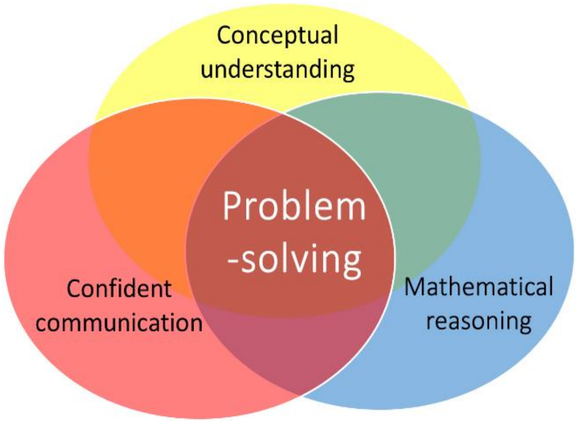
NATURE OF THE ACTIVITIES SUGGESTED HERE

With the surge of interest and sometimes confused interpretations of what is meant by ***Mastery*** in mathematics, a number of different claims have been made about what it means and what is required. The efficacy of different approaches to implementing a Mastery approach to learning mathematics in the primary school, as demonstrated by higher performing jurisdictions in the Far East, as measured by PISA* and TMSS* have been questioned and challenged.

However, there are some essential points which appear to be in common when examining different approaches.

Research in mathematics education, that curriculum developers and educationalists in the Far East have used, have been known for many years and including Bloom's* theories of *Mastery,* the development of *deeper conceptual understanding* through a progression in *Concrete-Pictorial-Abstract (CPA)* experiences, first discovered by Bruner*, the *realistic mathematics education* of Freudenthal*, and the seminal *Cockcroft Report*,* particularly, its emphasis on the importance of *practical experiences* and *problem-solving*. More recently, Lo's* research in the subject of *Variation Theory* has been prominent in exploring how to plan learning for understanding through small steps in conceptual and procedural variation when teaching.

All of these principles have informed the sample of activities presented here. Proponents of Mastery in mathematics (e.g. Drury*) also argue that teaching and learning must focus on enabling children to develop ***rich connections*** between different facets of their mathematical experience and learning. These aims are also highlighted in the 2014 National Curriculum Aims*. The diagram below shows how these facets are all inter-related, and how teaching to connect these is crucial to ***deeper mathematical learning.***



Hence, the activities suggested here are designed to promote the following:

- practical activity manipulating concrete resources where possible;
- working in pairs or groups to encourage the confident use of the language of mathematics through explanation and reasoning with other children;
- ensuring that formal written arithmetic develops from secure experiences with concrete, visual and mental understanding of the manipulation of number and the arithmetic operations;
- solving problems (or by playing games) with the potential for a useful or pleasing result;
- opportunities for finding more than one acceptable result, which children can compare and discuss through collaboration or (guided) peer-assessment.

NATURE OF THE ACTIVITIES SUGGESTED HERE

There is an expectation that discussion and exploration of misconceptions or errors is a healthy and productive feature of the classroom and that children are encouraged to explain their thinking and listen to others.

In some of the activities, it could be argued that a written sheet of exercises could be given to produce similar results. However, the use of concrete apparatus and visual images provides a medium for discussion and helps to establish a rich conceptual understanding, which is often insufficiently developed through an abstract engagement with written exercises alone. In other cases, children are using equipment to generate the problem to be solved, so can be more engaged in its solution.

Where it is suggested pairs or groups of children work together, the groups may of course be varied to suit the teacher's own judgement. For example, in a game intended for pairs, an odd number of children can be accommodated by a changing combination of 2 vs 1.

To make it more accessible when reading the description of the activities, children's names have been used to identify the sequence of interactions between learners working in pairs or groups.

For every activity, it is paramount that the teacher teaches by modelling the activity with the class, so that children see and imitate what they need to do. Simply providing a written instruction sheet or verbal series of instructions is insufficient for the children to understand and engage with most activities.

Each activity has suggestions for extending or simplification. The expectation is that each can be explored comprehensively within one classroom lesson of 45 minutes or more.

For more information about improving the capacity for teaching and learning mathematics in the primary school, visit www.MathematicsMastered.org

*References

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Lo, M. L. (2012) *Variation Theory and the Improvement of Teaching and Learning*, Gothenburg studies in educational sciences 323, Gothenburg University.

Programme for International Student Assessment (PISA), [Organisation for Economic Cooperation and Development (OECD)]

Trends in International Mathematics and Science Study (TIMSS), [International Association for the Evaluation of Educational Achievement (IEA)]

8. Mental Strategies for Addition and Subtraction **Add and subtract numbers mentally with increasingly large numbers.** **Use rounding to check answers to calculations and determine, in the context of a problem, levels of accuracy.** **Solve addition and subtraction multi-step problems in context.** The aim here is to get the children practise mental and informal strategies for addition and subtraction. In effect, the children will have to do several subtractions to solve the square, then check every total by additions of every row, column and diagonal.	**Magic squares** The children will need a magic square with some numbers missing. A magic square is one where the sums of the numbers in every row, column and diagonal are all the same. The easiest way to construct one is start with a very simple square, and then multiply the number in each cell by the same number; or add the same number to each square. For example, starting with a simple magic square, where each row, column and diagonal sum to 15: 2 | 7 | 6 9 | 5 | 1 4 | 3 | 8 But a more complicated magic square is produced by multiplying each number by 33: 66 | 231 | 198 297 | 165 | 33 132 | 99 | 264 Now the sum of each row, column and diagonal is 33 × 15 = 495. Provide the children with a square where some cells have been removed and tell them children that each row, column and diagonal adds up to 495. Tell them we need all the numbers to complete the missing cells. You can dress this as a story that the completed square provides the combination of numbers for the lock to a pirate's treasure chest, the vault of the Bank of England, or the staff room biscuit tin and you need their help to unlock it!	Do the children realise that they can calculate the value of any cell in a row, column or diagonal for which they already know two other cells? Do they recognise they need to add two numbers, then carry out a subtraction, to find a missing cell? Do children add and subtract values correctly? Do they check their calculations by adding up in other directions to confirm the total is the same for every row, column and diagonal?

It could also be used for practising expanded written or formal methods too, if desired.

66		198
	165	

Children compete in pairs and compare solutions. Encourage children to compare and check each other's mental and informal strategies.
The activity can be simplified by using a smaller multiplier, or including more numbers in the cells.
Extend the challenge by using a 4 × 4 square, for example:

11	14	2	7
4	5	9	16
13	12	8	1
6	3	15	10