**Mathematics Pilot EYFSP: suggestions from the Early Childhood Mathematics Group**

Sue Gifford, on behalf of ECMG

The Pilot proposals are an improvement on existing Early Learning Goals in many aspects, but lack research support in others, thereby risking unintended negative consequences. According to research, understanding numbers to 10, especially linking numeral values and counting order, is a key predictor for later mathematics achievement (Lyons et al, 2014). In contrast, the current Numbers Goal includes expectations about numbers to 20, adding and subtracting by counting on and back, and solving doubling and halving problems, none of which are supported by research (Gifford, 2014). Subitising (recognising a small number of things without counting) is important in helping children understand the cardinal value of numbers, according to the Early Intervention Foundation (2018). We suggest adding ‘counting out a number of objects from a larger group’, as a key predictor of number understanding (Sarnecka and Lee, 2009).

However, research is lacking for automatic recall of number bonds for numbers 0-5 and for 10as a goal for the majority of five year olds. While this may be a desirable goal for six year olds, these unrealistic expectations, combined with the phrase automatically recall, suggest rapid testing of abstract facts and are likely to produce inappropriate pedagogy and superficial learning, increasing the workload of both teachers and children. However, children may begin to learn number bonds and *corresponding partitioning facts* with visual images, for instance recognizing an image of six by breaking it into three and three: referred to as ‘conceptual subitising’, this is ‘thought to underpin the learning of counting and arithmetic’ (EIF, 2018:123).Therefore to *Explore patterns of numbers within numbers up to 10, including evens and odds,* is an appropriate goal, so long as this is clarified as meaning ‘practically and visually’ for instance with fingers, objects and images. The present wording risks being interpreted as referring to equations with number symbols, for which there is no research support for this age group.

The pilot ELG*Numerical Patterns* recognizes the importance of patterning as predictive of later achievement (Rittle-Johnson, 2016; EIF, 2018). However, studies usually refer to linear repeating patterns with objects, and not numerical patterns, with the key aspect being recognizing the core unit which repeats. According to the EIF and others, patterning also involves recognising the regularity of an arrangement of objects, which would include the symmetry of *doubles facts* shown as images (eg double four on a domino) and *patterns of numbers within numbers up to 10, including evens and odds,* if these were visual. We suggest that the key aspects of pattern might be included within current goals, by emphasising subitising and visual composition within Number, and clarifying patterning within Shape, Space and Measures.

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| ***Number* and *Numerical Patterns* Pilot Goals** | **ECMG proposal *Number*  Goal** | **Rationale** |
| *Children at the expected level of development will:* | With numbers to 12, children | Numbers to 12 indicate that counting can continue past the boundary and afford more interesting composition facts. |
| *Have an understanding of number to 10, linking names of numbers, numerals, their value, and their position in the counting order;* | * count out a number of objects from a larger group, * match numerals to amounts, * compare and estimate numbers, * predict adding or taking one. | Each of these aspects has been found by research to indicate deep understanding of numbers and counting and is predictive of later achievement. |
| *Subitise (recognise quantities without counting) up to 5;* | Children subitise (recognize a number of items without counting) up to 5 | Subitising is generally considered to contribute to early number understanding. |
| *Automatically recall number bonds for numbers 0-5 and for 10, including corresponding partitioning facts.* | and recognise how numbers are made up of other numbers.  They solve practical problems including adding, subtracting and sharing. | This emphasises understanding part-whole relations and connects addition with subtraction. This can include conceptual subitising and exploring patterns of visual arrangements of numbers. No level is specified: younger children may just recognize that 3 includes 2 and 1. (There is no research evidence for the level specified in the pilot Goal.) Problem solving is included to require application of addition and subtraction strategies. |
| *Automatically recall double facts up to 5+5;* |  | This is included in the item above. |
| *Compare sets of objects up to 10 in different contexts, considering size and difference;* | They solve practical problems including ..sharing. | Sharing problems provide important experience of comparing numbers practically. The meanings of ‘size and difference’ are ambiguous in the pilot goal. |
| *Explore patterns of numbers within numbers up to 10, including evens and odds* |  | This is covered above by *recognise how numbers are made up of other numbers.*  There is no research evidence to show that concepts of evens and odds are understood at this age, so these are better left to KS1. |
|  | Children communicate their mathematical thinking in a range of ways. | This is to ensure that understanding is assessed through a range of modes and that children connect different representations of number relations and concepts. |

**Shape, space and measures**

The pilot EYFSP proposes omitting shape, space and measures not only as a goal, but from the reception curriculum:

*Mathematics Educational Programme*

*Developing a strong grounding in number is essential for providing children with the platform to excel mathematically. Children should develop a deep conceptual understanding of the numbers to 10, the relationships between them and the patterns therein. By providing frequent and varied opportunities to build and apply this understanding, children will develop a secure base of knowledge from which mathematical mastery is built. (DfE, 2018:12)*

However, it seems obviously desirable that young children develop early familiarity with the properties of shape and measures and the language to describe and compare these, in order to progress in learning about geometry and measures in KS1 and 2. Furthermore there is increasing evidence that early spatial skills are predictive of later mathematical and STEM achievement (Utall et al, 2013; Cheng & Mix, 2014; Lauer and Laurenco, 2016; Young et al, 2018) and that teaching these improves mathematics, including number understanding (Cheng & Mix, 2014; Hawes et al, 2017). Research points to a focus on spatial reasoning, which includes visualizing spatial relations, predicting the results of movements and thinking diagrammatically. This is underpinned by a large range of spatial experiences, with interventions including construction and puzzle activities involving combining and rotating shapes. Focusing on spatial thinking is likely to increase access to mathematics, especially for groups who may be disadvantaged in terms of early spatial experiences, such as girls and poorer children (Ontario, 2016). Overall, the evidence as summarized by Young et al (2018) points to ‘supporting spatial thinking and learning beginning early in life’ in order to improve mathematical understanding. It also points to an emphasis on dynamic and spatial aspects of ‘shape and space’ in the early years curriculum. Currently the ‘space’ aspect is represented by ‘position’ and hidden in a list of things to ‘talk about’. There is a danger that the current Goal is translated into what Sinclair and Bruce (2015) describe as a ‘passive emphasis on vocabulary (naming and sorting shapes by properties)’. Research points to the need to signal the importance of fostering early spatial thinking: including this in a Goal is likely to encourage teaching and investment in this area, including professional development and resources. If this is not a Goal, senior managers are unlikely to prioritise funding for eg quality construction materials, thereby further disadvantaging some groups of children. There are further implications for strengthening spatial reasoning in primary education.

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| **Shape, space and measures** | | |
| ***Current Goal*** | **ECMG Proposal** | **Rationale** |
| *Children use everyday language to talk about size, weight, capacity, position, distance, time and money to compare quantities and objects and to solve problems.* | Children:  make comparisons of length, weight and capacity | This reduces the number of aspects teachers must assess. ‘Comparisons’ includes language and practical problem solving.  ‘Length’ replaces ‘size’ (which is non-specific) and ‘distance’ (an aspect of length). Research does not indicate ‘time’ and ‘money’ conceptual understanding for this age group, so these are omitted. ‘Position’ is included in the sentence about ‘space’ below. |
| *They recognise, create and describe patterns.* | begin to identify the rule in a pattern | The predictive early patterning skill is identifying the core unit of repeat. ‘Rule’ is suggested to include a greater range of patterns. |
| *They explore characteristics of everyday objects and shapes and use mathematical language to describe them.* | select and combine shapes for a purpose and talk about their properties | This encourages a focus on properties of shapes and the way they fit together, with decision making and verbal explanation to show reasoning about these. Construction and puzzles would provide contexts, involving rotating and combining shapes, which are predictive aspects of spatial reasoning. |
|  | follow directions and describe positions and routes | This involves key aspects of spatial reasoning ie bodily movement and orienting, understanding positional and directional language and identifying locations and spatial relations between objects. These may be also be represented by models, maps and symbols, and include visualisation skills, as in a treasure hunt. |

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