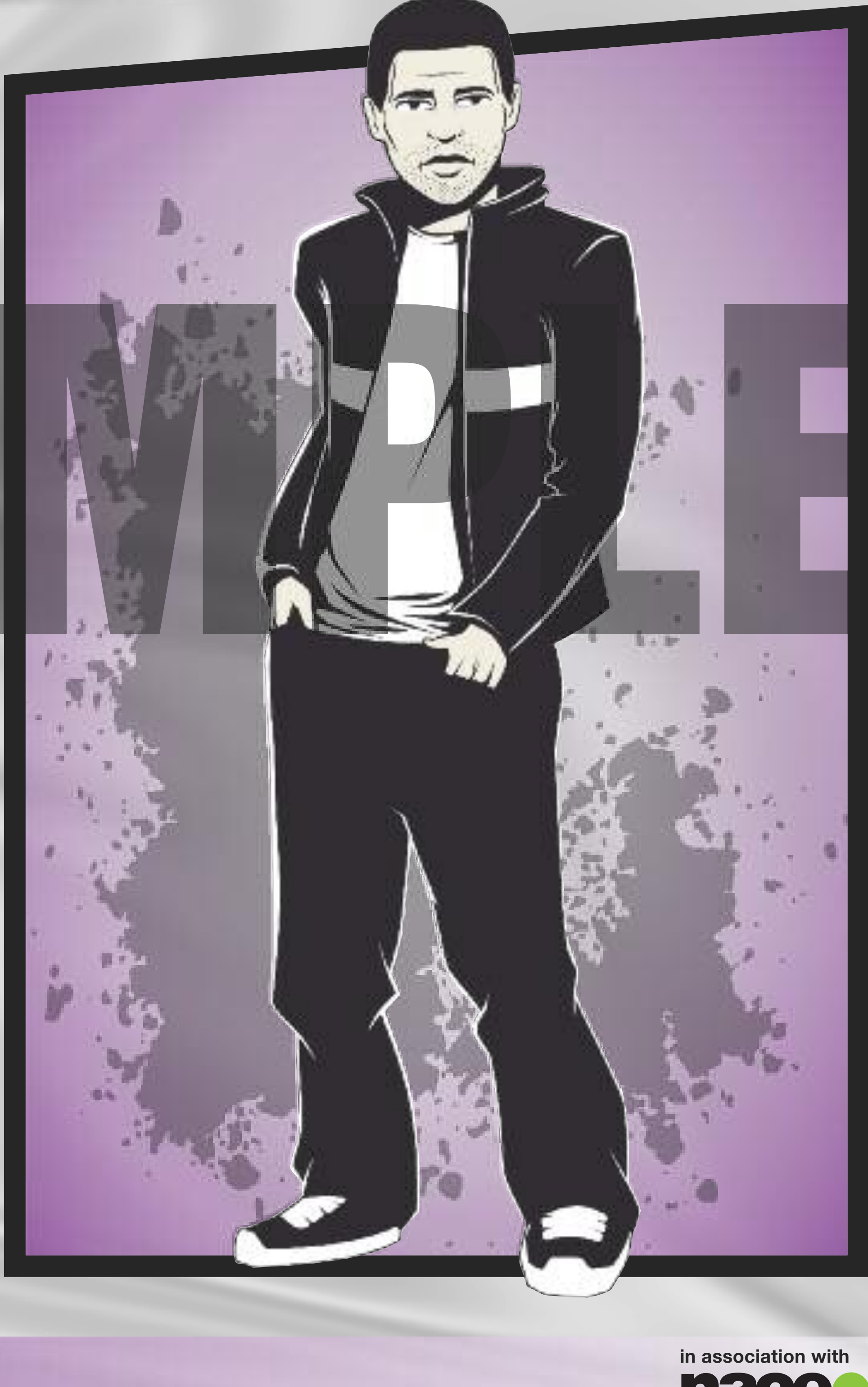
# THE DI PI MYSTERIES

## THE GOLDEN CROWN

WRITTEN BY JACKIE FAIRCHILD



DI PI IS UNRAVELLING ONE OF THE MOST UNUSUAL CASES OF HIS CAREER - THE INFAMOUS ARCHAEOLOGIST, DR JONES, IS CLAIMING THAT A GOLDEN CROWN AND SCEPTRE, BELIEVED TO BE THOSE OF AN INCA KING, STOLEN BY SPANISH CONQUERORS MANY CENTURIES AGO, IS HIDDEN IN RICHVILLE CASTLE. THE MAYOR IS INSISTING THAT PI TAKES ON THE CASE ...



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THE CASTLE HAS A LONG HALL IN WHICH, ACCORDING TO DR JONES, IS HIDDEN A SECRET DOOR LEADING TO A PASSAGE WHICH LEADS TO A SECRET COMPARTMENT. THIS WAS MADE TO HIDE A TREASURE CHEST CONTAINING THE GOLDEN CROWN AND SCEPTRE.

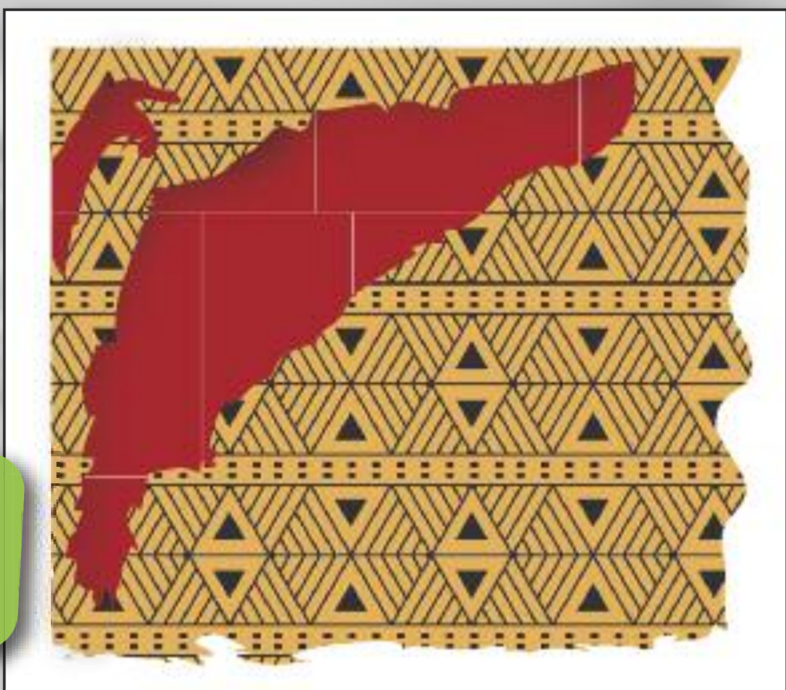
WHEN THE SECRET DOOR WAS BUILT, THE WALL WAS TILED BUT PLASTER WAS ADDED MUCH LATER ON, COVERING UP THE OLD TILES. THE PLASTER IS BEAUTIFULLY DECORATED AND IT IS IMPORTANT TO PRESERVE AS MUCH AS POSSIBLE OF THIS.

OVER THE YEARS, DAMPNESS HAS CAUSED SOME PLASTER TO COME OFF THE LEFT-HAND SIDE OF A WALL IN THE LONG HALL, REVEALING SOME OF THE OLD TILES UNDERNEATH. DI PI HAS SENT YOU A SCALE DRAWING (1 CM REPRESENTS 20 CM) TO SHOW THE TILES UNDER THE PLASTER DAMAGE. DI PI REASONS THAT THE SECRET DOOR WILL BE LOCATED WHERE THE TILES LINE UP VERTICALLY WITH ONE ANOTHER SO THAT THERE ARE NO SPLIT TILES TO GIVE AWAY ITS LOCATION. THE WALL IS 26 M LONG.

1 WHAT ARE THE POSSIBLE POSITIONS OF THE LEFT-HAND SIDE OF THE SECRET DOOR?

Think through the problem before deciding your strategy.

2 HOW WIDE MIGHT THE DOOR BE TO AVOID SPLIT TILES ON THE RIGHT-HAND SIDE?

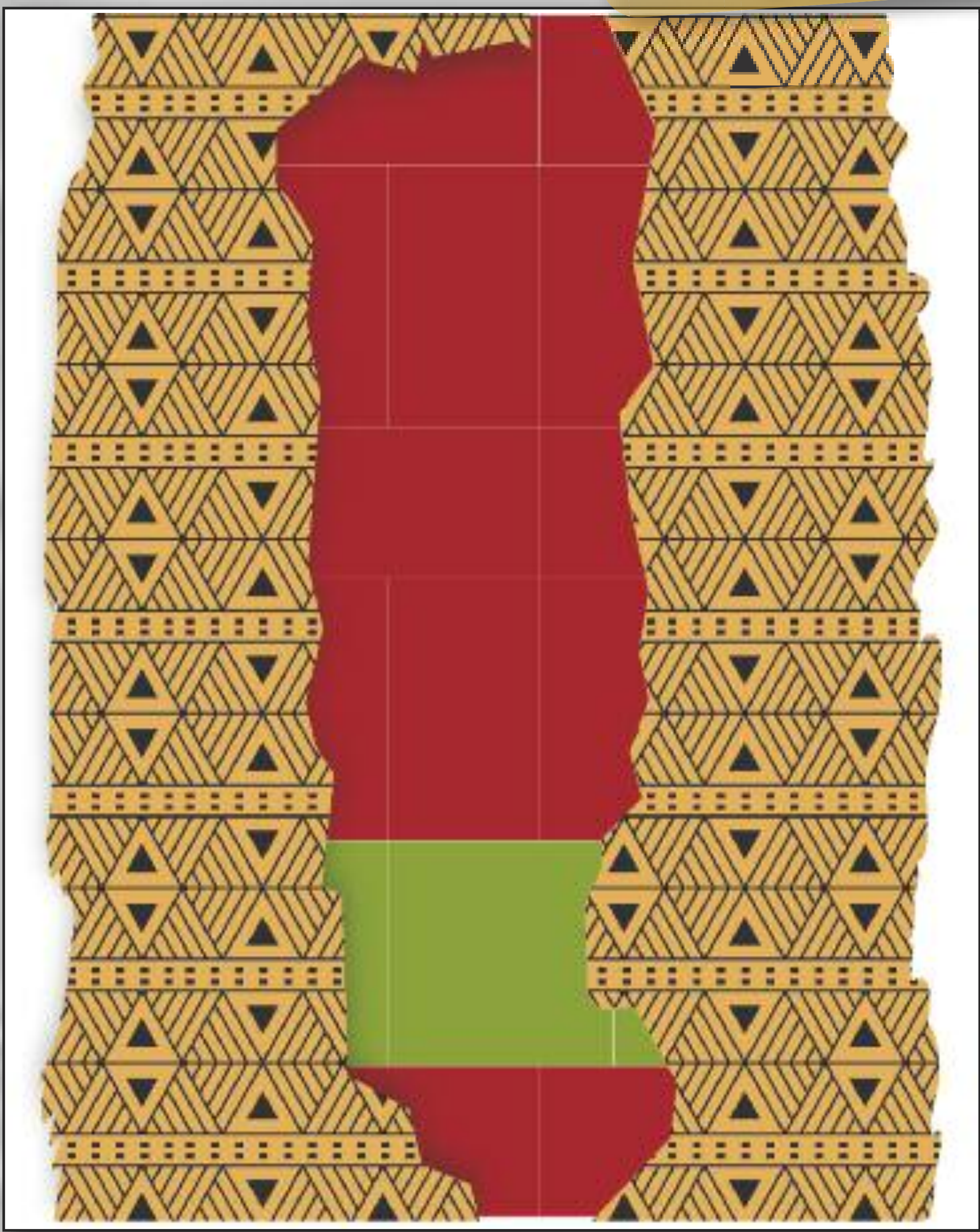


DI PI USES YOUR CALCULATIONS TO TRY TO LOCATE THE POSITION OF THE DOOR. HE TAKES OFF MORE OF THE PLASTER IN ONE OF THE POSSIBLE POSITIONS OF THE SECRET DOOR AND FINDS THAT THE REDDISH TILES LINE UP VERTICALLY AS EXPECTED BUT THEN HE SEES ANOTHER ROW OF TILES. THIS MAKES THE PROBLEM MORE COMPLICATED. DI PI TAKES AWAY JUST ENOUGH PLASTER TO SEE THE WIDTH OF ONE OF THESE TILES AND TO CHECK WHAT TILES HAVE BEEN USED FROM THE TOP TO THE BOTTOM OF THE WALL.

HE SENDS YOU A SECOND SCALE DRAWING, SHOWING THE FULL HEIGHT OF THE WALL.

**3** WORK OUT THE POSSIBLE POSITIONS OF THE LEFT-HAND SIDE OF THE SECRET DOOR.

**4** WHERE MUST THE SECRET DOOR BE POSITIONED SO THAT ON THE RIGHT-HAND SIDE OF THE DOOR THE TILES ARE NOT CUT DIFFERENTLY BECAUSE OF THE DOOR?



Support your answer with reasons using your workings.

**5** FIND THE WIDTH OF THE DOOR.

PI GOES THROUGH THE SECRET DOOR AND FINDS HIMSELF IN A PASSAGE ABOUT 5.5 M LONG AND BLOCKED OFF AT THE END. THERE MUST BE A COMPARTMENT SOMEWHERE WITHIN THE WALL OF THIS PASSAGE WHICH STORES THE TREASURE CHEST. AGAIN, PI REASONS THAT THE TILES WON'T HAVE BEEN SPLIT AROUND THE FRONT OF THE COMPARTMENT.

AN OLD PAINTING IN THE HALL SHOWS THE KING STANDING, WITH ONE ARM LEANING ON THE TREASURE CHEST. THE CHEST APPEARS TO BE A CUBE.

**6** WHAT ARE THE MOST LIKELY DIMENSIONS OF THE FRONT OF THE COMPARTMENT? EXPLAIN YOUR REASONING.

DI PI LOOKS FOR CLUES TO HELP HIM LOCATE THE COMPARTMENT. DAMAGE TO THE PLASTER REVEALS THAT THE TILE PATTERN IS THE SAME AS THAT USED IN THE HALL. THE PASSAGE FLOOR IS LEVEL WITH THE HALL FLOOR.

**7** WHERE MIGHT DI PI TAKE PLASTER OFF THE WALL TO TRY TO LOCATE THE COMPARTMENT?

**8** WHAT IS THE LARGEST POSSIBLE VOLUME OF THE TREASURE CHEST?

**9** SHOW HOW TO WORK OUT THE VOLUME OF THE INSIDE OF THE TREASURE CHEST BASED ON THE OVERALL VOLUME AND THE THICKNESS OF ITS SIDES.

DI PI FINDS THE CROWN BUT THE SCEPTRE IS NOT IN THE CHEST! DR JONES NEEDS TO KNOW ITS LENGTH SO HE CAN CONTINUE HIS RESEARCH.

**10** WHAT IS THE LONGEST LENGTH OF SCEPTRE WHICH COULD HAVE BEEN STORED IN THE TREASURE CHEST?

Were you able to solve this Mystery successfully?
Explain your methods and give reasons to support your conclusions.
Were there aspects of this investigation that were more difficult to solve? Why?
What have you learned that would help you to carry out this type of investigation again?
How else could you use these problem-solving skills?

Send us your feedback, or other Mystery ideas, to dipi@risingstars-uk.com

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# The Golden Crown

## Key Framework and Target Assessment links

### KS2 Mathematics Framework

**1 Using and applying mathematics**

Solve problems by breaking down complex calculations into simpler steps, choose and use operations and calculations strategies appropriate to the numbers and context, try alternative approaches to overcome difficulties, present, interpret and compare solutions.

Identify, collect, organise and analyse relevant information; decide how best to represent conclusions and what further questions to ask.

Explain and justify reasoning and conclusions, using notation, symbols and diagrams.

Use step-by-step deductions to solve problems involving shapes.

### KS3 Mathematics Framework

**1.1 Representing**
**1.2 Analysing – use mathematical reasoning**
**1.3 Analysing – use appropriate mathematical procedures**
**1.4 Interpreting and evaluating**
**1.5 Communicating and reflecting**

**2.2 Integers, powers and roots**
Use multiples, factors, common factors, highest common factors, lowest common multiples and primes.

**4.1 Geometrical reasoning**
Understand and apply Pythagoras' theorem when solving problems in 2-D and simple problems in 3-D.

**4.2 Transformations and coordinates**
Use and interpret maps and scale drawings in the context of mathematics and other subjects.

### APP Assessment guidelines

**AF1 Using and applying mathematics – levels 6 to 8**

**AF2 Numbers and the number system**
Recognise and use number patterns and relationships – **level 5**

**AF5 Shape, space and measure**
Calculate volumes of cuboids – **level 6**
Understand and apply Pythagoras' theorem when solving problems in 2-D – **level 7**

## Prior learning / SEAL and PLTS opportunities / Suggested approaches

The first part of this task uses common multiples but it is not essential that pupils have been exposed to lowest common multiple before. The final questions use Pythagoras' theorem and the volume of a cube; some previous knowledge of this would be appropriate. The Mystery is designed to develop aspects of learning including self-awareness, motivation and social skills. Before starting, encourage pupils to discuss and propose different ways of tackling the Mystery, and prompt them to select the most viable option and to reach their own supported conclusions. Encourage pupils to work collaboratively where appropriate, e.g. to talk through and explain the story together so that they can picture the storyline before embarking on the maths. There is scope for pupils to adopt a questioning approach and develop convincing arguments to support and challenge assumptions, to experiment with their own numeric values and to draw on their knowledge and understanding in order to generalise. Encourage pupils to explain their reasoning in the context of the problem, using diagrams where appropriate, and to monitor and improve their own performance by inviting and reflecting feedback from others.

Rising Stars would welcome your feedback on how using this resource has impacted on pupils' learning or your teaching. Please email any comments to dipi@risingstars-uk.com

## Guidance and answers

## Answers

Q1 Encourage pupils to discuss in groups and make sense of the situation, drawing out the fact that if the tiles are of different sizes then pupils need to use their lengths to work out when they will line up vertically. The scale drawing shows that the tiles are 40 cm by 70 cm. These tiles will align every 280 cm. Pupils might discover this by continuing a scale drawing or by reasoning about the lowest common multiple. The positions from the left would then be every 2.8 m, i.e. 2.8 m, 5.6 m, 8.4 m, 11.2 m, 14 m, 16.8 m, ...

Q2 In order to avoid splits in the tiles, the door would have to be 2.8 m wide. Encourage pupils to discuss if this is likely and what other possibilities there might be. In question 4, pupils discover that it is located at the end of the wall where the tiles are split in any case.

Q3 Measurement should show that the green tiles measure 60 cm by 60 cm. Pupils need to find the lowest common multiple of 40 cm, 70 cm and 60 cm, i.e. 840 cm. Some pupils might use their previous answer and reason that 60 cm is not a factor of 280 cm or 560 cm but is a factor of the next multiple of 280 cm, i.e. 840 cm. Another way is to consider the 40 cm and 60 cm widths together. They will line up every 120 cm if they begin aligned to the same left-hand edge. When combined with 70 cm, both 120 cm and 70 cm have a common factor of 10 cm and the lowest common multiple is therefore 12 × 70 cm = 840 cm.

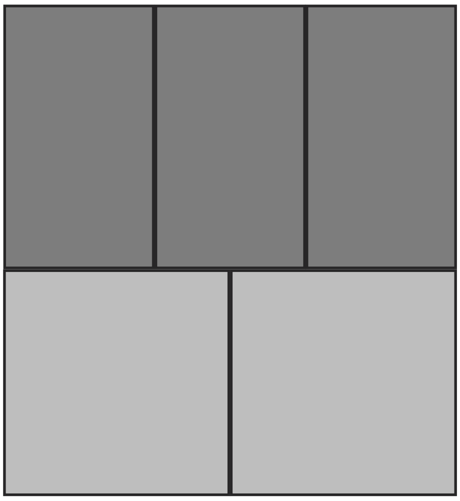
The left side of the door is therefore located 8.4 m, 16.8 m or 25.2 m from the left end of the wall.

Q4 Pupils might reason that in order to avoid extra cuts to insert the door, the width, taking account of the newly discovered square tile, would need to be 8.4 m. Some pupils may already have thought through the fact that the door must be located at the end of the wall. If not, encourage them to think through each possibility of where the door could be located and to discuss – a sketch might help. The door must be located at the far end of the wall, i.e. 8.4 m × 3 = 25.2 m from the left-hand end.

Q5 The door is therefore 26 m – 25.2 m = 0.8 m wide.

**Q6** Encourage pupils to make some approximation of the size of the treasure chest from the information given about the painting and then to reason through different possibilities using the tile widths. If the 40 cm and 70 cm tile widths both form part of the front then the width of the compartment will be 2.8 m which is much too big. The only smaller possibility is involving only the 40 cm and 60 cm widths and the 70 cm and 60 cm heights.

The compartment must be behind this set of tiles:



It measures 40 cm × 3 = 1.2 m in width and 70 cm + 60 cm = 1.3 m in height.

**Q7** Encourage pupils to discuss strategies for locating the compartment by taking as little plaster off as possible. The bottom of the compartment is 0.4 m above the ground. A small piece of plaster could be taken out of the wall at a height of 0.4 m at intervals of 1.2 m. If the passage is 5.5 m long, then the positions working down it on either side of the wall could be at 1 m, 2.2 m and 4.4 m. Three small patches of plaster could be taken out of either side of the passage at a height of 0.4 m to see if a knife could be slid between the tiles where the expected bottom edge of the compartment is. It is best to look for the bottom of the compartment as any inaccuracy in tile width will be compounded further up the wall.

**Q8** The largest possible cube length would be 1.2 m, although this would be extremely difficult to get out with only a gap at the top. The overall volume would be $(1.2\text{ m})^3 = 1.728\text{ m}^3$.

**Q9** When working out the volume of the inside of the treasure chest, pupils need to decide on the thickness of the wood used to make it. The inside cube length is then 1.2 m – 2 × thickness, e.g. if the thickness is 2 cm then the inside cube length is 1.16 m and the capacity of the chest is $(1.16\text{ m})^3 = 1.56\text{ m}^3$ (3 s.f.). Encourage pupils to explain their suggestion using a clearly labelled diagram.

**Q10** Pupils can answer this question at more than one level. Using Pythagoras' theorem on the dimensions of the inside of the chest, it might be assumed that the sceptre lies across the diagonal of one side of the cube. The maximum length is then $\sqrt{2}$ multiplied by the inner side length. If a pupil considers the sceptre to be placed diagonally across the cube then Pythagoras' theorem in three dimensions is needed. Diagonally across the base is the same length as diagonally across the side as all of the faces of the cube are the same, i.e. $\sqrt{2}$ multiplied by the inner side length. The diagonal of the base of the cube forms a right-angled triangle with a vertical edge of the cube and the sceptre. The maximum length of the sceptre is then $\sqrt{((\sqrt{2} \times \text{side})^2 + \text{side}^2)} = \sqrt{(3 \times \text{side}^2)} = \sqrt{3} \times \text{side}$. Pupils will work with the side length which they have assumed for the internal dimension of the cube. The generalised form is given here to make it easy to check pupils' work based on different cube side lengths.

You might encourage some pupils to move from their particular side length to a general side length. Some of these pupils may be able to write an exact answer, e.g. $\sqrt{3}\,s$, where $s$ is the inner side length of the cube, instead of writing the first few significant figures of $\sqrt{3}$ as a decimal.

The DI Pi Mysteries and Teacher's Guidance are published by:
Rising Stars UK Ltd, 22 Grafton Street, London W1S 4EX
www.risingstars-uk.com/dipi Freephone 0800 091 1602

Published in association with NACE
(National Association for Able Children in Education)

Published 2010

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*British Library Cataloguing in Publication Data*
A CIP record for this book is available from the British Library.

ISBN: 978-1-84680-722-0

Printed by Ashford Colour Press Ltd