills in matching, comparing, sorting, labelling, mapping and ordering. It is particularly important for children at this stage to fully understand the concept of 'same' and 'different'. This is usually acquired in an unstructured manner, together with the associated maths language and conversational skills, through interaction with peers and adults and by being absorbed in day-to-day activities.

Although pupils with Down syndrome experience significant cognitive delay they go through the same developmental stages as their typically developing peers but at a slower pace. Thus, pupils of similar developmental levels are likely to share the same level of competence in counting skills and counting principles.

The level of cognitive development of children with Down syndrome will have a considerable impact upon their ability to grasp mathematical concepts and skills and successfully carry out calculations and tasks. The development of maths concepts and mathematical thinking will be slower not only as a result of any developmental delay but also as a result of limited experiences caused by delayed fine and gross motor skills and/or any coordination and manipulation difficulties.

It is essential that children with Down syndrome spend more time in an environment rich in opportunities to explore and manipulate objects so as to gain the relevant early pre mathematical skills.

Mathematics requires almost exclusively higher order abstract thinking and reasoning skills. This is a critical developmental milestone, which occurs at the developmental age of seven+. As a result, many children with Down syndrome may need the support of concrete manipulatives for a significantly longer time in order to carry out basic mathematical operations before being introduced to formal written activities.

The transition from informal to formal should therefore be very gradual. Pupils with Down syndrome may encounter difficulty associating informal maths knowledge with formal school maths. Connections are likely to be made slowly and sometimes maths may be perceived as a set of unrelated facts.

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Making these connections takes time, a variety of experiences and carefully directed teaching. Worksheets with pictorial representations of mathematical facts are semi-abstract and symbolic. If introduced too early they can confuse the fragile links being formed between existing concepts.

The use of structured concrete materials is important in securing these links, not only in the early years but also during concept development stages in higher level mathematics. Concrete materials can be held, moved, grouped and separated, allowing pupils to visualise mathematical processes. This makes them much more real than pictorial representations alone.

Generalising

Nevertheless, it is important that children realise that there is a real purpose to the use of mathematics and that it is not just an activity that takes place in school. It is vital, therefore, to create real situations with everyday objects to count e.g. giving out pencils or exercise books, setting the table for lunch or putting straws in bottles of milk.

b) Developing basic numeracy

Provide practical activities that will develop competency in:

Classification

Understanding that things can be the same in one respect and different in another but can be classified in one aspect.

Provide activities that give opportunities for sorting and matching from a selection of attributes according to size, colour, shape and purpose. Such as familiar classroom objects and equipment such as pencils, pens and books.

Rote counting

Pupils with Down syndrome often have good rote memorising capabilities. Rote learning enables retention of facts, reduces stress on short-term memory and enables the development and use of mathematical processes and strategies.

Provide activities that give opportunities to counting forwards and backwards in ones. The understanding of what each numeral represents is not necessary initially. More important is the child's ability to say the number sequence accurately.

One to one correspondence

Understanding that each object being counted must be given one count and only one count.

Teach children to always touch each item as it is counted and to move an item out of the way as it is counted. Take care to avoid sliding the finger over a number line or group of items.

Stable order principle

The understanding that the counting sequence stays consistent. It is always 1, 2, 3, 4, 5, 6, 7, etc., not 1, 2, 4, 5, 8.

Ensure accuracy in rote is achieved. Count objects already laid out from left to right on a number line and progress to placing objects on the number line always starting on the left.

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Counting object from left to right:

one	two	three	four	five	six	seven	eight	nine	ten
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	8	9	10

one	two	three	four	five	six	seven	eight	nine	ten
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1	2	3	4	5	6	7	8	9	10

Cardinality of number

Understanding that the last count of a group of object represents how many are in the group. Any child, who recounts when asked how many objects are in the set that has just been counted, does not yet understand the cardinality principle.

Conservation of number

Understanding that the count for a set group of objects stays the same no matter whether they are spread out or close together.

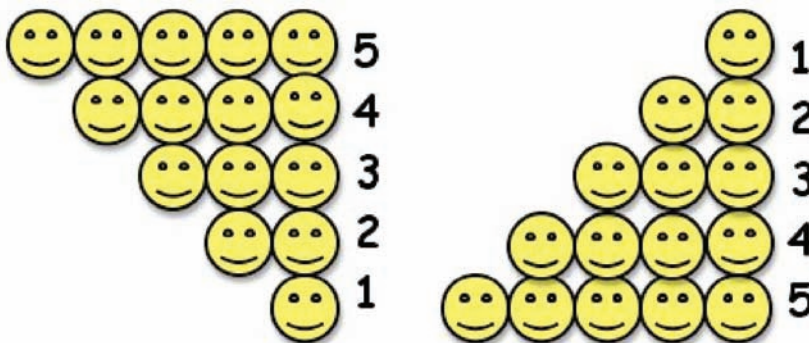
Order irrelevance

Understanding that counting objects can begin with any object in the set and the total will stay the same.

Movement magnitude

Understanding that as you move up the counting sequence, the quantity increases by one and as you move down or backwards, the quantity decreases by one (or by whatever number you are counting by as in counting by 10's, the amount goes up by 10 each time).

Numbers increase and decrease by 1:



Abstraction principle

Understanding that objects of any kind can be counted and that the count can contain a variety of different objects.

Practical activities to develop these principles should be devised, progressing along the following sequence:

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1. Sorting and matching like objects by colour, size and shape.
2. Rote counting objects from 1-10.
3. Counting up to 10 objects in a row.
4. Associating numerals with the written words, spoken words and appropriate amounts.
5. Selecting up to 5 objects from a set of 10.
6. Matching numerals 1-5.
7. Selecting numeral 1-5 on request.
8. Sequencing numerals 1-5 in correct order.
9. Sequencing amounts 1-5 in correct order.
10. Identifying and selecting correct numeral on request.
11. Labelling amounts 1-5 with correct numeral.
12. Copying numerals 1-5 on request.
13. Repeating items.
14. Using numerals 1-10.
15. Counting left to right using 1:1 correspondence.
16. Organising materials so they can be counted accurately.
17. One digit addition e.g. 3+4.
18. Counting objects to 20.
19. Subtracting one digit e.g. 4-2.

Commercially produced materials may be helpful at this stage but should always be used alongside real objects. Although colourful and fun to use, materials such as 'Compare Bears' or 'Peg People' are still in a sense artificial, as we do not count such things in real life situations. Additionally, commercial materials may inhibit learning, as pupils may prefer to view them as rather than a tool for learning.

Visual imaging of place value:



However, recent experience suggests that the 'Numicon' materials produced at The University of Brighton, may be of real value to children with Down syndrome. 'Numicon' is concerned with how all children learn about numbers and emphasises the value of using structured visual representations to teach the relationships between numbers.

Its multi-sensory approach is proving successful because of the ability of pupils with Down syndrome to learn by using their visual and spatial memory. 'Numicon' materials make use of patterns and aim to develop pupils' number concepts by providing information on position, action, colour and shape. Children internalise the images of the number plates to give them a visual image for each number that will support later numerical operations.

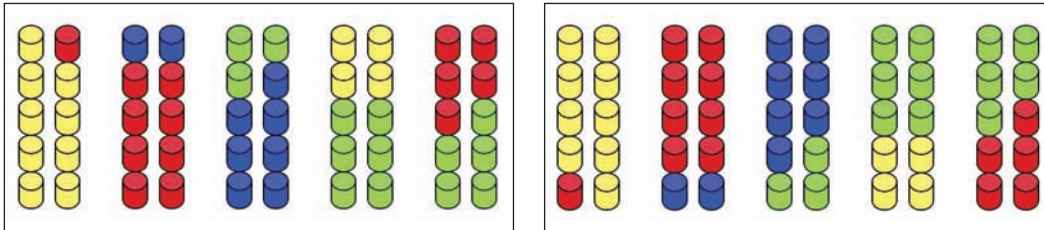
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Addition and subtraction

When children can count to ten provide practical experiences grouping items and combining and separating number shapes to provide the visual images of simple addition facts.

Reversing the combined images can show that $4+6$ is the same as $6+4$.

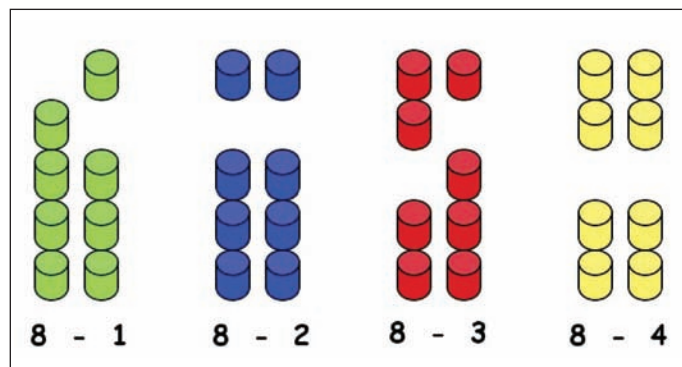
Combining items to show addition facts:



Combining images to show addition facts:



Separating items to show subtraction facts:



Addition and subtraction requires the rote learning, retaining and recalling a great deal number facts. This is likely to be challenging for children with Down syndrome. Practise counting forwards from numbers other than one. This will not only give children the skill to know the next number in any count but will enable them to count on from one of two given numbers to be added, for example, $9 + 4$, by saying and storing 9 and counting on for the 10, 11, 12 and 13 giving the answer 13.

Counting in 2's odd and even will enable the child to add 2 to any number.

Multiplication and division

Prioritise and select the multiplication tables according to the child's ability. Work initially on the tables of 2's, 5's and 10's. Show as repetitive addition of each. Rote counting the stations of each table makes less demand upon retention, recalling, memory and language skills. Division can be shown as sharing in 2's, 5's and 10's.

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Counting in 2's, 5's and 10's:

How many 2's?

The table of twos

one 2

two 2s

three 2s

four 2s

The table of fives

one 5

two 5s

three 5s

four 5s

The table of tens

one 10

two 10s

three 10s

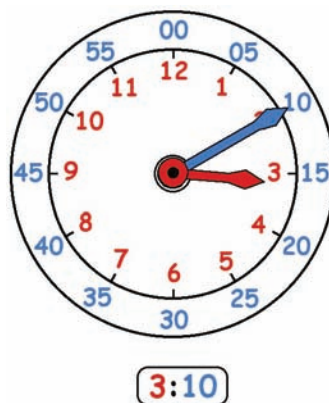
c) Maths skills for everyday living

Time

Skills in telling and using the time are an essential life skill. Analogue recording is extremely difficult for most children and is especially so for children with Down syndrome. It is extremely demanding in terms of language and number. Instead, introduce time in digital format that can be done using an analogue clock depicting hours 1-12 on an inner circle and minutes in 5's on an outer circle.

Provide opportunities for practising counting in 5's and 10's around the clock. Using the inner and outer circles read time using the hours in the inner circle then the minutes on the outer circle. i.e. hour hand then minute hand 3.05, 3.10, 3.15 etc.

Digital analogue clock:



Money

Focus upon coin recognition and call each coin or amount by its full name. For example, say '2 pence', and '5 pence'. Never refer to money in numeric format by calling a coin 2 when it is 2 pence. Confusion arises when 1 object is referred to as 2. Progress to recognition of groups of 2 and 3 coins without counting.

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Use visual support to show equivalent values by placing coins on number shapes then combining the shapes to show the value.






Understanding equivalent coin values:








Teach children to round up to the nearest pound and encourage listening to what is said. More than a pound will be clear in words.

Use coins to teach children to count in 2's, 5's, 10's 20's and 50's, far more useful in real life than learning their 3 or 4 times tables.

Counting with two pence coins using even numbers:

	two pence		four pence		six pence		eight pence		ten pence
									
	2p		4p		6p		8p		10p

Counting with two pence coins using odd numbers:

one pence		three pence		five pence		seven pence		nine pence	
									
1p		3p		5p		7p		9p	

d) The language of maths

Difficulties in processing language, together with remembering what to do and in which order, restrict the ability of children with Down syndrome to complete mathematical tasks. Calculations and word problems all require language. Prior to undertaking any mathematical operation or task, the language skills and short-term memory of the pupil are the first to be put to the test.

Difficulties arise as a result of:

- The abstract language of maths, which is unlikely to provide a basis for understanding.
- The use of symbols to represent numbers and the use of concepts which cannot be decoded using contextual cues as in reading.
- The need to recall and use many steps, rules and number facts, which require language.

As mathematical levels increase, so do the demands placed on reading and language skills. It may also take longer to develop the understanding of and associated language for the basic concepts of more and less, high and low, big and small associated with both

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number, shape and measure, etc., and more complex concepts and comparative language such as, big, bigger, biggest, short, shorter, shortest and light, lighter, lightest, etc.

Visual support for more and less associated with high and low, big and small numbers:



Limited language and general knowledge together with difficulties in recalling and selecting relevant information affect the child's ability to think, reason and solve problems or carry out tasks.

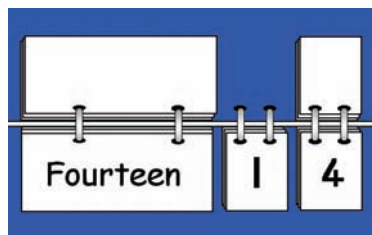
Learning maths vocabulary alongside developing understanding is vital. Similarly, children should be taught to recognise and understand associated maths terms and symbols.

Teaching the concept and language together:

five	eight
5	8

Teach maths concepts and skills and language of maths together rather than as an afterthought. Teach vocabulary using the process of matching, selecting, naming and understanding all associated words, (see section Reading). Personal word lists and keyword flash cards displayed clearly during tasks and assignments will help jog the children's memories.

Associating words and numerals:



Using and applying maths

Results, outcome, check, explain, record, make, test, predict.

Number and algebra

A lot, all, some, both, another, not any, many, same, more, less, every, enough, as many

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as, first, second, third..., last, add, subtract, take away, guess, estimate, two times, multiply, units, tens, hundreds, odd, even.

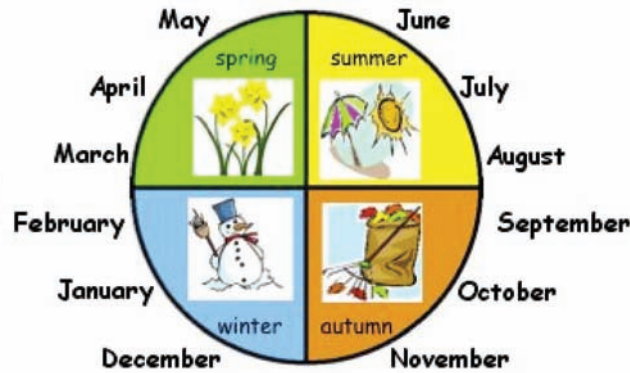
Fractions

Same, different, as big as, smaller than, larger than, greater than, whole, piece (of the...), part, complete, halves equal, unequal, quarters, one quarter, two quarters, three quarters, one half.

Time

Again, now, after, soon, today, before, later, yesterday, early, late, once, tomorrow, twice, quick, slow, first, next, last, days of the week, weeks in a month, months of the year, o'clock, half past, quarter past, quarter to, seconds, minutes, hours, days, weeks, months, years.

Day spinner and seasons cycle:



Size width, height, length

Big, small, little, fat, thin, long, short, thick, wide, narrow, comparative and superlative and superlative forms of words, as big as, longer than, shorter than, order and compare, all units of measure.

Weight

Heavy, light, heavier than, lighter than, heaviest, lightest.

Area, volume, capacity

Alot, lots, a little, a bit, a small bit, empty, full, much, most, more, more than, less than, same, and all units of measure.

Money

Coins, how much, how much altogether, cost, price, change.

Shape

Round, dot, spot, line, circle, rectangle, square, hexagon, pentagon, oval, triangle, diamond, sphere, cylinder, cuboids, pyramid.

Spatial relationships

In, on, under, by, beside, behind, in front of, next to, over, through, inside, outside, out, to, off, above, below, round, up, down, front, back, left, right, forwards, backwards, top, bottom, middle, first, last, next.

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e) Difficulties associated with learning maths

Difficulties that arise from visual-spatial impairment in some pupils may mean that they will encounter difficulty when differentiating between numbers, e.g. 6 and 9, 2 and 5, 17 and 71, and between operation symbols e.g. + and x, – and =, < and >.

The directional aspect of maths may be problematic e.g. using a number line, vertical addition, left-right regrouping and alignment of numbers or writing across the paper in a straight line. The recognition and understanding of the associated vocabulary should be taught alongside each, to help reduce confusion.

Some children encounter difficulties with fine and gross motor skills and may have problems in handling small objects. Consequently they may not develop concepts through manipulation of objects in loosely structured exploratory play.

Opportunities need to be created in a structured and progressive way, encouraging pupils to manipulate, investigate and use concrete materials. Adult intervention may be necessary to explain what is being discovered and why. This should then be followed by sufficient practice to consolidate their learning.

Other problems with maths faced by some children with Down syndrome include counting past a given number, as they may have forgotten the specific number or may not fully understand the cardinal principle of final tag representation.

Reinforcing the cardinal aspect of numbers:



Providing a visual prompt to help children stop at the correct number can help in the early years. Ensure they touch each item and say the number as they count. Teach that two items are called two and count “one, two” emphasising the ‘two’. Introduce three items and then four. If they are confident, interrupt the count and ask them to predict what the next number will be.

Predicting the next number in a count:



Typically pupils may not be able to assess whether they have the necessary skills to solve a problem, identify and select appropriate processes, organise information, examine the problem solving process they are using, make adaptations to the process when necessary, evaluate their answers and identify errors, generalise strategies to different situations.

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Additionally, it is important to consider whether or not concepts have been adequately covered in previous lessons and whether any component part has been omitted e.g. it would be inappropriate to teach long division to children who have not yet understood the principle of division as sharing or made the connection between multiplication and division.

Lack of significant thinking skills compounds problem solving difficulties. Pupils need to be given opportunities to undertake problem solving and other maths 'thinking' activities even before they have mastered computation. Encourage the pupil to:

- Read and understand the problem.
- Look for the key questions and recognise important words.
- Select the appropriate operation.
- Write the number sentence (the equation) and solve it.
- Check their answers.
- Correct any errors.

Help pupils to solve problems by demonstrating and providing a permanent model i.e. a completed item or task. Verbalise the key words associated with each step with the permanent model in view. Instruct the pupil to complete each step while saying the key words out loud. Finally, allow the pupil to complete subsequent problems on their own, with the teacher's model still available.

Provide adequate experiences with real life materials, time for exploration and situations where the 'right' answer is irrelevant. Use careful, accurate and appropriate language. Provide helpful technologies and convey to the pupil that getting it wrong is a necessary part of learning.

Acquiring basic skills

When planning the maths curriculum for children with Down syndrome, learning outcomes should be feasible and activities and tasks manageable, within the resources available. They should be relevant to each individual child's capabilities and realistic, by providing the appropriate skills for future needs.

In curriculum planning, neither a child's IQ nor the Down syndrome label are helpful in target setting. More relevant are the child's ability to count accurately and the level of understanding of the task, the suitability of tasks and instruction and the pupil's individual and preferred learning style. Additionally, it is important to bear in mind that self-motivation is usually difficult and that achievement particularly on challenging tasks is not commonly a motivating factor. Rather it is the exceptionally interesting reward that is provided upon completion that drives the child.

All skills and concepts will usually need to be revisited and revisited and key mathematical terminology taught as a specific skill. Use directed practice together with teacher instruction, followed by independent practice and positive feedback. During the directed and independent practice, provide many and varied opportunities to manipulate concrete materials to assist conceptual understanding.

Consider existing background knowledge. Mathematics depends heavily on previously learned skills. Consequently, it is important to ensure that prerequisite skills have been acquired prior to the introduction of new ones.

Attentiveness during practice is as crucial as the time spent on the task. Distributed practice, meaning regular practice in small doses, is particularly beneficial e.g. two ten minute sessions per day are likely to be better than a two hour session once a week.

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Generalisation and understanding of the abstract nature of maths also relies upon a considerable length of time with structured, concrete, 'real' materials, slowly building connections. Gradually children will grasp the concept of conservation of number, the realisation that five objects, regardless of size, shape, colour or arrangement, still count as five.

Essentially, competence in a number of children with Down syndrome is linked to their level of knowledge and understanding, not to the syndrome. Each will make good progress when good teaching methods are applied.

f) Useful reading

Berger, A. Morris, D. & Portman, J. (2000) **Implementing the National Numeracy Strategy for Pupils with Learning Difficulties**. David Fulton Publishers.

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Horstmeier D. (2004) **Teaching Math to People with Down syndrome and Other Hands on Learners Book 1**. Woodbine House.

Horstmeier D. (2008) **Teaching Math to People with Down syndrome and Other Hands on Learners Book 2**. Woodbine House.

g) Maths resources

DownsEd

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Graded Steps to Maths Achievement

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Winslow Press

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