WHAT STUDENTS NEED TO KNOW AND UNDERSTAND ABOUT SPATIAL CONCEPTS AND GEOMETRY

Introduction

The following sections contain information about what your students need to understand about space, what happens when they do not understand, how to recognise this, and what to do about it.

For organisational purposes of the curriculum, space is broken into three areas of study. These include:

1. Shape
2. Transformations
3. Location, direction and movement

While each is thought of separately, concepts developed in one of these areas will impact on the development of understandings within the others. Central to learning within each of the areas is the ability to visualise (make pictures in the mind) objects, shapes, locations and movements. Young students will need many opportunities to manipulate shapes, construct and deconstruct them, view shapes from various points and in various orientations and use appropriate language to describe what they see. They will also need experiences that help them to develop understandings of locations in space – moving within and describing pathways, locating objects within a space and giving information about their location.

Shape

Concepts students need to understand

- Students need experience in sorting shapes into conventional categories. In the early years, students need to have a well developed understanding of the criteria being applied in order to successfully sort shapes.

- Students need to develop an appropriate vocabulary to describe what they see. Spatial words such as straight, curved, round, pointy, flat, as well as conventional descriptions like rectangular, triangular, are used by students to sort and describe shape.

- Construction and deconstruction of models provides experiences that help young students to build perceptive understanding of shape. As students construct models of shapes, they attend to the component parts of the original shape they are modelling. They come to understand that their model must contain all of the component parts in the right size (can be enlarged or reduced) and shape, with the correct relationship to each other.
  Students who gain experience in deconstructing shapes discover valuable information about component parts and how they are linked to form 'nets'. Later, such experiences lead to the ability to predict which nets will fold to construct a specified shape and the ability to design their own nets.

Strategies to help develop understanding

- In order to develop consistent understandings about shape, young students will need hands-on experiences that give them opportunities to construct, manipulate, deconstruct and use a variety of shapes.

- Hands-on activities with shapes and the discrimination of shapes within the environment will assist students to further develop the ability to apply criteria in order to identify categories that shapes fit into.

- Attention should be drawn to the properties of the shape students are manipulating and they should be encouraged to build mental pictures of the shape in various orientations and viewed from various angles.
- Variations within a category of shape can be introduced to broaden students' personal understanding of general categories and subgroups of shapes. For example, there are many different variations that can be provided to develop a 'picture' of what the geometric properties of a rectangle are. Students subsequently given a square shape should surmise that 'square' must be a subgroup of the rectangle category because the square fits their understanding of 'rectangle', but not all rectangles are squares (all rectangles have 2 sets of congruent sides, and all angles are 90°. This fits squares as well, but additionally squares have all sides are congruent.)
- Links between 2D and 3D shapes must be made apparent. This coupled with the handling and manipulation of 3D shapes, develops the students' ability to visualise them from all angles and orientations. They become able to predict what a shape will look like when viewed from other locations.
- Links between 2D and 3D shapes become especially necessary as 2D representations of 3D shapes are viewed and drawn by students. Various techniques that are used to construct these representations, often distort aspects of the 3D shape and students need a well developed 'picture' of what the shape looks like in reality in order to interpret them.

Transformations

Concepts students need to understand
- When students have a well developed ability to visualise shapes, and can mentally move and rotate these pictures, they will be able to imagine the effects of transformations such as flips, slides, turns and enlargements and predict what the shapes will look like when such transformations are performed.
- Enlargements or reductions of shapes preserves the look of the shape but changes the size. When enlargement or reduction is performed, the angles that form the shape must remain the same. It is the length of the sides that changes, but the same ratio of change applies to all.
- Flips, slides and turns preserve the shape and size of the object that they are being applied to.
- A shape has symmetry if individual parts or points within the shape can be transformed without changing the original shape (e.g. folding the shape in half to give an exact mirror image, rotating the shape around a central point to find another angle where the shape exactly fits the original position).

Strategies to help develop understanding
- Students' understanding of transformations will be assisted by providing opportunities for many hands-on activities that encourage students to perform these transformations, observe the changes that occur and construct mind pictures of a transformation and its effects.

- Young children should be introduced to transformations through movement of their bodies through space. As students demonstrate slides (translations), flips (reflections) and turns (rotations) using their bodies, they become intimately aware of the changes that occur when they are applied and can develop a visual picture of them.
- Students should be encouraged to notice flips, slides and turns as they occur in the environment and in designs. Many structures and tessellating patterns will provide examples of these transformations. Students can be encouraged to use shapes to create their own designs using flips, slides and turns.
- Students should be introduced to two main types of symmetry. These are:
    - Bilateral symmetry: one half of the shape is the mirror image of the other so that if viewed in a mirror which is placed down the line of symmetry, it will look like the original shape. When folded down the line of symmetry, the two halves will match.
    - Rotational symmetry: when the shape is rotated in either direction for part of a turn, the shape will look the same and fit back into its original outline. The part of the turn needed is not specified and varies according to the shape.

Location, direction and movement

Concepts students need to understand
- As students position themselves physically within a space or find paths to specified locations, they develop the language needed to describe these locations and pathways and skills used to record them visually.
- Students describe their location in relation to different objects or structures that are nearby using terms such as near, beside, in front of. Students need to understand that if they change their location within the same space, their description will also change. Later, students may add directional information to their descriptions (e.g. facing the cupboard).
- The use of everyday language to describe the location of objects in relation to other objects will begin with terms such as on, in, under, beside. Later, descriptions of locations can be broadened to include detail of things that are far apart. Students may add detail that describes degrees of proximity (e.g. "The library is between the covered area and the tuckshop. It is nearer to the covered area than the tuckshop.").
- Students need to understand that plans are two dimensional representations of a space that show the placement and relative size of objects within the space. They are drawn using a top view.
- Students learn that maps are two dimensional representations of locations or regions that provide information on the layout of points within the region. Initially, students' attempts at constructing maps may show little attention to relative distances between objects and directional information.

Strategies to help develop understanding

- Young students need opportunities to explore location, direction and movement within their own environment.
- Opportunities to draw and redraw simple plans of familiar spaces will develop their ability to describe the location of objects within a space and assist them to draw simple plans.
- Provide opportunities for students to practice finding and describing pathways within familiar environments. These should be varied to find pathways to the same location but approaching from different directions. Through these experiences, students learn and use vocabulary associated with direction (up, down, clockwise) and movement (forward, backwards, turn).

Experiences that encourage students to visualise familiar pathways will assist students to develop skill in constructing and reading maps.