

Developing Spatial Reasoning in Foundation and Intermediate Phase Learners

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INTRODUCTION

Spatial reasoning is a skill used in everyday life to solve problems using concepts of space, visualisation, and reasoning. As a cognitive skill, spatial thinking has been linked to high performance in both mathematics and science and is integral to the studies of engineering, geography, earth and environmental sciences.

The Foundation Phase CAPS document (2011a) specifically mentions spatial relationships (the position of two or more 3D objects in relation to the learner) and directionality (the ability to follow directions and to move/place oneself within a specific space) within the Space and Shape learning domain. Learners should be given opportunities to follow and give directions as well as describe their own positions and the positions of others, and other objects, in space using appropriate vocabulary.

In the Intermediate Phase CAPS document (2011b) it is outlined that learners should be able to recognise and describe shapes and objects in their environment that resemble mathematical objects and shapes, as well as explore properties of shapes by sorting, classifying, describing, drawing and interpreting as well as constructing and deconstructing models and objects. The learner's experience of space and shape in this phase moves from recognition and simple description to classification and more detailed description of characteristics and properties of two-dimensional shapes and three-dimensional objects.

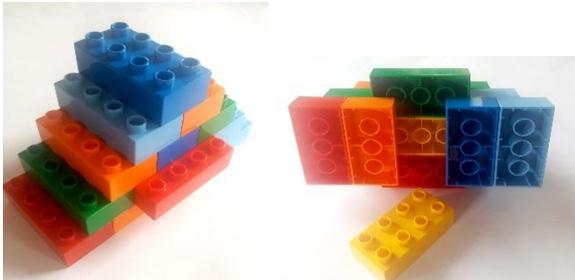
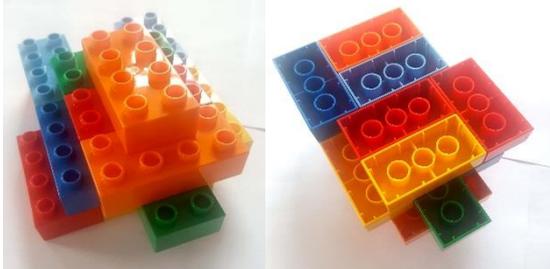
INTERMEDIATE PHASE ACTIVITIES

The following two activity sequences are suitable for use with Intermediate Phase learners. The first activity involves the exploration and deconstruction of complex 3-dimensional objects. The second activity engages the learners in constructing complex 3-dimensional objects through guided descriptions of spatial relations.

Activity 1: Exploring and deconstructing 3-dimensional objects

In this activity learners are required to work in pairs or groups of three. Working in pairs or groups of three encourages learners' development of informal vocabulary through describing the mathematical objects, and their discussion around the activity is important in supporting their developing understanding of the nature of these objects.

Provide learners with an assortment of 3-dimensional objects made from rectangular blocks or small boxes (e.g. matchboxes). Learners must be able to pick the objects up and view them from all sides and perspectives. They should also be able to dismantle the object, i.e. they should be able to take it apart. Some examples of such objects are illustrated in the following table. Three difficulty levels are shown, from basic to more challenging.

Examples with building blocks	Examples with boxes
<p>Basic: All blocks are visible</p> 	<p>Basic: All boxes are visible</p> 
<p>Medium: One block is hidden from view</p> 	<p>Medium: One box is hidden from view</p> 
<p>Challenging: One or more blocks are hidden from view and the object is more irregular in shape</p> 	<p>Challenging: One or more boxes are hidden from view and the object is more irregular in shape</p> 

First, ask learners to determine how many blocks or boxes the object contains. Because learners are not able to see all the blocks that make up the object, this encourages them to recognise that 3-dimensional objects have the property of volume, and to realise that there are blocks that cannot be seen but that are nevertheless part of the object.

Once learners have arrived at a number, allow them to deconstruct the object. It is to be expected that some learners will have counted fewer blocks than are present, as not all blocks were visible in the original object. Ask these learners why they think they did not get the correct answer and guide the discussion to help them realise that this was because there were blocks that they could not see. Learners should get the opportunity to do this with at least 3 objects.

At the end of the activity all objects will have been deconstructed into their individual blocks and boxes. The final step in the activity is to allow learners to build an object that includes blocks that cannot be seen. This reinforces what they have started to learn about the nature of 3-dimensional objects, and prepares the objects for another round of counting and deconstructing.

The difficulty level can be increased by increasing the number of blocks/boxes that are hidden from view, and by creating objects that are more irregular in shape. It is important that these objects can be deconstructed, so use Prestik or paperclips to join the boxes as opposed to gluing them together.

Activity 2: Guided construction of 3-dimensional objects

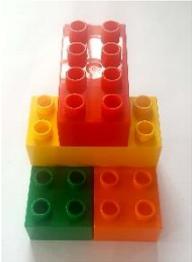
In the previous activity learners worked together and were encouraged to verbalise their thinking to help them develop an informal vocabulary to describe 3-dimensional objects. In this activity formal vocabulary is introduced: edges, vertices and faces.

Learners are guided through the construction of a 3-dimensional object through verbal instructions from the teacher. This activity requires a collection of rectangular blocks or boxes that are identical in size and shape. Each learner needs a minimum of six of these, and each learner will work individually. There should be a piece of paper on the desk in front of each learner that they will use as the surface on which they build.

Before starting the activity establish the vocabulary that will be used with the learners in terms of how you will be describing the blocks and how you will describe where to place the blocks. The blocks can be described with the words: long, short, large, small, face and edge. The position of the block should be described with reference to the learner, i.e. ‘hold the block so that you can see a long, smooth face’; ‘place the block on the page with one of the smallest faces closest to you’. The words ‘top’ and ‘bottom’ should be used to describe whether the block should be added above or below another block; the descriptors ‘left’, ‘right’, ‘top of the page’ and ‘bottom of the page’ can be used to describe where to place the block on the page.

The following table provides an example of a set of instructions for building a 3-dimensional object. All of the pictures have been taken from the position of the learner. The vocabulary words are printed in bold.

Instructions	Examples with building blocks	Similar construction with boxes
1. Turn the orange block so that one of the smallest faces is towards you and put it on the desk. 2. Take a green block and turn it so that one of the smallest faces is towards you and place it to the left of the orange block. It must touch the orange block and the front two faces must be in line .		
3. Pick up a yellow block and turn it so that you are looking at one of the long, smooth faces . 4. Place it over the orange and green blocks. It should be placed so that the back face lines up with the back faces of the bottom blocks .		

<p>5. Pick up a red block and hold it so that you can see the shortest face.</p> <p>6. Place the block in the middle of the yellow block so that the face lines up with the front face of the yellow block.</p>		
<p>7. Pick up a light blue block and hold it so that you can see one of the long, smooth faces.</p> <p>8. Place it over the red block so that the front faces of the red and light blue blocks create one smooth face.</p> <p>9. The left half of the light blue block should not be connected to the red block.</p>		
<p>10. Pick up a dark blue block and hold it so that you are looking at the shortest face.</p> <p>11. Place it on top of the light blue block so that it lines up with the red block.</p>		

Once the learners have completed their constructions allow them to compare the resulting objects with one another. Repeat the instructions while demonstrating how to construct the object.

FOUNDATION PHASE ACTIVITIES

The next two activity sequences are suitable for use with Foundation Phase learners. Both activities focus on directionality. The activities require learners to follow a set of instructions that incorporate descriptions of spatial relations – words such as **forwards, backwards, up, down, under** and **over**.

Activity 1: Directionality

For the first activity each learner needs the following:

- The cardboard lid of a box of A4 photocopying paper, or alternatively a sheet of A4 paper.
- A set of six blocks, or alternatively a selection of six other items you can find in the classroom, such as an eraser, pencil, ruler, sharpener, scissors, a crayon, a counter or stone, a dice, a glue stick.

The cardboard lid or sheet of paper provides the boundary space within which each learner will work. Once each learner has their boundary space and their blocks or assorted objects, the teacher reads out a list of instructions/directions incorporating important spatial relations. On completion, get learners to compare their final layout with one another. An example of a set of directions is provided in the following table - body parts and directionality words have been printed in bold.

Six blocks script	Other items script
<ol style="list-style-type: none"> 1. Pick up the yellow block in your right hand. Put it at the top right-hand corner of your paper, with the short edge facing you. 2. Find the red block. Turn it so that the long edge is facing you. Put this at the bottom left-hand corner of your paper. 3. Pick up the red block. Turn it upside down. Put this in the middle of your paper with the short edge facing you. 4. Find the light blue block. Pick this up in your left hand. Place it on top of the yellow block. 5. Pick up the green block in your right hand. Put it in the middle of the top edge of your paper. 6. Pick up the dark blue block in your left hand. Cross your left arm over your body. Place the block in the middle of the right-hand edge of the paper. 	<ol style="list-style-type: none"> 1. Pick up the ruler in your right hand. Line it up with the top edge of your paper. 2. Find the eraser. Turn it so that the long edge is facing you. Place this at the bottom left-hand corner of your paper. 3. Pick up the sharpener. Turn it upside down. Put this in the middle of your paper with the short edge facing you. 4. Find the pencil. Pick this up in your left hand. Place this on top of the ruler. 5. Pick up the counter in your right hand. Put it in the middle of top edge of your paper. 6. Pick up the glue stick in your left hand. Cross your left arm over your body. Put the glue in the middle of the right-hand edge of the paper.

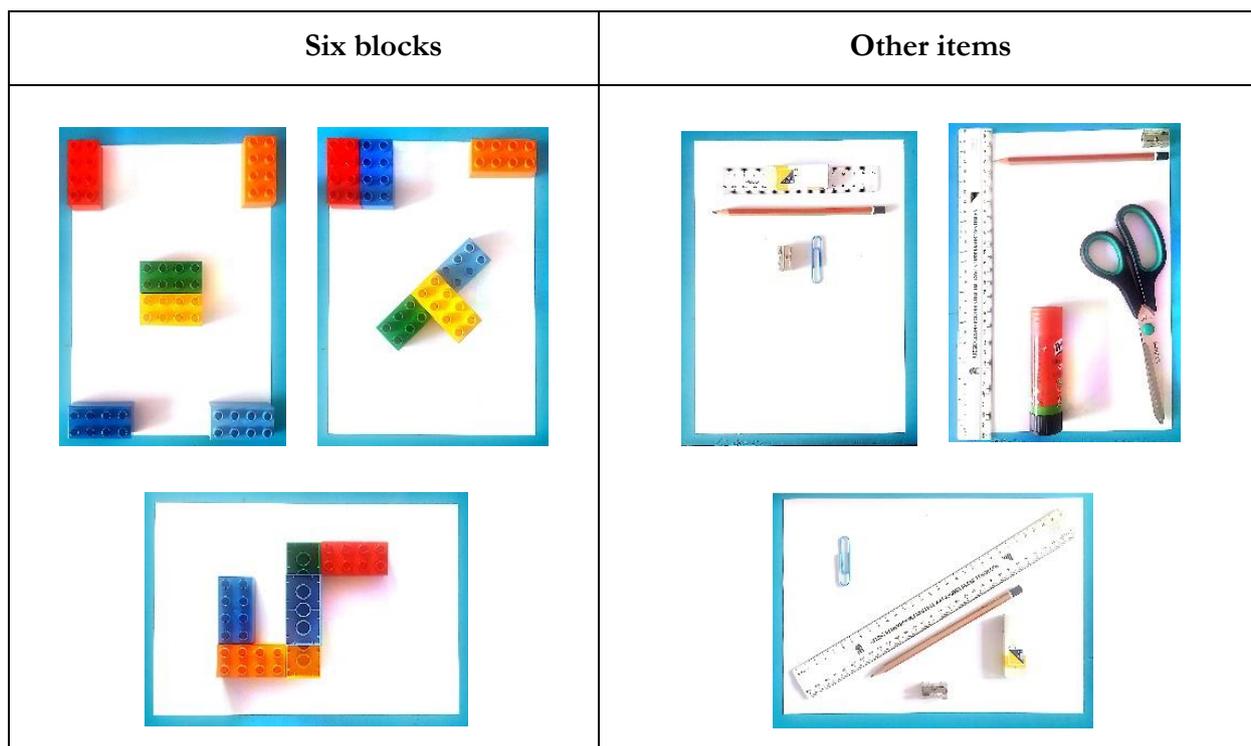
Activity 2: Building/arranging with instructions

Once learners are conversant with the first activity, you can increase the difficulty of the task by moving on to the second activity. Use similar items as for the first activity. It is a good idea to limit the number of items to five or six so that the arrangements do not become too complex to describe. Two learners sit back-to-back. One learner arranges the six blocks or other items and then describes the arrangement to the other learner who must try to copy it exactly. The first instruction must be how to orient the piece of A4 paper, i.e. long edge or short edge facing you. When they are done, the learner who was building the arrangement should compare their structure with the original design of the learner providing the description. The two learners can then discuss the accuracy of the built arrangement and how the instructions could have been given differently. This allows for a further opportunity to develop spatial awareness and spatial vocabulary. The two learners can then change roles, with the learner who originally followed the instructions now providing the instructions/description.

During the course of the activity encourage learners to use vocabulary such as:

- **Position in space:** next to ; on top of ; lined up with ; in a line ; under ; underneath ; between ; in front of ; behind
- **Direction:** right ; left ; top ; bottom ; middle ; diagonal
- **Size and shape:** long ; short ; big ; small ; round
- **Tactile language:** sharp ; bumpy ; smooth
- **Formal terms:** edge ; vertex ; face

Here are some examples of possible layouts:



We hope these activities provide teachers with ideas for developing spatial thinking. The activities can readily be carried out in the classroom as the required objects should already be available in and around the classroom. Alternatively, one could ask learners to collect objects from home and bring them to school as this has the added advantage of creating a personal connection with the activities.

REFERENCES

- Department of Basic Education. (2011a). *Curriculum and Assessment Policy Statement Grades 1-3: Mathematics*. Pretoria: Department of Basic Education, South Africa.
- Department of Basic Education. (2011b). *Curriculum and Assessment Policy Statement Grades 4-6: Mathematics*. Pretoria: Department of Basic Education, South Africa.

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