Reply to an article in NCETM's *Early Years Magazine*, Issue 3

We welcome this opportunity to clarify some points in Thompson's interesting article on a recent study that repeats Hughes's 'tins game', research that was significant since it was the first time young children's *own* mathematical representations had been investigated (1986). However, rather than - as Thompson argues - our analysis and taxonomy 'constituting an attempt to interpret and classify children's examples that Hughes categorized as 'idiosyncratic' (i.e. 'unclassifiable'!)' , we have built on and developed a taxonomy that goes beyond our earliest focus on the form and types of marks and symbols as Hughes did - to focus instead on the *mathematical functions and meanings* of *children's mathematical graphics*.

Graphics are one aspect of semiotics (the study of signs and meanings and their communication in cultures) and analysis of their *mathematical function and meaning* is of great significance in helping adults understand, value and assess children's graphical marks, symbols and other representations.

Developing a taxonomy

We did in fact take Hughes's four categories as the starting point for our earliest analysis. Our first attempts (in 2003 began with five 'forms' of marks, symbols and graphical representations that we found. We omitted 'idiosyncratic' from Hughes's categories and added 'dynamic' (i.e. marks that are lively and suggestive of action) and 'written' (i.e. using letters or words) to Hughes's 'pictographic', 'iconic' and 'symbolic'.

Our numerous published examples show that children employ the same range of 'pictographic', 'iconic' and 'symbolic' forms that Hughes identified, with the addition of these two new categories of 'forms'. However, we soon realised that these 5 categories failed to acknowledge the complex ways in which the children's graphics embodied their *mathematical function and meanings* and this led to the development of our taxonomy.

Whereas Hughes focused on only two areas: children representing quantities that they had counted, and research by Jones and Hughes (Hughes 1986) into addition and subtraction, we identified six different domains of written number and quantity, and five domains of calculations, allowing for greater detail and analysis of *children's mathematical graphics* from birth to 8 years. Ian Thompson's own research is important in showing how older children develop their own written methods beyond the ages that are our focus.

Our taxonomy provides a global view, charting young children's developing understanding of mathematical semiosis. We introduced the taxonomy for the first time in a paper presented at a research conference in 2003 (subsequently published in 2005) and in our book, *Children's Mathematics, Making Marks, Making Meanings*, (first published in 2003).

It may be that some of those examples Martin Hughes referred to as 'idiosyncratic' were scribbles, and rather than 'idiosyncratic', we refer to many of such examples as *'early explorations with marks: attaching mathematical meanings'*. We believe that these early representations are of considerable significance since they provide contextual evidence of children using abstract graphical marks and symbols to signify their mathematical thinking.

It is significant that the examples *of children's mathematical graphics* we have analysed are made in contexts in which children deliberately choose to communicate their mathematical thinking, and teachers ensure that the children understand the communicative function of their marks, symbols and other graphical representations (see Munn, 1997, above, and Carruthers and Worthington, 2011). They are much more readily understood in naturalistic contexts of the child's own nursery or setting, where teachers know the children well and understand the contexts in which they use graphicacy to communicate their mathematical thinking.

Those who have spent their careers teaching very young children recognise the importance of these early marks, and we have made a conscious decision to view children's graphics from a positive perspective. We understand that the earliest marks to which children attach mathematical meanings have a significant role in their developing understanding of the abstract symbolic language of mathematics.

References:

Carruthers, E. & Worthington, M. (2005) 'Making sense of mathematical graphics: the development of understanding abstract symbolism' *European Early Childhood Education Research Association Journal*, (EECERA) Vo 13, No.1 (pp. 57 – 79).

Carruthers, E. and Worthington, M. (2011) *Understanding Children's Mathematical Graphics: Beginnings in Play*. Maidenhead: Open University Press.

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