The Widden mathematics strategy is a working document which is overseen by the mathematics learning lead but led by the classroom teaching staff and teaching assistants. The primary aim of this strategy is to provide our children with the necessary skills to access and solve an array of mathematical problems and to reason mathematically.

As a school we have identified problem solving and mathematical reasoning as an area of development and as such it is a central part of our school action plan. We have large numbers of children who excel in arithmetic but perform below the expected level in reasoning in the key stage 2 SATs. This is often the result of problem solving and reasoning questions.

Effective progress has been made in this area in recent years and this has been evidenced by our progress in attainment in mathematics and our meeting of the national progress in end of KS2 tests, despite the significant array of barriers our children face. In order to ensure that we equip our pupils to succeed and ultimately excel in this area we have devised and implemented a whole school reasoning strategy. This strategy focuses on the key areas and approaches we will employ when teaching problem solving and reasoning across the school.

Recognition of and definition of reasoning

The Oxford dictionary defines reasoning as:

'the action of thinking about something in a logical, sensible way'.

As such we feel that it is both appropriate and reasonable to develop a clear whole school strategy for solving reasoning problems, and devote allocated daily time for exploring and practising reasoning questions. In Key Stage 2 we have also implemented specific blocks of learning time throughout the academic year which will allow us to focus, in depth, on developing the pupils' reasoning skills.

Within each weekly or fortnightly unit, children work within a lesson structure which always includes both arithmetic and problem solving and at some point each week will also include reasoning.

Types of reasoning questions

Across the Key Stage 1 and Key Stage 2 curriculums our children will encounter a number of reasoning problems. These may include (but are not limited to):

Spot the mistake	Another and another	Undoing
Which is correct?	Possible answers	Unpicking
True or false?	Other possibilities	What else do you know?
What comes next?	What do you notice?	Convince me
Do, then explain	Missing numbers	Prove it
Make up an example	Missing symbols	Explain thinking
Write more statements	Connected calculations	Make an estimate
Create a question	Use the inverse	Always, sometimes, never
Can you find?	What's the same, what's different?	Odd one out
Ordering	Complete/ continue the pattern	Shape patterns

Our pupils will encounter a vast array of reasoning style questions across both of their reasoning exams and to a lesser degree in their arithmetic papers at 11. Furthermore, the use and relevance of mathematics for many of our pupils is low and largely pointless unless it can be embellished with real world scenarios and applications.

We actively encourage all of our class teachers and teaching assistants to provide a range of simple and complex reasoning problems to our pupils. These can be both logical and mathematical in nature.

Systematic teaching of problem solving at Widden

We will provide our pupils will logical frameworks which they can apply or adapt to help them solve mathematical problems. The primary focus here is on providing the children with the necessary questioning tools and capabilities to identify the relevant information.

We will employ two primary approaches which will be both core and compulsory for every Widden pupil to master as a part of our 'Widdenised' mathematics curriculum. The two approaches are very similar: the first, explores the solving of mathematical questions; the second, explores instructional questions.

Word problems	**QUESTION**	***Read it:*** read all of the words in the problem. ***What is the question?*** Look for the question mark or instruction. This is usually at the end.
	INFORMATION	***What are the functions?*** What is happening? Do the words or actions tell us which function or functions to use? ***What are the numbers?*** Can we find any numbers that may help us? ***Write an equation (number sentence):*** can we write this event or problem using only numbers?
	ANSWER	***Solve it:*** use what we know to try and solve the problem. ***Embellish it:*** now you have the answer can you present it in context.

The model presented is exemplified using the following SAT's style question:

*Mr Todd buys **7 drinks** at **48p** each and **8 drinks** at **52p** each.*

*What is the **total** cost of the 15 drinks?*

*You **must** show your working.*

First, encourage the children to read the problem and find the question:

*Mr Todd buys **7 drinks** at **48p** each and **8 drinks** at **52p** each.*

*What is the **total** cost of the 15 drinks?*

Once the question has been established we move to step 2: find and record all of the relevant information. Can we find the numbers?

Mr Todd buys **7 drinks** at **48p** each and **8 drinks** at **52p** each.

What is the **total** cost of the 15 drinks?

You **must** show your working.

Hopefully the children will also be able to identify the frequency of the action. 7 drinks at 48p means that Mr Todd bought a drink for the same price 7 *times*. Now they have the functions they will hopefully begin to record them in a number sentence. In this instance it would look something like the following:

7 x 48 = 336

8 x 52 = 416

The question itself asks for the '*total* cost'. The second step would be to add the two costs/ prices *together*. This leads us into step 3: solve it.

336 + 416 = 752

Finally, the children should look to embellish the answer. This demonstrates their ability to understand the real-life application of mathematics.

Mr Todd paid £7.52 for his drinks.

Although a significant amount of the questions included in the reasoning papers revolve around word problems we must also recognise that some problems do not provide us with words to indicate the action/ operation (+ - x ÷) challenges. Some problems, as cited earlier, lean more toward logic and may include number patterns or movement of shape for example.

Here the strategy we teach alters slightly. The first and last parts remain mainly unchanged (red and green) however the 'information' (yellow) part will alter significantly. Instead here it is blue.

Other reasoning problems	**QUESTION**	***Read it:*** read all of the words in the problem. ***What is the question:*** look for the question mark or instruction. This is usually at the end.
	INFORMATION	***What is the problem:*** what is happening. Do the words, pictures, shapes, diagrams give us any information of where to start? ***What are the clues:*** can we find any information that may help us? ***Write a number question:*** can we write this event or problem using only numbers?
	ANSWER	***Solve it:*** use what we know to try and solve the problem. ***Embellish it:*** now you have the answer ask yourself – do I need to embellish this answer?

The model presented is exemplified using the following exam style question:

Write the missing numbers to make this multiplication grid correct.

X		5
		35
12	24	

First, encourage the children to read the problem and find the *instruction*:

'*write the missing numbers* to make this multiplication grid correct'

Once the question has been established we move to step 2: explore the problem. What do we know? Are there any clues or points we can start from?

In this example, yes, we know that the missing square, circled in blue, is the product of ? x 5.

Establishing a clear start point in reasoning problems often provides children with more clues. Once children find a starting point they are quite often able to complete the problem.

Write the missing numbers to make this multiplication grid correct.

X		5
		35
12	24	

Step 3: solve the problem.

The children are now able to continue solving the problem as they are able to employ the strategy used to other blank boxes. This should allow them to solve the problem.

Please note: although they will provide effective support, the mathematical problem-solving models proposed here are templates and a single template could never help to solve all reasoning problems. Pupils should be aware of this, understand this and be encouraged to deviate away from the template when they feel that it does not apply effectively. This in itself demonstrates a high level of thinking and reasoning ability.

Systematic teaching of reasoning at Widden

In order to support the systematic teaching of reasoning at Widden we use the DAB model. The DAB model was developed by the National Centre for Excellent in the Teaching of Mathematics (NCETM) and is a simple structure which enables children to begin to reason mathematically with written questions.

The structure encourages children to agree or disagree before expanding on their ideas by explaining them. This then, where appropriate, supported by a mathematical example. There is a positive example of this being used in the piece of work below:

Embellished reasoning questions – each day, each class with work together to explore and deconstruct a mathematical problem. This process is facilitated by the class teacher who promotes, models and praises good use of logical, reason within argument and a range of mathematical language. This process ensures that all of our children are able to see, hear and participate in some form of mathematical reasoning on a regular basis.

Reasoning units of work –

In Key Stage 2 we have included units of work where we will focus on developing reasoning skills. These units will be used to explore the steps and strategies employed to problem solve in mathematics. It is essential that the teachers and teaching assistants work through questions with

children at various points through the lesson. This provides demonstration and facilitates supported learning in reasoning.

Reasoning problems presented should vary and be wide ranging however teachers may feel that is appropriate to the children's needs to focus on a particular style of reasoning problem at any given time. *This is at the discretion of the class teachers and their professional judgement.*

Reasoning questions should be appropriate to the children's ability and will usually be selected as the allow the children to expand on and deepen their application of already known mathematical knowledge. For example, if a class has been learning long division the teacher may provide the children will reasoning problems focusing on the sharing of money.

Increased opportunities to solve exam styled questions –

Past exam papers and SAT's style questions can be excellent extension tasks for children in class. When used as a holding activity it can allow other children to catch up while the rapid graspers can select problems from the exam papers in which they feel they could apply their mathematical skills to begin problem solving.

In January, March and June each year all Year 2 and all Key Stage 2 classes will complete age appropriate exams. These exams have been developed by the maths lead, with support from class teachers, and will focuses on the skills the children are expected to know at the end of their respective year groups.