DS6. UNDERSTANDING PEDAGOGICAL DESIGN REQUIREMENTS AND ITERATIVE EVALUATION (TEACHERS)

WeDRAW: data based outline of key considerations for design

Fractions: Overall challenges involve adding, subtracting and multiplying fractions. Children do not spontaneously transfer what they learn in one situation to another, for example, they don't easily make links between what they learn from partitioning and from correspondence situations. Specific challenges within this are identified below.

Specific challenges from teachers	Mapping to curriculum/ year group	Pedagogical considerations	Key Design considerations
Framing fractions: the concept of 'a whole' or the 'unit'	KS 1: ages 5-7 understanding 'fractions of' discrete and continuous quantities by solving problems using shapes, objects and quantities.	Two types of situations for using fractions: measurement and division. Children use different action schemas for these two situations: • <u>Partitioning</u> is used in <u>measurement</u> situations – e.g. need ½ litre of milk in a recipe • <u>Correspondence</u> is used in <u>division</u> situations - a quantity to be shared and a number of recipients for sharing (e.g. when you share 3 cakes among 4 people they have ¾ each) Young children find partitioning (**requiring understanding of 'inverse' relationships**) harder to grasp than correspondence situations	Building on informal knowledge of fractions (and other concepts) from everyday experiences/ contexts. How to foster the establishment of links between measurement and division situations. Inclusion of situations where fractions are used to represent relations. Use familiar informal contexts for the problem solving (serious games narrative). Appropriate use of metaphor – for designing meaningful action e.g. physical actions that play out 'partitioning' or 'dividing'.
Direct and complement fractions	**Age 7:** Add & subtract fractions with the same denominator within one whole [for example, 5/7 + 1/7 = 6/7]. Compare and order unit fractions, and fractions with the same denominators	Children need to consider inverse and direct relationships i.e. the larger the numerator, the larger the quantity; but the larger the denominator the smaller the quantity (fraction equivalency). For example, children understand that a cake shared between 3	

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		people will give bigger portions than if shared between 5, but still think that $1/5^{th}$ is bigger than $1/3^{rd}$ because the denominator is a larger number.	Use of continuous movement, versus discrete actions . Clear & direct mappings between action and 'digital' or 'system' effect both at a physical and conceptual level for learning contexts. Mappings from bodily-based metaphor to abstract concepts e.g. moving forwards in time, adding is up; mapping of action to pitch, volume & tempo. Audio feedback. Sound characteristics such as volume can represent fractions (e.g. half or twice as loud). The characteristics of time signatures in music (3/4, 4/4, 6/8) to represent fractions through rhythmic patterns of notes of different durations (half notes, quarter notes). Frequency to represent relative size e.g. a bigger fraction may be lower in pitch.
Equivalences, and the related simplification of fractions	**Age 6:** Count in fractions up to 10, starting from any number and using the 1/2 and 2/4 equivalence on the number line (for example, 1 1/4, 1 2/4 (or 1 1/2), 1 3/4 , 2). **Age 9:** Compare and order fractions whose denominators are all multiples of the same number.	To understand fractions, children need to know whether two fractions are equivalent or not, and if they are not, which is the bigger	
Division and percentages, making the link between fractions, percentages and decimals VI - lack of practical experience of what percentages are and where they are used, leading to a challenge transferring from class to real life.	**Age 8:** Understand decimals and fractions are different ways of expressing numbers and proportions. Make comparisons and order decimal amounts and quantities that are expressed to the same number of decimal places. Represent numbers with one or two decimal places in several ways, for example, on number lines.		

Geometry:

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Isometric transformations Visualising rotation points When the point of rotation is remote from the shape it is hard for students to visualize it.	**Age 6:** Work with patterns made up of shapes, including those in different orientations.	More difficulty with reflection and rotation that involve sloping figures, than those on horizontal of vertical axes Decomposing complex shapes into simpler component shapes e.g. a rectangle and parallelogram of the same base & height are equal in area because the parallelogram transforms into the rectangle by subtracting a triangle from one end and adding to the other.	Opportunities to explore how shapes change as a result of different transformations. Re-enactment of the construction of geometric objects Activities that involve decomposing shapes into parts e.g. an isosceles triangle decomposed into 2 right angle triangles; and the inverse process
Symmetry: Symmetry is considered easier for simple shapes like circles and triangles but children struggle once the shape becomes more complex.	**Age 6:** Identify & describe properties of 2-D shapes, including the number of sides and line symmetry in a vertical line. **Age 8:** Identify lines of symmetry in 2-D shapes, in different orientations. Draw symmetric patterns to become familiar with different orientations of lines of symmetry. Recognise line of symmetry in a variety of diagrams, including where the line of symmetry does not dissect the original shape.	Understanding the lines of symmetry -becoming familiar with different orientations of lines of symmetry Perspective taking capability is important in symmetry Understanding the points of connection	A group makes a shape with hand or arm gestures or body, and another has to create a symmetrical shape using the line of symmetry. Use body/hands to make a shape that is reflected through a projected visualisation in relation to the line of symmetry. As their position/ shape changes, the symmetrical shape would change accordingly. Augment through visualisation on floor or wall; or tactile feedback along each line of connection; or matching sounds that link two connecting points.

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			Meaningful mapping of sound to points of connection. For example sound localisation techniques. With headphones, binaural effects can be used to place constant audio feedback to the right or left in a stereo field. As the line of symmetry is approached, the audio feedback moves closer to the centre. The nature of the audio sound itself could vary in tone, texture and timbre as the shape or line of symmetry is rotated, as this can be controlled independently of the stereo placement.
Understanding angles, specifically retention of the different angles. Children use strings, body movement, fans etc. for exploring angles. They identify them in class but once lesson over the ideas seem hard for them to retain (8-11 years).	**Age 6**: Use the concept and language of angles to describe 'turn' by applying rotations, including in practical contexts **Age 8:** Identify acute and obtuse angles, and compare and order angles up to two right angles by size.	Grasping that two angles in different contexts are the same e.g. turning 90 degrees and the corner of a book. Research shows that teaching angles in terms of movements (turning) is successful. Misconceptions with scale enlargements – i.e. that doubling the length of a shape also doubles its area	Experience angles by pupils themselves moving in turns, giving instructions to others to do so, and applying across different contexts Sounds map to specific angle degree, and to related body turns or arm turns similarly to lines of symmetry, meaningful mapping of sound to angle or turn. Jarring harmonies, distortion or jagged rough tones (e.g. square waves) could resolve into pleasing or purer tones (e.g. sine waves) sounds as key angles are approached through movment.

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			In groups, use arms to gesture the angle each person represents to make up different shapes. Meaningful gesture /action can comprise a direct mapping of angle created between two arms, for example
Cartesian plane: understanding the difference between 3D objects that they experience in the real world and their 2D representation. Being able to understand how coordinates can be used to represent a shape like a rectangle.	**Age 8:** Describe positions on a 2-D grid as coordinates in the first quadrant. Describe movements between positions as translations of a given unit to the left/right and up/down. Plot specified points and draw sides to complete a given polygon.	Plotting Cartesian co-ordinates is NOT generally problematic, but understanding how to work out the relation between 2 plotted positions is challenging	