A booklet about teaching mathematics in the secondary school.



Developing mathematics skills



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Preface

This booklet is designed to provide critical information and teaching strategies for secondary teachers and Learning Support Assistants to enable pupils with Down's syndrome to access the secondary mathematics curriculum.

The booklet outlines the mathematics learning process and the possible difficulties that may arise for young people with Down's syndrome. It focuses upon the importance of concept development and how developmental delay impacts upon learning. Advice and guidance are provided in the following areas:

• How pupils with Down's syndrome learn and the strategies that can be used to facilitate their learning.

• How the learning style of pupils with Down's syndrome affects their development of mathematics skills and concepts.

- Assisting pupils to demonstrate knowledge and understanding.
- Teaching a relevant mathematical curriculum.
- Using the curriculum to develop life skills.
- Using the mathematics curriculum to promote self esteem.

Differentiation of the secondary mathematics curriculum is vital to the successful inclusion of pupils with Down's syndrome and for this purpose the accompanying disk contains examples of differentiated teaching resources. This illustrates the levels of adaptation and differentiation that may be necessary and are focused upon the mathematics skills that are important to everyday life during school years and beyond.

This booklet was developed by Cecilie Mackinnon, Curriculum Development Officer for Down's Syndrome Scotland in 2006 and updated by Carolyn Thornton, Hub Development Officer for Down's Syndrome Scotland.

Introduction

Mathematics skills play an important role in our lives by providing what is needed in everyday activities such as buying food and clothes, telling the time, using public transport and playing games. They are vital for all children regardless of ability since they have a significant role in developing their understanding of the way their world is organised. They are hierarchical and need a degree of confidence with numbers and measure, an understanding of the number system, reliable computation and the ability and motivation to solve number problems in a variety of situations and purposes.

Generally, pupils with Down's syndrome have significant difficulty learning mathematical skills and concepts. The developmental stages and the acquisition of these skills is mostly similar to their typically developing peers, although a great deal slower. Number competence is linked more to levels of knowledge, understanding and language development than to Down's syndrome.

During the pre-school years typically developing children learn about their environment as they play. In this period early mathematics learning takes place. Through play children manipulate and investigate objects of many kinds and discover the elementary properties such as size, texture, weight, volume and capacity. Gradually they develop an understanding of concepts such as 'same' and 'different'.

Children with Down's syndrome often experience difficulty processing the information they receive from their senses and then coordinating movements. They may have trouble manipulating objects and not explore their environment to the same degree as their peers. Consequently, they may not grasp that objects can be the same in one aspect and different in another but still be classified as 'same'. This concept is vital to the development of skills in matching, comparing, sorting, labelling, mapping and ordering.

Children with Down's syndrome typically experience some degree of delayed speech and language. Any delay in learning to understand and use language development inevitably leads to cognitive delay. The ability to access the mathematics curriculum will, therefore, be compromised.

Some mathematical concepts may be beyond the ability of some pupils at a particular time but be appropriate at a later stage in development. This will determine the timing of teaching certain areas of the curriculum.

In view of this, it is advisable to follow a personally differentiated mathematics curriculum that observes the individual pace of learning and not necessarily cover all aspects of the Curriculum for Excellence (Scotland), or the National Curriculum (England) or the Welsh Curriculum.

To enable full access to the curriculum, support materials and tasks should be pitched at an appropriate cognitive and language level. Knowledge of a young person's strengths and needs will provide the necessary information in planning a mathematics curriculum. It should provide for a continuum of developing knowledge and understanding of concepts and skills.

Developing Concepts

Pupils with Down's syndrome commonly experience difficulties in acquiring concepts, particularly those of an abstract nature. Since numeracy and mathematics skills depend mostly upon knowledge and understanding of abstract concepts, it is safe to say that pupils who experience cognitive delay are likely to encounter some measure of difficulty in this area. In other words the difficulties that inhibit acquiring concepts create a barrier to learning mathematical skills.

In order to break down this barrier it is important to understand how concepts are developed. Initially, a concept requires information, which comes from the environment, people and from knowledge gained through past experiences and skills. This information must be accurate. It must be held in the short-term working memory long enough to be fully processed and stored in the long-term memory. It must then be retrieved when required to learn new and associated concepts. A critical factor is the loop that occurs and how concept development depends upon efficiency and accuracy throughout processing.



Information accuracy depends upon:

- 1. Language understanding.
- 2. Visual, auditory and perceptual difficulties.
- 3. Presentation of information: verbal with written, pictorial and/or demonstrated.
- 4. Accurate prior knowledge and understanding.

Processing efficiency depends upon:

- 1. Ability to hold data during processing in the short-term memory.
- 2. Level of thinking language.
- 3. Sequencing of information.
- 4. Processing speed.
- 5. Concentration span.

Long-term memory reliability depends upon:

- 1. Ability to retain knowledge and understanding.
- 2. Ability to retrieve knowledge and understanding.

The Five Counting Principles

Pupils need to learn the counting sequences, 'one, two, three...' together with the basic concepts and the five principles that apply to counting effectively.

1.One to one correspondence – only one word tag (one, two) is assigned to each counted object;



2. Cardinality – the value of the final word tag represents the quantity of items in the counted set. If the pupil understands cardinality then they will repeat only the last number word. Below, numeral 7 represents the quantity.



3. Stable order – the order of the word tags (one, two, three) must not vary when counting sets.



4. Order-irrelevance principle – where the order and tag that each item receives is irrelevant. Objects can be counted and then moved about. This principle makes the distinction between counting and labelling.



5. Abstraction – the preceding principles are applied to any collection of items.



Acquiring new skills

Acquiring mathematic skills and concepts depends heavily on what has been learned earlier. Before introducing any new skill consider existing knowledge and ensure that basic skills have been achieved. Reinforce these skills for several days to enable the pupil to select, recall and use the relevant operations for new or more complex operations.

Learning a new skill

Acquisition

Beginning to work accurately

Fluency

Able to perform skill accurately and fluently

Maintenance

Continues to perform skill accurately and fluently over long period

Generalisation

Able to apply skill to different tasks

, Adaption

Able to apply new skill in new setting without help

All new and previous knowledge, understanding and skills require practice and reinforcement. Those that are not practiced are likely to be lost. Practice opportunities should be:

- 1. Sufficient for obtaining fluency.
- 2. Distributed over time.
- 3. Regular, with opportunities to revisit and reinforce previous skills and build upon these as more skills are learned.
- 4. Varied, to promote generalisation and motivation for instance doing the same thing in many different ways, using a wide range of concrete materials.
- 5. Practised often, using real materials in real situations.

What Might Affect Mathematical Skills?

Language delay

Before starting mathematics, language attainment and short-term memory need to be adequate for the task. Difficulties in processing language together with remembering what to do and in which order, restricts the capacity to complete tasks. Calculations and word problems all require language therefore it is important to teach all mathematics vocabulary and the associated concepts together.

The different meaning of words in a mathematical context can often cause confusion.

Higher and lower – understanding the connection with more and less instead of physically higher and lower. For example there is no higher or lower number on a horizontal number line.



Before and after – can mean 'in front of' or 'behind' as a position in a queue. In mathematical terms it can mean the number before and the number after as shown on a number line.



Big and small – in relation to number quantity is different to their meaning when they are used in measure. For example, the pupil may find it difficult to identify which number is bigger if the numerals are physically the same size.



More – understanding the additional aspect of greater in quantity and not 'another one'. The use of symbols to represent numbers and concepts cannot be understood using clues, as in reading. Provide written words for numbers together with the symbol and the quantity. This can take the form of number lines that show words, digits and amounts.



Fine motor skills

Many pupils with Down's syndrome have poor muscle tone which may affect their fine and gross motor skills. This improves as the pupil matures into adulthood. Delayed milestones in motor development restrict early years experiences and add to the delay in cognitive development. Writing skills are often significantly delayed.

Areas of difficulty

- 1. Writing skills may be slow and lacking fluency.
- 2. Applying pencil pressure.
- 3. Manipulating small objects, such as counters.

Teaching Strategies

- 1. Use larger sized age appropriate concrete materials such as pencils, erasers.
- 2. Alternative writing implements such as soft 'B' pencil, felt pen and whiteboard or laminated white paper.
- 3. Reduce written tasks.
- 4. Provide alternative means of responding to convey knowledge and understanding, such as cut and paste or circle the correct answer, see page 8.

The Days of the Week				
	Monday			
	Tuesday			
Wednesday				
	Thursday			
	Friday			
	Saturday			
	Sunday			
4.	Cut and match	n.		
school day		school day		school day
school day		school day		weekend
weekend				

Sequential Skills

Areas of difficulty

- 1. Rote counting consistently without missing digits.
- 2. Remembering a great deal of number facts, operational steps and rules in the correct sequence when carrying out calculations and word problems.

Teaching Strategies

- 1. Practice rote counting daily.
- 2. Sing the numbers in order.
- 3. Provide a numeral and word number line.
- 4. Provide checklist of steps.

Task Checklist			
Tick the boxes Use a calculator Find the missing angle.			
A Add the two angles. Take the answer away from 180	B 35° C		
Write the answer.	ABC <u>105°</u>		

Short-term memory

Areas of difficulty

- 1. Processing and storing information, especially when processing speech alone.
- 2. Remembering things pupils have heard, auditory memory.
- 3. Learning new vocabulary, poor learning of colours is typical.
- 4. Remembering unfamiliar or abstract vocabulary.
- 5. Remembering sequences or lists, these are forgotten quickly if not rehearsed and used regularly.
- 6. Understanding information pupils have heard, auditory perception.
- 7. Following long instructions.
- 8. Learning number sequences, number bonds, multiplication tables.
- 9. Remembering word problems.
- 10. Forgetting task when concentration lapses.
- 11. Refocusing when distracted.
- 12. Remembering mathematical rules.

Teaching Strategies

1. For less able pupils limit mental arithmetic to number bonds of addition and subtraction of 1, 2 and 3.



2. Slowly introduce all new vocabulary and teach it together with the associated skills and/or concepts.

3. Provide number bonds calculating card.



- 4. Provide multiplication squares.
- 5. Teach the tables of 2s, 5s and 10s focusing upon using number stations such as 2, 4, 6,
- 8, 10 and 5, 10, 15, 20.

Visual spatial skills

Areas of difficulty

Pupils may encounter difficulty when differentiating between:

- 1. Numbers, for example: 6 and 9; 2 and 5; 17 and 71
- 2. Operation symbols such as: +x = < >

The directional aspect of mathematics may produce difficulty when:

- 1. Setting out vertical addition.
- 2. Using a number line.
- 3. Setting out Hundreds, Tens, Units and beyond.
- 4. Left-right regrouping and aligning of numbers, 3 + 4 = 7.
- 5. Writing digits in a straight line and in the correct order.

Teaching strategies

1. Provide number symbol and word cards as visual memory prompt.



- 2. Prepare pre-printed vertical and equation calculations and allow pupils to:
 - a. Write answers only.
 - b. Copy layout from pre-printed model.
- 3. Use pre-printed shadow written format calculations for pupils to overwrite.
- 4. Provide lined and squared paper.

5	7	4
+ 8	+ 6	+ 9

Consolidation and retention of facts

Areas of difficulty

- 1. Retention and retrieval of information.
- 2. Take longer to consolidate all new information, concepts and skills.

Teaching strategies

- 1. Teach all new skills in small careful steps.
- 2. Identify next steps that are minutely ahead of what has been achieved.
- 3. For some pupils limit mental arithmetic to number bonds of addition and subtraction of 1, 2 and 3.
- 4. Provide number bonds ready reckoner.
- 5. Provide multiplication squares.
- 6. Teach multiplication of and division by 2s, 5s and 10s using number stations.

Instead of teaching all addition facts within ten it may be beneficial to teach only addition and subtraction of 1, 2 and 3 from given numbers. The pupil may then achieve a degree of competence in mental numeracy. Practising rote counting in 1s, 2s and 3s forward and backward may develop this skill.

Complex Processes

Areas of difficulty

Complex processes such as long multiplication calculations as shown below require:

- 1. Concentration and good memory skills for times tables and holding on to data.
- 2. Sequencing skills necessary to complete each step in the correct order.
- 3. Visual spatial skills to be able to write each of the digits in the correct place with

reference to correct format and place value.

4. Recall and selection of the correct operation.

73 x 96 Steps involved	18. Remember to add carried 2 to 3 hundreds
1. Write sum	19. Correctly respond 5 hundreds
2. Identify 6x3	20. Write 5 in hundreds column
3. Correctly respond 18	21. Write 6 in thousands column
4. Write 8 in units column	22. Add units 0+8
5. Carry 1 ten	23. Correctly respond 8 units
6. Identify 6x7	24. Write 8 in units column
7. Correctly respond 42	25. Add tens 7+3
8. Remember to add carried 1 ten to 2 tens	26. Correctly respond 10 tens
9. Correctly respond 3 tens	27. Write 0 in tens column
10. Write 3 in tens column	28. Carry over 1 hundred
11. Write 4 in hundred column	29. Add hundreds 4+5 remember + 1 carried over
12. Identify 9x3	30. Correctly respond 10 hundreds
13. Correctly respond 27	31. Write 0 in hundreds column
14. Write 7 in tens column	32. Carry over 1 thousand
15. Carry over 2 hundreds	33. Add thousands 6 + 1 carried over
16. Identify 9×7	34. Correctly respond 7 thousands
17. Correctly respond 63	35. Write 7 in thousands column

Pupils who experience difficulty in one or more of these areas are likely to find the more complex mathematical operations difficult and de-motivating.

Teaching strategies

- 1. Provide a calculator for complex calculations.
- 2. Calculations involving division may need only whole number answers.

Concentration level

Areas of difficulty

- 1. Remaining on task during lengthy and complex operations.
- 2. Completing tasks if computation skills are slow.
- 3. Focusing on repetitive reinforcement tasks and activities.
- 4. Fluctuating attention span, which is significantly shorter when nonmotivated.
- 5. Maintaining self-motivation.

Teaching strategies

- 1. Match the task to the attention span of the pupil.
- 2. Provide short, focused and clearly defined tasks.
- 3. Provide a variety of tasks with varying degrees of demand.
- 4. Provide breaks between tasks.
- 5. Create an activity box containing practical mathematics activities and games the pupil enjoys, this is useful for occasions when the pupil needs a break.
- 6. Provide a calculator to maintain interest.

Mathematics curriculum

Counting practice

Counting practice should be flexible so that pupils are able to count objects in situations that they have not encountered before. For example, count objects laid out in unfamiliar patterns such as in a circle, or having to count the fourth item first and name it 'one'.

This requires 'hopping from item to item' in order to count them all. Successful completion of this task means that they are able to make use of all five of the counting principles.

Give plenty of practice in rote counting forwards and backwards in 'ones' and 'twos' using odd and even numbers. Activities designed to support this will enable pupils to gradually understand the principles of 'one and two more' and 'one and two less'. Give regular practice counting from numbers other than one and practise counting in 5s, 10s, 20s and 50s. Using similar activities will help to develop the number skills necessary for working with time and money. It will also help to provide a degree of success in mental arithmetic.

Teaching Strategies

- 1. Teach number words and rote counting together.
- 2. Use visual skills in rote counting.

- 3. Use number sequence patterns.
- 4. Develop routine for counting to practice this skill.
- 5. Teach vocabulary ahead of understanding. The pupil should watch and . listen.
- 6. Place items counted in a separate pile to keep track.
- 7. Explicitly teach one tag to one item.
- 8. Always point to each item once and only once.

Use group or class activities to reinforce such as:

- 1. Pupils rote count to a number and the next person must continue the count.
- 2. Number cards distributed to the class or group are counted in sequences of twos, fives or tens. The count moves from pupil to pupil as numbers are counted.

Addition and subtraction

When pupils can master counting numbers to ten they can group items together and begin to learn simple addition facts. Depending upon the level of attainment in counting skills some pupils will need to count all items in the groups. They will need objects to count. The use of counting aids will help to reinforce the concept of joining two or more groups together.



More able pupils may be able to count on from one of the quantities for example, 3 + 4, they will say and store 3 then count 4, 5, 6 and 7 to give the answer 7.

Formal written addition and subtraction

The transition from informal to formal addition and subtraction is very gradual. Pupils with Down's syndrome may have difficulty associating informal mathematics knowledge to formal school mathematics. Associations and connections are likely to be made slowly and sometimes mathematics may be seen as a set of unconnected facts. Making these connections takes time, a variety of experiences and carefully directed teaching. Worksheets with pictorial representations may be semi-abstract and symbolic. If introduced too early, they can confuse the tenuous associations being created between existing concepts, the strange and unfamiliar language of mathematics and formal written number problems.

The use of structured, concrete materials is important to securing these links not only in the early years, but also during concept development stages of higher-level mathematics. Concrete materials can be held, moved, grouped and separated. This allows pupils to visualise numerical concepts and makes them more real than pictorial representations. Using practical activities with written calculations will allow pupils to have hands-on experience of transferring concrete operations into formal written formats.



Place value

Learning about place value means pupils need to understand that numerals have different values in relationship to other numerals. They have to discriminate between some that are verbally confusing such as seventeen and seventy. Difficulties may arise in teen numbers for example seven spoken first but written in the units position.

Teaching strategies

Provide activities that visually reinforce the words and the numerals and give practice in listening, reading and matching number cards.

Provide activities that give pupils the opportunity to say and match numerals to their corresponding word cards.

Money

Some pupils may find it difficult to understand the value of coins. Confusion between coin value and coin quantity is common, such as two 1p coins have the same value as one 2p coin. It is important to use real situations using real coins not plastic coins.

Teaching strategies

1. Introduce activities that require the pupil to round up money amounts to the nearest pound. This will boost self-esteem by enabling the pupil to handle money confidently and independently by always giving sufficient money.





- 2. Reinforce counting in 2s, 5s, 10s and 20s up to 100.
- 3. Teach the recognition of coin groups for specific amounts.
- 4. Practice matching and categorising similar values made up of different coins.

5. Create meaningful opportunities and practical activities for shopping such as comparing prices of clothing, food, and other everyday items.

Time

It is important to teach the understanding of concepts, language and processes together. This includes telling the time on a clock and understanding the passage of time. Ability in this area varies widely. Some pupils will understand analogue and digital time and the 24-hour clock. Others may cope with one form of time. In such cases, allow the pupil to experience both analogue and digital time and identify their preference.

Some pupils may find digital time easier to understand as it is verbally consistent and requires less variation in language. It does not involve the use of ambiguous and confusing vocabulary such as to the hour, which may be confused with the number 'two'. Give plenty of opportunities to experience the concept of first, next and last.

			Da	ys of the W	'eek	
			Yesterday	Today	Tomorrow	
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			0		·	

Teaching strategies

- 1. Create real activities focusing upon familiar times of the day. This could include what happens before and after breakfast, coming to school, lunch and end of school day.
- 2. Use a calendar daily and practise: Yesterday, today, tomorrow. Months and seasons of the year. Day, month and year.
- 3. Introduce data handling activities that involve planning routes and itineraries using a variety of transport timetables.

Calculator skills

Introduce calculator skills as soon as the pupil begins simple addition facts. Match the tasks to the pupil's level of attainment. Some pupils may require a larger sized calculator. At secondary stage ensure that the calculator is adult in appearance. Tasks can be reduced to smaller units by checking answers after a selected set of calculations. The calculator will allow the pupil to work more quickly, remain motivated and undertake more complex tasks when calculation is the only difficulty.

Problem solving skills

A lack in critical thinking skills and/or the necessary language for thought can add to problemsolving difficulties. Time is needed to practise problem-solving skills and other mathematical 'thinking' activities. This should start at an early age and should focus upon the principle of trial and error where getting it wrong is acceptable and part of the learning process.

Problem Solving Cl	hecklist
Circle yes or	no
I read the problem.	yes 🔲 no 🗌
I understand the problem.	yes 🔲 no 🗌
I circled important numbers.	yes 🔲 no 🗌
I circled important words.	yes 🔲 no 🗌
I am going to add.	yes 🗌 no 🗌
I am going to take away.	yes 🔲 no 🗌
I wrote the sum.	yes 🔲 no 🗌
I checked my answer.	yes 📄 no 🗌
I need to correct my answer.	yes 📄 no 🗌

Pupils should be encouraged and supported to look for the key questions and recognise key words. This will help them to select the appropriate action. It is important that the pupil understands the need to check their answers and correct any errors.

Teaching strategies

- 1. Use simple and familiar language.
- 2. Provide operational key word lists such as add, altogether, how many more.
- 3. Underline or highlight the key words for mathematical operations
- 4. Provide problem solving checklists.

Generalisation and adaption

Before generalisation and adaptation take place the pupil must have a sound understanding of each mathematical concept or skill. They must have used it in a variety of situations and for a great many different purposes.

Although commercially produced counting materials are necessary for skills development and consolidation, they are intended solely for counting practice. This means that most classroom learning activities are contrived and artificial involving concepts and tasks which are abstract and out of context. Pupils with Down's syndrome need to see a purpose in what they are required to do and it is important that they are given real tasks in real life situations. Counting and giving out pencils or exercise books for the group will provide opportunities to consolidate all of the counting skills. The more relevant the task the more likely the pupil is to retain the skill.

Building self-esteem

The curriculum for many pupils with Down's syndrome will be very different from that of their peers. This can have an adverse effect on self-esteem and promote a poor self-image. Individuals may sometimes indicate a desire to undertake the same tasks. It is important therefore to look for opportunities that will allow them to do so. It may be the case that the task is of no academic benefit and the concept is beyond the pupil's understanding. However, the aim of the lesson in this situation is:

- 1. Being recognised as a real participating member of the class.
- 2. Developing self-awareness as part of the class.
- 3. Promoting positive self-image and self-esteem.

Planning the curriculum

It is essential to provide a mathematics curriculum that will prepare pupils to function independently after completing their education. For example, pupils with Down's syndrome need to acquire skills in money, time, measurement, and a basic knowledge and understanding of number in order to function effectively in daily living. Planning a differentiated mathematics curriculum programme for individual pupils requires designated planning time. It is dependant upon collaborative working between subject teachers, learning support assistants, the pupil and their parents and requires a sound knowledge of the individual pupil. Individual needs and support must be detailed and carefully planned and must consider:

- 1. Appropriate concepts and skills.
- 2. Preferred learning style and motivation.
- 3. Adaptations necessary.
- 4. Reinforcement activities.
- 5. Tasks variety and level of demand.
- 6. Methods of response.
- 7. Criteria for success.
- 8. Evaluation and assessment.

Forward planning of lessons is essential in order to prioritise and identify relevant, feasible, achievable content. Begin by identifying whether the work is P.A.R. for the course.



Purpose: identify the purpose of the lesson

- 1. Teaching new skills.
- 2. Developing self-esteem.
- 3. Taking part in same activity as the class.
- 4. Consolidation of skills.



Ability: should correspond with the pupil's

- 1.Cognitive development.
- 2. Language development.
- 3. Writing skills.
- 4. Previous knowledge and experience.



Relevant: should be relevant in terms of

- 1. Enhancing knowledge and understanding.
- 2. Developing skills for everyday living.
- 3.Continuity of skills development.
- 4. What the pupil;
 - a. Could already know.
 - b. Should know as a result of previously acquired skills.
 - c. Needs to know to enable independence.

Summary

Pupils with Down's syndrome develop and learn throughout life. They go through similar developmental stages as their typically developing peers but generally have significant difficulty. There may be times when a plateau appears to have been reached. In fact, this may be due to one or a combination of the following:

- 1. The pupil has been held at the same level for too long and has lost interest.
- 2. There is no variation in the presentation of teaching or tasks.
- 3. The work is beyond the pupil's capability at the time it is presented.

When teaching mathematics it is important to recognise that all areas need to be taught in the correct sequence. Success will rely upon competency and a sound understanding of all previous concepts and skills. For example the multiplication tables cannot be taught until addition has been mastered.

Important points

- 1. Teach new concepts in real situations and ensure understanding.
- 2. All skills must be practised and reinforced for longer using a variety of different materials. Learning should take place in carefully graded steps.
- 3. At every stage teach the understanding of the language of mathematics and the associated concepts together and make certain both are understood.
- 4. Support verbal instructions visually using written instructions, demonstration and examples of finished tasks.

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