SHAPE AND SPACE

1

A TEACHING AND LEARNING RESOURCE FOR USING MATHEMATICS

CONTENTS

Introduction

This resource enhances and consolidates pupil understanding of Shape and Space concepts. It uses practical activities, programmable devices and Logo software to promote using mathematical language and concepts related to position, movement and direction.

Position, movement and direction are all related to the Shape and Space area of the Mathematics and Numeracy curriculum and the Cross-Curricular Skill of Using Mathematics.

The learning opportunities in this resource encourage pupils to develop, describe and explain their understanding of the following curriculum concepts.

- There are specific words to use when describing position, movement and direction.

- Position is initially about where things are in relation to other things, for example 'beside', 'above', 'behind', 'in front of', 'in between' or 'next to'.

- Movement and direction are not the same; direction is about where to go and movement is about how fast or how far you go.

- When you use or give instructions about how to get from one place to another, you are using the concepts and vocabulary of position, movement and direction.

- Left and right direction depends on the position of the observer.

- It is possible to change position without changing direction and it is also possible to change direction without changing position.

- Turns are measured in angles.

- Routes can be created by using a combination of forwards and backwards steps, as well as left and right turns.

- The perimeter of every regular or irregular shape requires a full turn to complete it.

The activities in this resource address these concepts through a variety of contexts so that pupils can appreciate diversity in using and applying them. Some activities use programmable devices and software that allow you to address the Using ICT curriculum requirement for pupils to investigate, make predictions and solve problems by interacting with digital tools.

This resource also promotes using Logo beyond an assessment instrument and supports Using ICT Interactive Design integration more directly within the curriculum as a mathematical investigation platform.

The target area of learning is Mathematics and Numeracy, and the key Cross-Curricular Skill is Using Mathematics. However, Using ICT and Communication skills are also addressed throughout the activities.

This resource has a number of elements, including:

- practical activities designed to model the skills, thinking and concept development that pupils require to access the Logo environment in a meaningful way;

- modelling activities that introduce specific commands and skills that pupils need;

- Logo activities that integrate specifically with the requirements of the Shape and Space element within Using Mathematics at Key Stage 1 (these activities focus specifically on using and manipulating basic shapes, their properties and the relationships that exist between them); and

- challenges that offer the opportunity for pupils to apply and extend what they have assimilated.

What is Logo?

Logo is a programming language developed at the Massachusetts Institute of Technology. The word Logo is not an acronym but comes from the Greek word Λόγος (Logos), one of its meanings is 'to reason'.

The principle underlying its use is that it can provide the pupil with a tool to think with, providing an interface between their intention and reality. As the pupil attempts to manipulate the screen turtle, they receive immediate feedback on the consequence of their thinking in the turtle's movement.

An important element in the process of using Logo is that pupils physically take the role of the turtle and 'walk' the path they intend to draw. This enables them to reflect on the consequences of their actions.

Suggested Teaching Strategies

Practical Activities

A vital element in using and developing Logo within the curriculum is that pupils have sustained opportunities to work away from the computer, with transitional thinking objects that they are familiar with. The primary object is their own bodies as they walk around, turning and moving. It is very important that there is sufficient opportunity for them to move and 'play turtle' to mimic what they expect the outcomes to be from any command that they give to the screen turtle. Other objects may include plastic building cubes and shape templates.

Modelled Activities

This strategy may include whole class teaching sessions, with the teacher modelling different ideas and discussing the outcomes as a class group.

Paired and Small Group Activities

Discussion is an important element in the process and pupils should have the opportunity to consider and share their ideas and suggestions with each other. You may find **set 1** of our **Thinking Cards** a useful resource here.

Resource Activities

The activities in this resource are presented in a graded progression and make suggestions for supporting pupils' assimilation with practical activities. They are presented in three sections:

1. Pre-Logo activities;
2. Using Logo activities; and
3. Extending Logo activities.

Each section has supporting **Activity Cards**, which provide more detailed information for using the activities in the classroom. You may find it useful to give these Activity Cards to the pupils, where appropriate, or use them to structure your lessons.

Resource Overview and Curriculum Links

Key Cross-Curricular Skills	Using Mathematics and Using ICT
Key Stage 1 Processes in Mathematics	**Making and Monitoring Decisions** Pupils should be enabled to: • select the materials and mathematics appropriate for a task; • develop different approaches to problem-solving; and • begin to organise their own work and work systematically. **Communicating Mathematically** Pupils should be enabled to: • understand mathematical language and be able to use it to talk about their work; and • represent work in a clear and organised way, using symbols where appropriate. **Mathematical Reasoning** Pupils should be enabled to: • recognise simple patterns and relationships and make predictions; • ask and respond to open-ended questions; • explain their way of working; and • know ways to check their own work.
Shape and Space	**Exploration of Shape** Pupils should be enabled to: • sort 2-D and 3-D shapes in different ways; • make constructions, pictures and patterns using 2-D and 3-D shapes; • name and describe 2-D and 3-D shapes; recognise reflective symmetry; and • explore simple tessellation through practical activities. **Position, Movement and Direction** Pupils should be enabled to: • use prepositions to state position; • understand angle as a measure of turn; understand and give instructions for turning through right angles; • recognise right-angled corners in 2-D and 3-D shapes; • know the four points of the compass; and • use programmable devices to explore movement and direction.

Key Cross-Curricular Skills	Using Mathematics and Using ICT
Measures	Pupils should be enabled to: • use non-standard units to measure and recognise the need for standard units; and • recognise times on the analogue clock and digital displays.
Handling Data	**Collecting, Representing and Interpreting Data** Pupils should be enabled to: • collect data, record and present it using real objects, drawings, tables, mapping diagrams, simple graphs and ICT software.
Using ICT Desirable Features	**Interactive Design** Pupils should be enabled to: • explore a digital device or environment using simple commands; • enter commands to create movement or change; • input sequences of commands; • solve problems using a digital device or environment; • talk about how to improve their work; and • make modifications to improve their work.

Pre-Logo Activities

Pupils should have opportunities to engage in a range of practical activities using their own bodies as points of reference. They should also explore different types of movement (for example in the corridor, classroom, playground or gym) to reinforce the language and their physical understanding of forwards, backwards, left and right. Games to emphasise these concepts provide a foundation for the activities that follow.

This section includes examples of these games, which you may find useful to introduce at Foundation Stage. You may also find it useful to create more Shape and Space real-world activities, depending on your pupils' needs and previous experiences. It is essential that they have learned about movement before using Logo and that they understand the concepts of left and right.

Activity 1
Invisible Journeys

This activity allows pupils to explore the basic directions of left and right. It also offers the opportunity for them to visualise that direction and forward movement are independent. You should draw attention to the concept that they can change direction without having to move forward and vice versa.

Pupils should be working at: Level 2 (to 3)

Requirements for Using Mathematics:

- Collect and record relevant data for a given activity.

- Recognise right angles in the environment and understand angle as a measurement of turn.

- Use language and follow instructions, in practical situations, for turning movements.

Pupils, with their eyes closed, describe a journey from their classroom to another point in the school in terms of direction changes and forward movement.

They can use customised direction cards to record the sequence, for example:
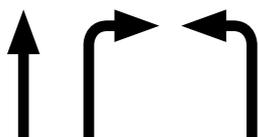
Ask pupils to plan the return journey and compare the results. Pupils will need to visualise where the new starting point is. The activity should involve pupils physically walking the journey and discussing the direction choices that they made.

Pupils might make a simple map to show their choices. The accompanying activity card suggests one form of recording; however, there are several efficient ways of recording. The example below is another. Pupils also have the opportunity to extend their knowledge and understanding of Handling Data by exploring ways to record the direction choices for their journey.

Their journey recording will provide tangible evidence that left and right are not fixed but depend on the way that they are facing.

Extension activity

In an extension of this activity, you might task the pupils with investigating the shortest or longest trip to the office etc.

Activity 2
Sheepdogs

This activity supports pupils in developing their understanding of left and right orientation. They are introduced to estimating distance using informal recording (steps). They are also introduced to visual challenge while giving instructions by asking the 'sheepdog' to adopt different positions in relation to the 'sheep'.

Pupils should be working at: Level 2

Requirements for Using Mathematics:

- Identify and use non-standard units to measure length, 'weight', capacity and area.

- Use language and follow instructions, in practical situations, for turning movements.

To introduce the activity, you might like to show a short video clip of a sheepdog managing sheep into a pen.

This is a paired activity. One pupil takes the role of the sheep and the other takes the role of the sheepdog. The 'sheepdog' gives instructions to the 'sheep' (**left**, **right** and **forward**) to negotiate a simple obstacle course in the hall to reach a pen that has been informally marked on the floor. The 'sheepdog' should be standing behind the 'sheep' so that their directions are orientated. The turns should be right angles only.

Introduce the concept of distance and ask them to estimate the number of steps they should take (for example **forward six steps**) to move within the course. The activity will benefit from you modelling the role of both sheep and sheepdog.

Extension activity

Change the relative positions of the 'sheepdog' and the 'sheep' from facing in the same direction to facing each other. This will allow pupils to explore how the instructions will need to be reversed and will enable them to explore their own sense of left and right and how this relates to others.

Activity 3
The Grand Old Duke of York

This activity introduces pupils to the concept that there are degrees of turns and that right or left turns can be combined to create larger turns. The final activity on the Activity Card allows pupils to consider the relationship between direction and analogue notation on the clock face.

Pupils should be working at: Level 2

Requirements for Using Mathematics:

· Read simple digital and analogue clock displays.

· Use language and follow instructions, in practical situations, for turning movements.

Using the nursery rhyme, prompt the class to explore how the Duke issued instructions to the men to get them up the hill and down again.

Pupils have the opportunity to explore how to instruct the men to reverse their direction using two right angle turns:

Either   or

This activity also enables pupils to explore how turning either left or right twice will leave them facing in the same direction. (Discussion and demonstration at this point can help pupils to recognise that combining multiple right or left right angle turns will affect both the direction they face and the direction of any subsequent movement they make.)

You might introduce the terms **clockwise** and **anticlockwise** here; however, you can also use 'to the right' or 'to the left'. Use a simple narrative on the **Jack and Jill** nursery rhyme to prompt discussion about the consequences if Jack turned right and Jill turned left at the top of the hill and whether they managed to face in the same direction to complete the return journey down the hill.

There is also the opportunity to illustrate the difference in turn sizes by using a clock face template. Draw their attention to the correlation between one right turn and the quarter past mark and two turns and the half past mark etc.

Activity 4
Revolutions

In this activity, pupils have the opportunity to investigate the angle properties of quadrilaterals and the concept of a full turn in constructing the shape. The activities use a number of transitional thinking tools (**Bee-Bots, plastic building cubes and their own bodies**) to help them to assimilate the concept that the sum of the turning angles in any quadrilateral forms a full rotation.

Pupils should be working at: Level 2–3

Requirements for Using Mathematics:

- Use language and follow instructions, in practical situations, for turning movements.

- Identify and use non-standard units to measure length, 'weight', capacity and area.

- Recognise right angles in the environment and understand angle as a measurement of turn.

For the initial activity, you will need a large square marked on the floor with a small cone at each of the two starting points, **A** and **B**:

A   **B**
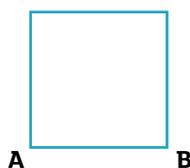
Invite pupils to walk around the shape, alternatively starting at each of the points **A** and **B**. Then, in pairs, ask them to direct each other to navigate the perimeter using the commands **forward** and **left** and **right**. Give pupils the opportunity to consider:

- the number of corners and their direction, for example left or right (at your discretion, you can introduce the terms **clockwise** and **anticlockwise**);

- the size of the corners: all corners are right-angled or quarter turns;

- how much of a rotation they made in total during the journey;

- whether it is possible to complete the activity using a combination of turns, for example some **left** and some **right**; and

- an informal measure system to help them estimate the distances.

The next activity allows pupils to program a Bee-Bot to navigate the perimeter of the shape. They should do this a number of times until they are confident with the distances and the sequence of turns and forward movements to guide the Bee-Bot.

Although not detailed in the activity card, time can be usefully spent here considering how to informally estimate the distances to program into the Bee-Bot to take it from one corner to the next. One strategy is to establish an informal baseline measurement where they had investigated how many Bee-Bot 'steps' were needed to cover a metre and apply this information to the dimensions of the floor square.

As they become familiar with the operation, pupils should record the sequence of the commands to guide the Bee-Bot, either on the interactive whiteboard (IWB) or on personal sheets. Ask pupils to delete the **forward** commands and then speculate on the effect of running the sequence using only the turns.

Invite pupils to input the new sequence of commands without the distances and observe the effect, mimicking the action of the Bee-Bot themselves and saying the commands as they put them into effect. Discussion at this point should direct them to observe that both they and the Bee-Bots have completed a full rotation as they completed the four turns.

Extension activity

1. In this activity, pupils use plastic building cubes to construct a tabletop square. The activity asks them to use 10 cubes for each side and highlights an anomaly between the number of cubes and the dimension of the sides. Using 40 cubes and attempting to construct a 10 × 10 square will result in four cubes left over, because the four corner cubes are counted twice as they form part of adjacent sides. Using 40 cubes will enable pupils to construct an 11 × 11 square. **(This can make a useful and interesting subsequent maths investigation.)**

   When pupils have constructed the square, ask them to remove each of the four corner cubes. They will now have four 'L' shaped sections and the challenge is to assemble the sections to build the largest turn that they can. This represents the full rotation:


2. For this activity, pupils will be in groups of five. Arrange four of the pupils to stand or sit at the cardinal points with the fifth pupil standing in the middle of the group. This activity is not included in the Activity Cards.

   The object of the activity is to issue instructions to rotate the pupil in the middle to face a particular member of the group standing on the cardinal points.

   Instructions can be varied and may introduce the terms **clockwise** and **anticlockwise**. The notation for the cardinal points can also be used if appropriate, as the activity can illustrate the relationship between the angles or bearing and the cardinal points, for example:

   • If Matthew turns two right angles to the right (clockwise), who will he face?

   • If he wishes to face Nicola, how many turns must he make and in what direction? Is there another way to do this?

   • If Rebecca wants to face the person directly behind her, does it matter if she turns to the left or right? (Explain your answer.)
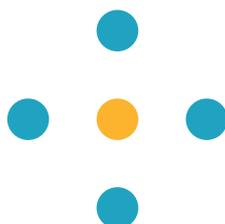
Using Logo Activities

In these activities, the progression builds on the accumulated understanding pupils have developed from the pre-Logo activities. Each of the activities can be trialled with both the Logo screen turtle and the Bee-Bot robot. At this point, pupils should be sufficiently prepared to enjoy exploring the Logo environment.

Initially, the only commands pupils will use are **forward** and **left** or **right**. Each command is followed by a numeric variable, for example **forward 50** means move the screen turtle 50 steps in the direction it is facing.

The angle command requires pupils to understand that the **right** or **left** command requires the variable **90**, to indicate that it is a right angle turn. Introducing the term 'right angle turn' is at your discretion; however, **90** must accompany the turn command to effect the turn.

As pupils become more comfortable with using the commands, a useful one to introduce is the **repeat** command. This allows them to apply their understanding of the properties of shape; for example, a square has four equal sides, so to draw a square we will have four iterations of the same command sequence. (If the turtle fails to leave a trail, then prefix their command list with the command **pd** for **pendown**. To clear the screen the command is **cs** for **clearscreen**.)
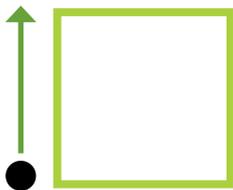
forward 50
right 90
forward 50
right 90
forward 50
right 90
forward 50
right 90   Becomes **repeat 4[forward 50 right 90]**

Other simple commands pupils might use will control the colour and thickness of the lines they have drawn.

The constructions for these activities will only be basic shapes, specifically squares and rectangles.

As pupils attempt each of the constructions, it is important that they are encouraged to move between the screen or Bee-Bot and physically walk an outline of the shape on the floor to check, confirm and explore how the spatial and directional relationships are integrated within their construction. This will help to reinforce their learning and understanding of position, movement and direction.

You may also wish to adapt these activities for different programmable devices and/or different PC, tablet or online software applications. Please note that if other software is used, the commands and/or procedures may be different. You may also wish to introduce activities by using an IWB to model some aspects of the activities.

Activity 5
Build a Square

see activity card 5

This activity is based around constructing a square and manipulating the shape. Each of the activities can be used with a Bee-Bot robot.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

· Recognise right angles in the environment and understand angle as a measurement of turn.

· Recognise tessellations through practical activities.

Ask pupils if they can construct a square or program the Bee-Bot to drive in a square path using only the **forward** and **right** commands. Repeat the activity using only the **forward** and **left** command. Ask pupils to comment on similarities and differences between the shapes.

forward 50	**forward 50**	
right 90	**left 90**	**repeat 4[forward 50 right 90]**
forward 50	**forward 50**	
right 90	**left 90**	**or**
forward 50	**forward 50**	
right 90	**left 90**	**repeat 4[forward 50 left 90]**
forward 50	**forward 50**	
right 90	**left 90**	

Challenge pupils to attempt to construct a square using four **forward** commands and a combination of **left** and **right** turns, for example two **lefts** and two **rights**. Ask them to imagine the shape and sketch what they think it will look like before coding the turtle or Bee-Bot to draw it. They will realise that it is impossible to construct a square in this way.

Using the **repeat** command, ask pupils to investigate and predict the effect of changing the order of the commands.

A: repeat 4[forward 50 right 90]

then

B: repeat 4[right 90 forward 50]

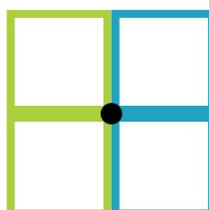When this is repeated using the **left** command, a four square combination is drawn.

A: repeat 4[forward 50 right 90]
B: repeat 4[right 90 forward 50]

then

A: repeat 4[forward 50 left 90]
B: repeat 4[left 90 forward 50]

Activity 6
Rectangles

In these activities, pupils have the opportunity to explore and construct rectangles to compare the similarities and differences between their properties and the properties of squares.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Recognise, name and describe common 2-D and 3-D shapes.
- Recognise right angles in the environment and understand angle as a measurement of turn.

The initial activity is a tabletop one that involves square and rectangle tiles. It encourages pupils to note and express their understanding of the differences and similarities between their respective properties (for example, a rectangle's adjacent sides are at right angles and opposite sides are equal in length).

Ask pupils to construct a rectangle by writing a sequence of commands. This requires them to analyse the visual characteristics of the rectangle and begin to understand the relationship between the sides.

This introduces the repeat command in Logo and, as this is an abstract concept, some pupils may require additional support.

The follow-up activity includes asking them to program a Bee-Bot to follow a rectangular path and working in pairs, asking the pupils to 'play turtle' and direct each other around a marked rectangle on the floor.

They can investigate using Logo to construct rectangles when they have assimilated the following concepts.

- The direction changes and angles for rectangles are similar to squares and follow the same left and right orientation.
- In a rectangle, only the pairs of opposite sides have a similar dimension.

The first activity involves coding a rectangle with one of the sides twice the length of the other. This will ensure that the shapes can be combined to create patterns.

Give pupils the **repeat** command for a rectangle and then ask them to manipulate this to create patterns.
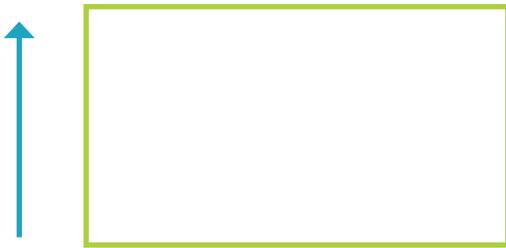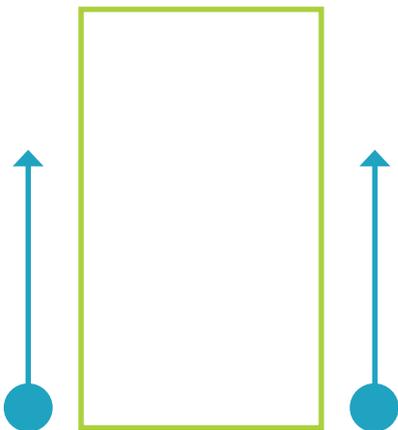
forward 50
right 90
forward 100
right 90
forward 50
right 90
forward 100
right 90

The repeat command for this sequence is:

repeat 2[forward 50 right 90 forward 100 right 90]

Then ask them to draw the rectangle from a different aspect.

Starting from either lower corner, the solutions are:

repeat 2[forward 100 right 90 forward 50 right 90]

repeat 2[forward 100 left 90 forward 50 left 90]
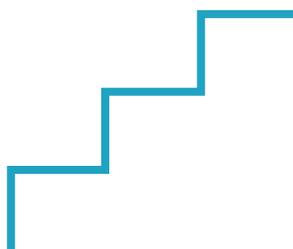
Activity 7
Build a Staircase

In these activities, pupils construct a staircase and investigate the concept of cumulative addition. The activities include number investigations on recognising and generating sequences. Pupils have the opportunity to investigate the sequences and identify patterns.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Collect and record relevant data for a given activity.
- Recognise right angles in the environment and understand angle as a measurement of turn.

The first activity introduces a sequence to draw a staircase and invites the pupils to continue with it.

forward 50
right 90
forward 50
left 90
forward 50
right 90
forward 50
left 90
forward 50
right 90
forward 50

The development of this activity prompts them to identify the repeating pattern in the sequence. Give pupils the opportunity to use the **repeat** command to construct stairs with multiple treads.

The repeating pattern is:

forward 50
right 90
forward 50
left 90

Using this they can now create code to construct multiple stairs.

This will construct a four tread staircase:
repeat 4[forward 50 right 90 forward 50 left 90]

The final section of the activity asks pupils to create a complementary descending staircase and then add a base.

Pupils then investigate how the ascending and descending patterns are similar and use the repeat command to construct both staircases.

| Ascending	The abbreviated code for building a four tread ascending and descending staircase is:	Descending
forward 50	repeat 4[forward 50 right 90 forward 50 left 90]	forward 50
right 90	right 90 (to realign the turtle for the descent)	right 90
forward 50	repeat 4[forward 50 right 90 forward 50 left 90]	forward 50
left 90		left 90
forward 50	The code to complete the base is:	forward 50
right 90	right 180	right 90
forward 50	forward 400	forward 50
left 90		left 90
forward 50	The final forward variable is the cumulative addition of the eight treads at 50 steps each.	forward 50
right 90		right 90
forward 50		forward 50
left 90	For simplicity, the top of the staircase has a double tread.	left 90
forward 50		forward 50
right 90		right 90
forward 50		forward 50

Extension activity

In this activity, pupils have the opportunity to investigate triangular and square numbers using plastic building cubes to construct staircases. However, as understanding of square numbers is a Level 5 requirement, these activities are discretionary. They can be scaled to an appropriate level of differentiation by using a trial and improvement strategy rather than requiring the pupils to recognise, calculate or understand the concept of square numbers.

Working systematically, pupils record the number of cubes needed to construct the levels in a single staircase and then predict how many numbers they will need to add subsequent levels and how their total changes.
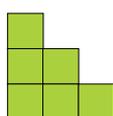
Triangular number sequence

Level	Total Cubes
1	1
2	3
3	6
4	?
5	?
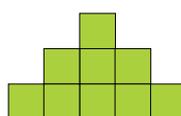
Square number sequence

Level	Total Cubes
1	1
2	4
3	9
4	?
5	?

You can extend the investigation by allowing pupils to check their calculations by constructing the shapes and by using prompt questions, such as:

• Could you build a single staircase with 20 cubes? Calculate and check.

• How many cubes are needed to build a five-level double staircase?

Activity 8
Amazing Mazes

These activities are based on investigating, constructing and navigating a series of trails and mazes. The activities allow pupils to explore combinations of right angle turns and estimate multiples of 20, 30, 40 and 50, as well as considering left and right orientation from different points of perception.

(Note: The familiar concept of a maze is that of a path navigated between obstacles, such as high walls or hedges, which prevent deviation from the path. In these activities, the concept simply identifies a path to be followed, allowing Logo to construct the paths and pupils to use physical resources, such as plastic building cubes.)

**Pupils should be working at: Level 2**

Requirements for Using Mathematics:

- Identify and use non-standard units to measure length, 'weight', capacity and area.

- Use language and follow instructions, in practical situations, for turning movements.

- Recognise patterns and relationships and make predictions.

In the first activity, pupils are encouraged to construct simple tabletop mazes using plastic building cubes. Some of these will be unstructured using randomly selected turns (all right angles) and distances. Others will be directed, for example:

Instruct pupils to create and colour code a specified number of these turns and connections and use them along with a directed number of straight sections to construct their own maze, using blue cubes to indicate the start and finish of the maze, such as:
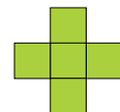
four × five cube lengths
six × four cube lengths
five × two cube lengths

Challenges could involve:

- asking a friend to complete the maze in the least number of turns;

- completing the maze without retracing any section; and

- completing the maze using a limited number of turns, for example only use four right turns.

Using the PE hall, pupils can construct their own maze using pairs of cones or bean bags to create a series of obstacles that need to be navigated **around** or a series of 'gates' that need to be navigated **through**. Working in pairs, they can then guide their partner around the course using the direction and movement commands that they are familiar with from Logo. Pupils can also attempt this activity in teams of three who are being navigated through the course.

This enables them to investigate using informal measures (steps), trial and improvement, estimation and calculation of formal lengths, for example if 1 m requires n STEPS then 2 m = $2n$ STEPS. **(Notation is not required at this level.)**

This investigation can be continued and developed using a Bee-Bot.

There are two types of activity for using Logo:

Activity A

In the first activity, pupils are encouraged to work in pairs or small groups to create a simple directed maze using a specified number of turns and distances. The distances are in multiples of 30 steps (*the multiples can be changed at your discretion*). When the maze is constructed, pupils have the opportunity to swap screens or save and recall the procedure for their friends to solve. Specify the pen thickness and colour of the initial maze track and make sure it is different to the pen thickness and colour of the trailing pen to facilitate tracking visibility.

Activity B

In the second activity, pupils have the opportunity to explore and investigate preloaded maze paths. Before beginning, pupils may change the size and colour of their turtle pen for effect. (One maze is already available in the BlackCat Logo background library.)

Maze 1

Activity A:

- Help the turtle to escape from the centre. All the distances are 50 steps. The escape points are the external vertices.

- You must use a turn and a movement in sequence.

- You have 4 **forward**, 1 **right** and 2 **left** commands.

- How many escape routes do you have?

Solution:
There is only one route available with these commands.

Activity B:

- Help the turtle to escape from the centre. All the distances are 50 steps and the escape points are the external vertices.

- You have 2 **left** and 4 **forward** commands.

- You must use **all** the commands

Solution:
There is only one route available with these commands.

Maze 2

With this maze, the challenge is:

- to travel from one end of the maze to the other without either retracing a path or crossing a path; and

- to use only seven turns in total.

There are two solutions depending on which starting position pupils choose. The correct maze path has been highlighted.

Maze 3

In this maze, the turtle has to track each line once only without crossing any tracks already made.
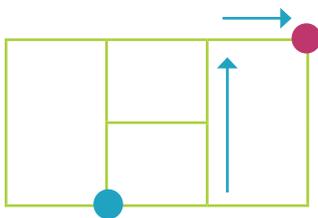
Each dimension is either 100 steps or 50 steps.

The solution is:

forward 50

left 90

forward 50

repeat 2[right 90 forward 100]

right 90

forward 50

right 90

repeat 4[forward 50 left 90]

right 180

forward 50

repeat 2[right 90 forward 100]

(Other solutions may start from other points.)

Maze 4

The narrative for this maze is that it is a pirate's treasure map. Peter the Pirate has found the map and knows that the treasure has been buried at one of the external vertices. He has a list of directions to help him find the treasure; however, one of his men has dropped the list and they are now out of sequence. The challenge is to sort the list to track a path to one of the corners.

All dimensions are either 50 or 100 steps.

There is only one solution.

The instruction list is:

right 90

right 90

left 90

forward 100

forward 50

forward 50

The blue dot indicates the start and the pink dot indicates the correct finish

The solution is:

right 90

forward 50

left 90

forward 100

right 90

forward 50

Activity 9
Build a House

This activity is based around constructing a square and an equilateral triangle (the equilateral triangle is the easiest triangle to construct). Pupils will be familiar with constructing each shape; therefore, the focus is on investigating and identifying the most efficient starting place for the turtle to draw a combination of the shapes.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Use appropriate mathematical language to discuss and describe their way of working and respond to questions.

- Recognise, describe and name common 2-D and 3-D shapes.

- Recognise right angles in the environment and understand angle as a measurement of turn.

Initially, pupils should have the opportunity to revisit Activity 5: Build a Square and recall the four combinations of turn and forward commands to help them investigate the most efficient starting point for their drawing combination. Discuss with the class to establish that the composite shape of the **house** they wish to draw is really two constituent shapes of a **square** and an **equilateral triangle**.

repeat 4[forward 60 right 90]

repeat 4[right 90 forward 60]

repeat 4[left 90 forward 60]

repeat 4[forward 60 left 90]

The shapes above indicate the basic 'house' shape and the coding commands of each of the squares drawn, starting from the yellow dot position.

Similarly, pupils should have the opportunity to recall previous activities and the commands to draw an equilateral triangle using either left or right turns.
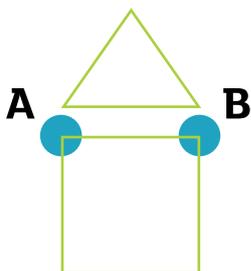
right 30

repeat 3[forward 60 right 120]

left 60

repeat 3[forward 60 left 120]

Activity 9 continued
Build a House

This should prompt them to identify the most efficient starting position for drawing the house as either **A** or **B** below.

Starting at A:

repeat 4[right 90 forward 60]

right 90

repeat 3[forward 60 left 120)
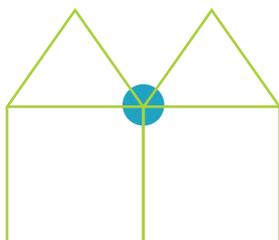
Starting at B:

repeat 4[left 90 forward 60]

left 90

repeat 3[forward 60 right 120]

Due to the direction alignment of the turtle when it finishes drawing the square, no adjustment of position is necessary to begin drawing the triangle.

Extension activity

When pupils are familiar with and confident in investigating different starting points for their drawings, suggest that they investigate constructing different combinations of the squares and triangles as below.

Terrace

The green spot identifies the most efficient starting point:

repeat 4[right 90 forward 60]
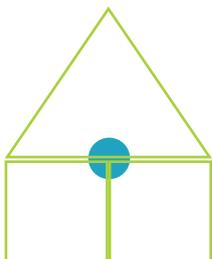
right 90

repeat 3[forward 60 left 120]

left 90 **(to reposition the turtle to draw the left side house)**

repeat 4[left 90 forward 60]

left 90

repeat 3[forward 60 right 120]

Semi

The green spot identifies the most efficient starting point:
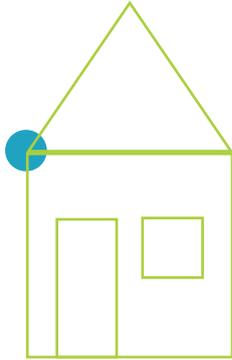
repeat 4[right 90 forward 70]

repeat 4[left 90 forward 70]

left 90

forward 70

right 120

repeat 3[forward 140 right 120]

With a door and/or windows

Below is a possible solution (pupils may attempt other solutions):

repeat 4[right 90 forward 100]

right 90

repeat 3[forward 100 left 120]

right 90

forward 100

left 90

forward 20

left 90

repeat 3[forward 60 right 90 forward 30 right 90]

(Using repeat 3 here draws the door and repositions the turtle to draw the window.)

left 90

penup

forward 10

pendown

repeat 4[forward 30 right 90]

Activity 10
Tessellations

In this activity, pupils apply the experience that they have gained from manipulating squares to produce a simple tessellating pattern. Initially, they are asked to create a pattern using tiles. They then transfer the pattern to the Logo screen using a simple combination of **repeat** commands and direction and movement commands to place the screen turtle appropriately.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Recognise tessellations through practical activities.
- Understand that multiplication is commutative.
- Identify and explain patterns and relationships and make predictions.

Initially, ask pupils to create a simple tessellating array using tiles. This can be completed as a tabletop activitiy. There is a condition in the activity that creates a simple investigation. Ask them to explore the different arrays that can be created with 12 tiles. Using 12 tiles will allow them to create the following arrays or patterns: 12 × 1, 6 × 2 or 3 × 4.

Then give the class two **repeat** commands or, if they are confident, they can devise their own command.

repeat 4[forward 60 right 90]

repeat 4[forward 60 left 90]

When they use both of the commands, they will see the following simple tessellation:
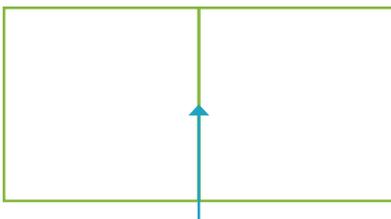
To complete the activity, ask pupils to use the **forward 60** command and the **left 90** and/or **right 90** command to position the screen turtle, before using the **repeat** command again to build the tessellation.

The final screen display will depend on their creativity and ability to manipulate the commands.

TIP: *You may find it useful to instruct pupils to take a screen shot of their Logo work which can be saved, printed, or copied and pasted into another document. This allows them to create evidence for evaluation or assessment purposes.*

Extending Logo Activities

In this section, pupils have the opportunity to investigate and apply the concepts that they have used previously.

The activities are themed around familiar nursery tales and extend the development of Logo from the previous section. The class management structure should again encourage pupils to use tangible objects like Bee-Bot to model the shapes and continue to 'play turtle' by walking around the shapes they are trying to construct.

Please note
These are extension activities and although concepts covered are appropriate for Key Stage 1, the thinking required may be more appropriate for early Key Stage 2 pupils.

These activities require sufficient time for pupils to explore and experiment with ideas and to discuss approaches to find ways to solve problems. You may not wish to do all activities, but choose those which are most appropriate for your pupils.

Activity 11
Hansel and Gretel

The narrative is that Hansel is **'left and right challenged'**. He cannot tell which is which. Gretel is aware of her brother's confusion and is constantly rescuing him from situations. This dynamic provides the stimulus for the activities. When asked to go **right**, Hansel will always go **left** and vice versa.

The activities focus on Hansel misinterpreting directions and finding himself in the wrong position and his sister Gretel trying to unravel his error and locate his actual position.

The preliminary activity includes work with a Bee-Bot and physical movement within the class or PE hall.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Recognise right angles in the environment and understand angle as a measurement of turn.

- Work systematically and check their work.

This is a confidence building activity for two pupils. One pupil has their eyes closed and the other pupil directs them around a series of obstacles in the PE hall using Logo commands. The pupils can take it in turns to play the part of Hansel, making the necessary adjustments to the commands they hear, such as if they are directing Hansel and they want him to turn RIGHT, they must say LEFT.

Using Bee-Bot or Roamer, ask pupils to plan a trip using a specified number of turns and a uniform forward command.
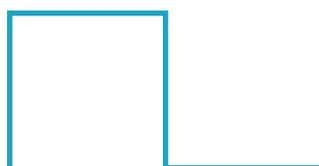
forward 30

right 90

forward 30

right 90

forward 30

left 90

forward 30

Remind the pupils that when Hansel plans this trip and guides the Bee-Bot, there will be a problem.

Ask them to plan the trip as Hansel might interpret it and visualise and predict where the Bee-Bot might stop, then investigate the extent of the error.

Ask pupils to program another Bee-Bot to reach and rescue him, interpreting the original instructions to identify where he might be. Instruct pupils to input a new series of commands in the second Bee-Bot to find the shortest path to Hansel's position and then return to the starting position with the 'rescued' Hansel. Pupils can use squared paper here to plan and investigate the positions.

As a possible challenge, you might suggest that on a separate occasion, Gretel has discovered that Hansel has taken two **right 90** turns, one **left 90** turn and four **forward 60** steps into the woods and he is now lost. Where might he be? How many possible positions could he be in?

There are several different possible positions for Hansel depending on the sequence that he chooses to apply the instructions. You could encourage pupils to explore these and record Hansel's different positions before creating the sequence of commands needed to mount a 'rescue' mission to find and recover him. This activity can equally be modelled using Bee-Bot.

To leave all the separate combinations and positions for Hansel on the screen as they create the sequences in Logo, pupils will need to return the turtle to the starting position for each successive sequence. To do this, they will need to add the following commands at the end of each sequence:

home: moves the turtle to the starting position

Or select the HOME icon from the side navigation bar for the same effect.

Suggest to pupils that they may like to select a different colour for the lines in each of the sequences.

Activity 12
Red Riding Hood

The narrative is that Red Riding Hood likes to go for a walk in the woods every day. Her path is a square one and her friend the woodcutter watches her to make sure that she is safe.

The conditions are that he must stay out of sight and that their paths must not cross.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Recognise right angles in the environment and understand angle as a measurement of turn.
- Explore ideas, make and test predictions and think creatively.

This activity involves coding concentric shapes.

Red Riding Hood's path

The woodcutter's path
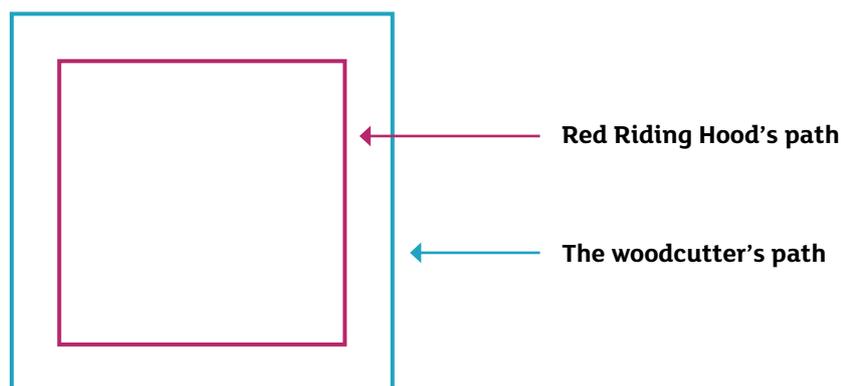
Initially, you can prepare this activity on the floor of the PE hall where the pupils work in pairs to model the narrative. Draw attention to the following points.

- Both shapes are similar and all angles and turns are identical.
- The lengths of the sides are not identical; the outer path has longer sides.

Encourage discussion using terms like longer, shorter and identical to help develop their observation.

Using pairs of Bee-Bots and in small groups, pupils can program them to reflect the narrative.

At this point, they should realise that the outside track would need to have longer sides. The issue to be resolved now is where to position both Bee-Bots.

Placing them adjacent will reveal an anomaly that will become evident at the end. The outside Bee-Bot will intersect with the track of the inside one. Pupils should understand that for the tracks to be concentric, the difference in length will have to be accommodated at both ends of the **forward** command; the outside line will have to extend beyond the inside line in both directions.

Tracks will overlap on the final side if both Bee-Bots are started side by side on parallel tracks.
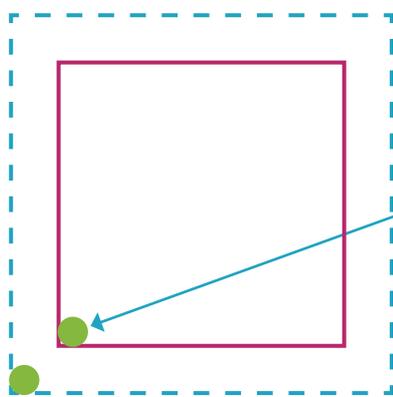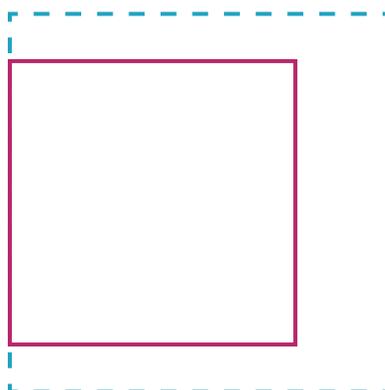
To avoid this, the starting positions need to be offset slightly. This will be evident from the Bee-Bot use and directed teacher observation.
For example, if the woodcutter is following Red Riding Hood, should he be beside her or behind her when he starts? Shall we try that?

After the turtle has drawn Red Riding Hood's path, it will need to be repositioned before drawing the woodcutter's path.

repeat 4[forward 50 right 90]

One solution is given below:

penup: deactivates the drawing function so that the turtle will move without leaving a trail

backward 20: moves the turtle to the woodcutter's path

left 90: aligns the turtle to match the direction of the woodcutter's path

forward 20: moves the turtle to the starting position for the woodcutter's path

right 90: sets the turtle on the starting direction for the woodcutter's path

pendown: enables the drawing function again so that a trail is drawn

Using the Bee-Bot investigation, pupils should have discovered that the woodcutter's trail will need to be longer than Red Riding Hood's trail. For this example, the assumed dimensions are 50 for Red Riding Hood's trail and 90 for the woodcutter's, 20 + 50 + 20, so the gap between the trails at any point is always 20 steps.

This activity can also be planned using squared paper to record the intended paths for both Red Riding Hood and the woodcutter.

Activity 13
The Three Little Pigs

The narrative is that the pigs have just bought six square living modules that they now have to assemble to create a new home for themselves. Pupils are tasked with designing the arrangement of the individual modules or spaces and then constructing a 'wolf-proof' fence to go around the outside to protect the pigs from the wolf.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Recognise tessellations through practical activities.
- Explore ideas, make and test predictions and think creatively.

The pigs are discussing how to distribute the spaces. Percy says that as he is the eldest he should have the most. Peppa says that as she is a girl she will need more than one and Peter says that he doesn't mind how many he has.

(Alternatively, the challenge can be set up more simply: Percy is the eldest and wants the most and Peppa says she needs more than Peter.)

Using identical squares, pupils can investigate how to create an array to satisfy the conditions. This discussion will be teacher led. Key questions should include who will have the most and who will have the least.

The condition is satisfied with **Percy having three, Peppa having two and Peter having one**.

Introduce a second condition or challenge and state that because of the danger from the wolf, each space must adjoin the other two (*to allow adjoining internal doors*) so that the pigs can escape to any part of the space if the wolf breaks in.

There are three possible arrays:
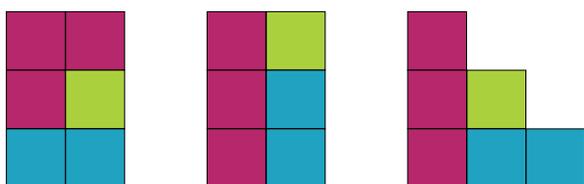
Using Logo and the **repeat** command, you could now task pupils with drawing the ground plan for their chosen design and a perimeter outside fence to keep the pigs safe from the wolf.

Their previous work on Activity 10: Tessellations and Activity 12: Red Riding Hood will help pupils to draw the squares needed for the ground plan and construct a larger square surrounding their ground plan as a safety fence.

Activity 14
Rapunzel

The narrative is that Rapunzel is trapped in her tower and pupils are tasked with rescuing her. The tower door is locked with a magic key and cannot be opened, so pupils will have to build an external staircase to reach her window and then she can use the steps to climb down safely. Fortunately, someone has left a wagon full of square boxes that they can use to build the staircase.

Pupils should be working at: Level 3

Requirements for Using Mathematics:

- Add and subtract mentally two 2-digit numbers within 100.

- Recognise, name and describe common 2-D and 3-D shapes.

- Identify and use non-standard units to measure length, 'weight', capacity and area.

The condition set is that Rapunzel can only negotiate one step at a time; no step can be more than one rung higher or lower than the previous one. Each box is 10 steps square and the tower is 50 steps high.

Allow pupils to use plastic building cubes to model the narrative. Teacher-led discussion directs them to devise a strategy rather than haphazardly building a staircase. You could ask pupils the following questions.

- If her tower is 50 steps high, what height must the highest stair reach so that Rapunzel can step out onto it safely?

- If the highest stair is 40 steps high, how will you reach it to place the final box?

- If you can only reach up one step or box at a time, what do you think will be the highest box you can place before you need something to stand on?

- Would it be better to build the horizontal platforms before building the vertical columns? Why do you think so?

When pupils have constructed a model using plastic building cubes, then instruct them to model the scene in Logo. The code for building the tower for Rapunzel is:
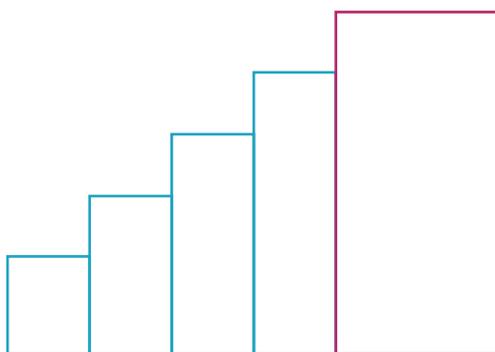
repeat 2[forward 50 right 90 forward 30 right 90]
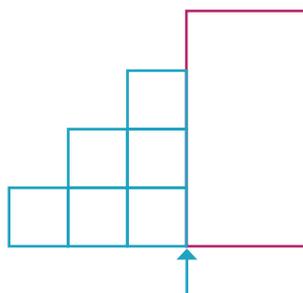
The turtle is now positioned on the bottom left corner. The staircase can be constructed on the left side using squares.

The coding for the staircase simply involves placing a series of squares together in layers to create a staircase effect. This activity is similar to Activity 10: Tessellations.

As an alternative investigation, the narrative can advise that, instead of square boxes, there are a number of rectangles of different sizes available and ask pupils to choose an effective method for assembling the staircase. The easier method visually is to construct a vertical rectangle first and then create a series of diminishing rectangles.

Through teacher-led questioning, directing the investigation will prompt pupils to consider the height of the first and subsequent rectangles.

One possible solution is listed below.

repeat 2[forward 100 right 90 forward 30 right 90] **constructs the tower**

left 90

forward 20

right 90

These commands are needed to position the turtle to draw the rectangle beside the tower. They are required after each rectangle is drawn to reposition the turtle.

repeat 2[forward 80 right 90 forward 20 right 90] **constructs the first rectangle**

repeat 2[forward 60 right 90 forward 20 right 90] **constructs the second rectangle**

repeat 2[forward 40 right 90 forward 20 right 90] **constructs the third rectangle**

repeat 2[forward 20 right 90 forward 20 right 90] **constructs the fourth rectangle**

(The size of the first **forward** command in the sequences to draw the rectangles reduces by 20 as the vertical heights of the rectangles diminish.)

Activity 15
Rumpelstiltskin

The narrative is that Rumpelstiltskin has set a puzzle that has to be solved. In this case, the puzzle is a geometric one. He introduces the puzzle in a rhyme.

> 'Squares have I.
> One, two, three, now four.
> Lay them on the table please.
> Now can you show me five?
>
> Can you draw a design to solve my riddle?'

**Pupils should be working at: Level 3**

Requirements for Using Mathematics:

* Recognise, name and describe common 2-D and 3-D shapes.

* Explore ideas, make and test predictions and think creatively.

The class can work in small groups. The resources for each group are four square shapes. The challenge is to arrange them in an array so that five squares can be seen in total.

This is a group activity and requires teacher-led discussion on the possible ways to arrange the squares and counting what can be seen. The class needs to be aware of the properties of the square, such as its sides and angles are the same.

There are two possible solutions:
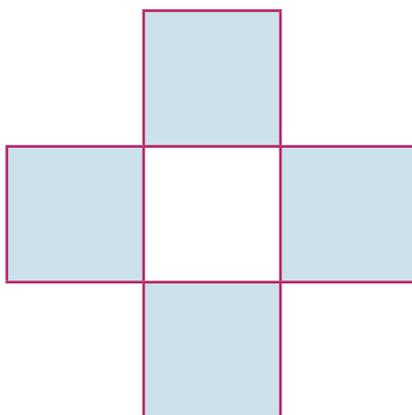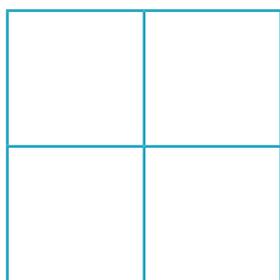
In both cases, the fifth square is created by aligning the other four.

The final activity tasks them with creating a Logo code to draw the design to satisfy the puzzle.

Activity Cards

(Pre-Logo) Activity Card 1
Invisible Journeys

You will need to find a partner to complete this activity.

- Together, decide on a trip that you would like to make from your classroom, for example to the office or to the canteen.

- Can one of you now close your eyes and imagine that you are walking along the route?

- Can you describe to your partner what you are doing using the words **left**, **right** and **forward**?

- Now, can your partner draw a map of your journey on a sheet of paper, using the signs to record what you are telling them?

- Your map may look a little like this:

Start   **Finish at canteen**

(This means that when you went out the door of the classroom you turned **left** then walked along a corridor before turning **right**. Walking along another corridor, you turned **right** again before walking along the final corridor to reach the canteen.)

- Finally, you could change roles and draw another version of the map and, when you have permission, perhaps you could test your maps by walking together quietly along the route.

- Were your maps accurate?

(Pre-Logo) Activity Card 2
Sheepdogs

You will need to find a partner to complete this activity and you will need to use the PE hall.

- Before you begin, you should watch a video clip of a sheepdog guiding sheep into a pen.

- First, decide who will be the **sheep** and who will be the **sheepdog**.

- Together with your partner, can you create a simple obstacle course on the floor of the hall with cones?

- Use one of the cones to mark the starting point and perhaps a large hoop to represent the sheep pen.

- Whoever is the **sheep** has to follow the instructions of the person who is the **sheepdog**.

- The **sheepdog** can give three instructions only. These are **left** or **right** and **forward**.

- When they give the **forward** instruction they must add a distance, for example **forward 6 steps**.

- Can you guide the **sheep** into the pen? Stand behind the **sheep** to give your instructions.

- You can changes roles when you have finished.

To make things a little more interesting, try the activity with the **sheepdog** facing the **sheep** instead of standing behind them. What differences did you notice?

(Pre-Logo) Activity Card 3
The Grand Old Duke of York

- Listen carefully to the rhyme and imagine what the soldiers did when they reached the top of the hill.

- Imagine that you are one of the soldiers; however, you are marching to the top of your class instead. What must you do when you get to the top, before you can march down again?

- Can you decide how far you must turn before you can retrace your steps on the way back?

- Investigate how many of the turn commands you will need. Will you need to use one turn command or two?

1   **2**

- Investigate what will happen if you decide to turn **left** instead of **right**.

- Turning to the right is called a **clockwise** turn. If the Grand Old Duke used a clock face instead to direct his soldiers, what time on the clock do you think they were facing when they got to the top of the hill? What time would he tell them to face to march them back again?

(Pre-Logo) Activity Card 4
Revolutions

- Mark a large square on the floor and then put a small cone at each of the two starting points, A and B.
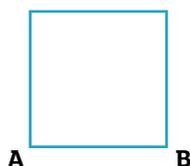
- Can you walk around the shape, starting first at point A then at point B, and discuss what you have noticed? What can you say about the turns you have made?

- Can you program the Bee-Bot to complete the same journey, making sure that it returns to the same position and direction it was facing at the start? Can you write down the Bee-Bot commands on a large sheet of paper? What have you discovered?

  – How are the commands for starting point A different or similar from starting point B?

  – What do you notice about the order or sequence of the commands you need to give the Bee-Bot?

  – What have you noticed about what the Bee-Bot did each time?

- For the next activity, remove the forward commands from the list and leave only the four turn commands. What do you think will happen now when you activiate the Bee-Bot?

  – Can one of you pretend to be the Bee-Bot and copy what the Bee-Bot is doing, calling out loudly what each command is before you do it?

  – What can you say about how far both you and the Bee-Bot have turned by the end of your journeys around the perimeter of the square?

- Use plastic building cubes to construct a tabletop square with each side 10 cubes long. Before you start, can you decide how many cubes you will need? (It is not as simple as it seems.) Count the cubes on each side carefully. Can you discover what has happened to the number you thought you needed?

- Now break off each of the four corner sections and try to join them together to make the biggest angle that you can. You will have four sections like these. What did you discover about the size of the turn needed to walk around the complete square shape?

(Using Logo) Activity Card 5
Build a Square

- In this activity, you are asked to investigate and build squares. You can use a Bee-Bot first if you have one and the Logo screen turtle.

- Find a square tile or a square shape marked on the floor to remind you what it looks like.

- Use only the commands **forward 50** then **right 90**. Can you draw a square? How many times do you think you will have to use the commands?

- Can you repeat the activity, only this time use the command **left 90** instead of **right 90**?

- What have you noticed? Can you write a sentence to describe what you see? Could you explain what has happened?

- The **repeat** command is a useful one. It will save you having to write out long lines of similar commands.

- Clear your screen by typing **cs**. Now type this command:

  repeat 4[forward 50 right 90]

  Can you see the square? Now type this command:

  repeat 4[right 90 forward 50]

  Before you type the commands, can you explain how they are different and predict what you think will happen and what will be drawn?

- This time, use the same **repeat** command and change the direction from **right** to **left**. Before you type the commands, can you predict what you think will happen? Could you draw a diagram to show what you think will happen and how your four shapes will be positioned?

- Finally, use the **cs** command to clear your screen. You have now learned a lot about squares and how to draw them using four direction and four movement commands. Instead of four **right** or four **left** commands, do you think it is possible to use two **right** and two **left** commands? Could you investigate this and give an explanation? You could draw out some of the shapes you think might be drawn.

(Using Logo) Activity Card 6
Rectangles

- Work with a partner and select some square and rectangle shaped tiles. Can you decide what the differences and similarities are between them? How could you explain the differences to someone who has never seen them before? Could you write three key facts to give someone the information they need to recognise which is which?

- Try to guide a Bee-Bot to drive around a rectangle shape marked on the floor, or 'play turtle' and guide your partner to walk around the shape.

- Using the **forward** and **right** commands, could you guide the Logo turtle to draw a rectangle? Which commands do you think will be the same as the square commands? How will the **forward** commands be different? Can you make one pair of the sides of your rectangle twice as long as the other pair of sides? **(Clear your screen by typing cs when you have finished.)**

- Using the **repeat** command, you can draw this rectangle easily:

repeat 2[forward 50 right 90 forward 100 right 90]
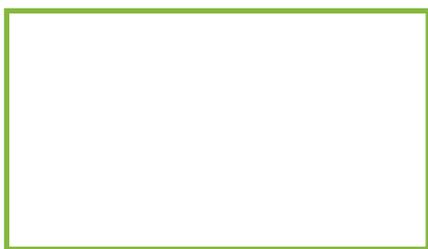
- Do you think you could change the Logo **repeat** command instruction to draw the rectangle in this way?

(Using Logo) Activity Card 7
Build a Staircase (Card 1)

- Can you use these commands to make the Logo turtle draw a shape?

forward 50

right 90

forward 50

left 90

forward 50

right 90

forward 50

left 90

forward 50

right 90

forward 50

Look carefully at the commands. Before you ask the turtle to draw them, could you draw on a separate sheet the shape that you think it will draw?

When it has drawn the shape, could you write the commands to add another three steps to the shape?

- Look carefully at the list of commands that you have now and at the drawing the turtle has made. Can you identify the pattern in the commands and where you think the pattern repeats?

  A repeating pattern is one that keeps repeating again and again. For example, in this letter sequence **XYZXYZXYZXYZ**, the letters **XYZ** keep repeating, so the repeating pattern is **XYZ**.

  Similarly, in this sequence **MN23MN23MN23MN23MN23**, the letters and numbers **MN23** are repeated, so **MN23** is the repeating pattern.

- You can use the **repeat** command and the repeating pattern you discovered to draw longer stairs without having to type in all the letters. For example, for a six-step stair you could type:

 **repeat 6[*your repeating pattern here*]**

- When you have completed your staircase, you will need to add a side and base to the staircase to prevent it from falling over. You will need to calculate the height and width of your stair. Think carefully about how many steps you have used and what the **total** of their heights and the **total** of their widths might be.
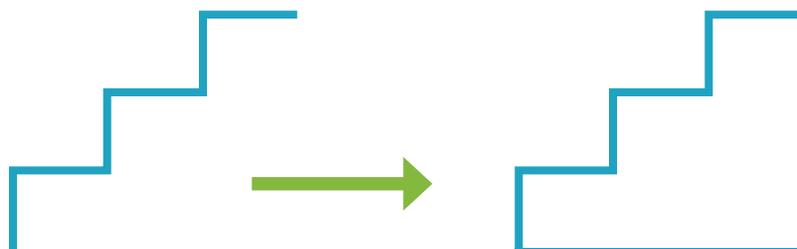
(Using Logo) Activity Card 7
Build a Staircase (Card 2)

- Now that you can draw a single ascending stair using the **repeat** command, could you program the turtle to draw the descending flight to complete your stair? Could you use the same **repeat** command? Would you need to change the direction that the turtle is facing when it is at the top of the stair before it begins to descend?

- Can you draw what you think it will look like before you start?
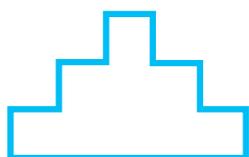
More stairs

A. Can you use some plastic building cubes to build a three-layer stair like this?
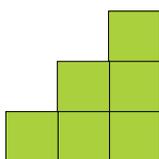
Draw a table and record the **total** number of cubes you needed to construct the stair as you added each layer.

How would the **totals** change as you add another two layers?

- Can you see a pattern in the sequence of totals? Could you calculate how many cubes you will need for a seven-layer stair? What is the tallest stair you could build with 37 cubes? Try to build one to see what happens.

B. Can you use your cubes to build a double, ascending and descending stair?
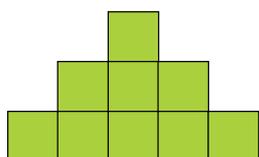
Draw another table and record the **total** number of cubes you needed to construct this stair as you added each layer.

How would the **totals** change as you add another two layers?

Use the cubes from any of the double stairs you have built and try to arrange them into another pattern. What do you discover?

- Can you discover the pattern in the **totals** as they change when each new layer is added? Can you calculate how many cubes are needed to create a six-level stair? What is the tallest stair you could build with 60 cubes? Can you build them to test your calculations?

(Using Logo) Activity Card 8
Amazing Mazes (Card 1)

- These activities give you the chance to have some fun investigating mazes.

- In a small group, can you sort 32 red plastic building cubes into two each of these types of corners and connectors?

- Now find:
  - 12 yellow cubes and arrange them into lengths of two;
  - 20 green cubes and arrange them into lengths of four; and
  - 24 black cubes and arrange them into lengths of six.

- You will also need two blue cubes, to mark the start and finish of the maze.

- Investigate how many of the pieces you can click together to make your own maze.

- You can now challenge your friends to complete your maze. You will have to make up some rules for using the maze. Make sure that you test your rules to check if the maze can be completed using them, for example:
  - complete the maze in the shortest distance;
  - complete the maze without retracing any section; or
  - complete the maze using the least number of turns.

- In the PE hall, create a maze using pairs of cones to create 'gates' that you must pass through. You can also use the cones as obstacles that you must move around, for example:

- Lay them out on the floor with a hoop to mark the start and finish. Ask a friend to close their eyes and try to guide them through the maze using only the commands **left**, **right** and **forward**.

- To make it really fun, ask three friends to stand in a line, each with their hand on the shoulder of the person in front to form a little 'snake'. The person at the front is the head and the person at the end is the tail. Now try to guide the 'snake' through the maze. They will need to listen to the instructions very carefully to wriggle through the maze. (**Hint:** If the head turns, will the tail have to turn **at the same time**?) They might even have to practice a few times.

- Now try to program your Bee-Bot to complete the maze. You will need to find a way to judge the distances between the gates and obstacles. You could measure one of the distances in steps or with a metre stick and test how many Bee-Bot steps are needed to cover that distance. Then use that information to estimate the other distances.

(Using Logo) Activity Card 8
Amazing Mazes (Card 2)

- You can import and use these mazes for the next activities. Import and use the maze template grids in Logo to help you to plan your journey through the maze.

- The first maze has two separate activities, A and B.

Maze 1
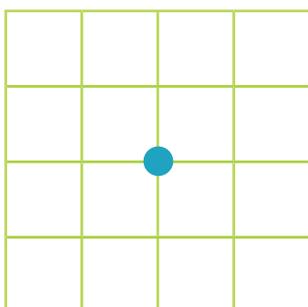
The turtle is in the middle and the distance between each intersection is 50 turtle steps.

Set your pen size to 1 and choose a different colour for your pen so that you can see your track.

Activity A:

- The turtle has to reach one of the four outside corners.

- You have 4 **forward 50** commands, 2 **left 90** commands and 1 **right 90** command. You must use **all** of them. Can you help the turtle to escape?

Activity B:

- The turtle has to reach one of the four outside vertices.

- You have 4 **forward 50** commands and 2 **left 90** commands. You must use **all** of them. Can you help the turtle to escape?
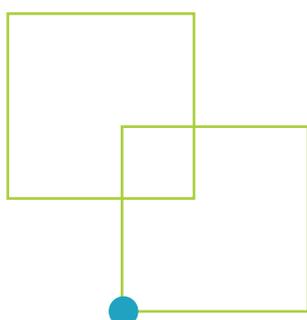
Maze 2
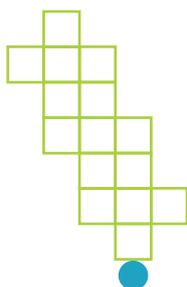
With this maze, the challenge is:

- to travel from one end of the maze to the other without either retracing a path or crossing a path; and

- to use only seven turns in total.

There are two solutions depending on which starting position you choose.

Maze 3

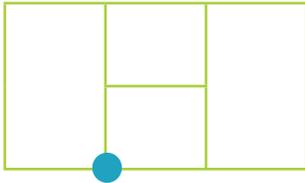In this maze, the turtle has to track each line once only without crossing any tracks already made.

Each dimension is either 100 or 50 steps.

(Using Logo) Activity Card 8
Amazing Mazes (Card 3)

- In this activity, you will have the opportunity to assist Peter the Pirate and his men reassemble a treasure map that they have discovered.

Maze 4

Peter the Pirate has found this treasure map and knows that the treasure has been buried at one of the external vertices or corners.

He has a list of directions to help him find the treasure; however, one of his men has dropped the list and they are now out of sequence.

The challenge is to sort the list to track a path to one of the corners.

All dimensions are either 50 or 100 steps.

Can you help him to find his treasure?

The instruction list is:

right 90

right 90

left 90

forward 100

forward 50

forward 50

(Using Logo) Activity Card 9
Build a House (Card 1)

- Choose two shape tiles that you think could be combined to make a simple house shape.

Can you remember the names of the shapes you will need? What facts do you remember about them?

Do you remember the commands to draw these shapes?

repeat 4[forward 50 left 90] will draw a square

repeat 3[forward 50 left 120] will draw a triangle

Unfortunately, the builder has assembled the roof inside the house.

- Can you find two ways to solve the problem and draw the triangle on top of the square?

1. First possible method:

   - You will need to think carefully about where the turtle is and the direction it is facing **after** it draws the square, and where it should be and the direction it needs to be facing **before** it draws the triangle.

   - Draw your shapes on the floor and walk around them to help you decide how to move the turtle from the end of the square to the beginning of the triangle.
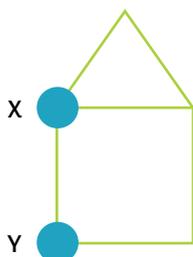
X is the start for the triangle and Y is the start for the square.

repeat 4[forward 50 right 90] will draw the square

forward 50
right 90 } these two commands will reposition the turtle

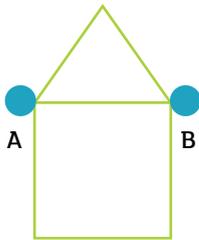**repeat 3[forward 50 left 120]** will draw the triangle

2. Second possible method:

   - Look carefully at the house and try to imagine if the start and finish positions for the **square** would be the same as the **start** and **finish** positions for the **triangle**. There are two possibilities.

   - Do you remember in the Build a Square activity you discovered that you could change where the turtle drew the square and triangle by changing the direction and the order of the turns?

   - Can you think carefully about what you learned then and perhaps practice it again? This will help you to decide where the best starting place is for you to draw the house shape.

The best place is the one where you need the least amount of repositioning commands to move the turtle after you have drawn your first shape.

(Using Logo) Activity Card 9
Build a House (Card 2)

- If you begin drawing at either of these two points then you will have the least commands to use.
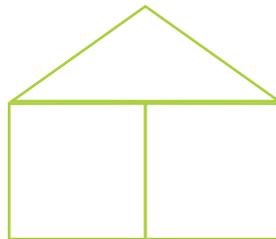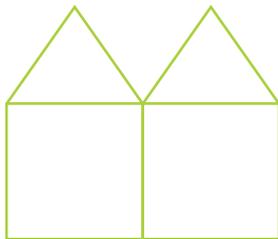
Starting at point A, these are the commands to draw your house:

repeat 4[right 90 forward 60]

right 90

repeat 3[forward 60 left 120]

Can you find commands now that will draw the house if you started at point B?

- Could you investigate how to draw two houses side by side with either one roof or two roofs?

- You will need to think carefully about where to start the turtle drawing and what direction it is facing after each command.

- Do you think that you could draw a house and add a door and a window? You will have to use the **penup** and **pendown** commands to move the turtle without leaving a trail.

(Using Logo) Activity Card 10
Tessellations

- The word **tessellation** comes from the Latin word 'tessa' and means a 'tile'. The Romans enjoyed creating lovely patterns using square tiles.

- Work with a partner and use 12 tiles. Arrange them into a simple tessellation that has four neat sides. How many different ways can you find to arrange the 12 tiles?

- Could you use the commands you remember in Logo to create a tessellation?

  These first two **repeat** commands will draw right and left squares for you:

  repeat 4[forward 60 right 90]

  repeat 4[forward 60 left 90]

  These commands will move and change the direction of the turtle for you:

  forward 60

  right 90

  left 90

- Now you can use your imagination to create a tessellation.

- When you have finished, you might like to print a copy and then perhaps colour it in lightly.

(Extending Logo) Activity Card 11
Hansel and Gretel

- Gretel has to look after her little brother Hansel because he has difficulty remembering which direction is left and which is right. He always gets them confused.

- One day, he sets off in his Bee-Bot and gets lost. Fortunately, Gretel has found his list of commands and knows where he might be.

- Can you read the commands, decide what Hansel has typed in and then help Gretel write the commands to find him?

forward 30

right 90

forward 30

right 90

forward 30

left 90

forward 30

- This time, Hansel is really lost because Gretel does not know in what order Hansel has used the commands. She only knows that he has used:

  2 **right 90** turns

  1 **left 90** turn

  4 **forward 60** commands

  Use a sheet of squared paper and investigate all the possible positions where Hansel might be. You will have to try all the combinations of the different orders in which he may have used the commands.

- Can you draw all Hansel's possible locations using Logo?

- At the end of each command to return the turtle to the start without leaving a line, using the **home** command.

- Can you help Gretel to write the commands to reach and rescue Hansel from every position where he might be?

(Extending Logo) Activity Card 12
Red Riding Hood

- Every day, Red Riding Hood goes for a walk in the woods after her breakfast. She always walks the same path. It is a square path.

- Her father's best friend, the woodcutter, follows her each day to make sure that she is safe. He keeps hidden and she never sees him.

- In the PE hall, could you and a partner mime the walk that each of them takes? Can you describe the differences in their paths? Where might the woodcutter stand to avoid being seen?

- Could you program two Bee-Bots to follow each of their paths? Remember, their paths must not cross at any time or the woodcutter will be spotted.

- Make two squares from plastic building cubes, one to represent Red Riding Hood's path and one for the woodcutter's path. Then arrange them on your desk to show how the paths looked from above. How will the squares be different?

- Can you use Logo to draw their paths?

- If you used this command to draw Red Riding Hood's path, how could you make the command different for the woodcutter's path?

  repeat 4[forward 50 right 90]

- Draw the woodcutter's path then use **cs** (**clearscreen**) to clear the screen. Can you use Logo to draw both of their paths, as they will look from above?

Hint: You will need to use some extra commands to move the turtle to the start of the woodcutter's path after it has finished drawing Red Riding Hood's path.

(Extending Logo) Activity Card 13
The Three Little Pigs

- Peppa, Percy and Peter, the Three Little Pigs, have just bought six new living spaces. They are square and can be connected to make a house for them to live in together.

- Percy is the eldest and says that he should have more than either of the others. Peppa says that she has a lot of clothes and will need more than one. Peter says that he doesn't mind how many he has.

- Can you use six plastic building cubes to solve the problem of how many each of them will have? When you have finished, use red cubes for Percy's spaces, blue cubes for Peppa's spaces and yellow cubes for Peter's spaces.

- Peppa then suggests that it will be safer if her spaces are joined to Peter's **and** Percy's in case the wolf attacks. Then she will have two escape routes. They agree that each of them should be able to escape into each other's spaces.

- Here is one possible arrangement:

There are two other ways for them to arrange the spaces so that each of them has two escape routes. Can you use plastic building cubes to build them?

- Could you use LOGO to draw the three possible arrangements or plans for the spaces?

- You can use the **repeat** command to draw a square:

repeat 4[forward 60 right 90]

- Think carefully about where to draw the first square to make sure that you do not have to move the turtle too much between each square. (**Hint: Look at the Build a Square activity again.**)
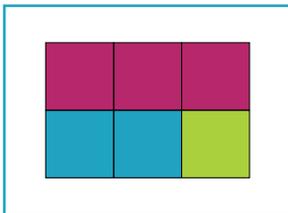
The pigs decide that they would be even safer if they had a fence built around their new home to protect them from the wolf.

Could you use Logo to help them to draw a '**wolf-proof**' fence around each of their plans?

You will need to use the commands **penup** and **pendown** to make sure the turtle does not leave a track.

(Extending Logo) Activity Card 14
Rapunzel

- An evil witch has locked Rapunzel in her tower. The tower door is locked with a magic key and cannot be opened, so you will have to build a staircase on the outside of the tower to rescue her. Fortunately, there is a wagon nearby filled with square and rectangular boxes that you can use.

- Can you use plastic building cubes first to plan what you are going to build to help her? The tower is five cubes high and each of the square boxes is one cube long. The rectangles are different lengths. Some are one cube, some two, some three and some four cubes long. You can choose either the squares or the rectangles.

- For safety reasons, each step must not be more than one cube higher or lower than the step beside it.

- When you have solved the problem, can you draw a model of what the tower and the staircase will look like using Logo? First, use squared paper to draw a model of your design to remind you what you are trying to build.

- The commands for drawing Rapunzel's tower are:

repeat 2[forward 50 right 90 forward 30 right 90]

- Her tower is 50 steps high and 30 steps wide.

Can you save her?

(Extending Logo) Activity Card 15
Rumpelstiltskin

- Rumpelstiltskin is a very tricky fellow indeed and likes to confuse people with his riddles. His latest riddle is below:

  'Squares have I.

  One, two, three, now four.

  Lay them on the table please.

  Now can you show me five?

  Can you draw a design to solve my riddle?'

- For this activity, you can work with a partner or in a small group.

- Can you find four squares and try to arrange them on your desk so that you can see five squares in total? There are two ways to do this. Can you find both ways?

- When you have solved his riddle, draw out the answers on squared paper.

- Since you are now an expert at using Logo to draw squares, do you think you could write a Logo procedure to draw the designs?

  (A Logo procedure is a list of Logo commands.)

Appendix

Appendix
Glossary of Logo Commands

Command	Meaning
forward	This command must be followed by a variable, for example **forward 50** will move the turtle 50 steps forwards in the direction it is facing. The command can be abbreviated to **fd**.
backward	This command must be followed by a variable, for example **backward 50** will move the turtle 50 steps backwards from the direction it is facing. The command can be abbreviated to **bk**.
right	This command must be followed by a variable. The variable indicates the size of the turn to the right. The default direction is always facing up the screen, for example **right 90** will turn the turtle 90 degrees in a clockwise direction. The command can be abbreviated to **rt**.
left	This command must be followed by a variable. The variable indicates the size of the turn to the left. The default direction is always facing up the screen, for example **left 90** will turn the turtle 90 degrees in an anticlockwise direction. The command can be abbreviated to **lt**.
cs	This command clears the screen and returns the turtle to the home position. The **home** position is in the centre of the screen with the turtle facing upwards.
home	This command returns the turtle to the **home** position. All existing drawn lines will remain visible.
penup	This command deactivates the drawing function on the turtle. It allows you to move the turtle without leaving a line drawn to its new position.
pendown	This command reactivates the drawing function, allowing the turtle to resume drawing a trace of where it is going.

Rewarding Learning