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Respecting children's personal symbolism

Maulfry Worthington

Introduction

Learning (and yes, learning mathematics too) should be empowering, life enhancing and joyful. Rather than mathematics belonging exclusively to the policy makers, curriculum writers and adults, children should have some *ownership* of their mathematics so that they develop agency and confidence, and enjoy and understand mathematics at a deep level.

However, recent and rapid developments in education in England have had considerable impact on early years education. Driven in part by global competition, policy-driven changes dominate. The curriculum has become constricted and increasingly emphasises attainment in a narrow band of 'skills' in mathematics and literacy: this is particularly evident in reception classes and increasingly in nursery education. Roberts-Holmes observes that,

> '… the impact of such school-based testing regimes has the potential to subvert the early years from being a unique child-centred and play-based educational stage in its own right to that of subserviently preparing children for school' (2015: 303).

This severely restricts authentic opportunities for young children to develop personal and meaningful foundations in these subjects. It marginalises play, which has become increasingly misunderstood; play is often subsumed into adult-planned activities revealing the extent of misconceptions in policy relating to play (Wood and Chesworth, 2017). Teachers and practitioners are not to blame for this narrowing of children's experiences, but it is at best, misguided political intentions that shape the extent to which teachers must 'raise standards' and jump through endless hoops, a sort of educational obstacle course with no winners. [1]

Children's difficulties and disaffection with mathematics in school become adults' dislike of mathematics, but it does not have to be like this. George Monbiot emphasises that for 'a better world' there is an alternative, 'to tell a new, kinder story explaining who we are and how we should live… of belonging' (2017), something desperately needed in early years education and most pressing in mathematics and literacy.

Drawing on the findings of recent PhD research this article tells 'a new, kinder story' of mathematics education. The values and practice of the inner-city

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[1] The term 'teacher' is used elsewhere to refer to both teachers and early years practitioners

nursery school where data were gathered are built on democratic values established by the headteacher who, together with the staff,

> '… have developed an open and unstructured culture in which children are encouraged and supported as learners, and their emerging understandings valued. Adults have clear philosophies of young children as learners and of play and mathematics, and have developed deep knowledge of learning and significant pedagogical skills to support children's thinking and learning' (Worthington and van Oers, 2016: 63).

In place of a set list of skills to be covered the focus is on the children's *thinking* and *meaning making.* The children experience very rich opportunities for play and mathematics and to use and make sense of all their graphicacies (drawing, maps, writing): these include children's own mathematical notations, or *children's mathematical graphics* (Carruthers and Worthington, e.g. 2006).

Pretend play
In the UK a somewhat loose definition of play suggests child-initiated activities, but rather than a generalised interpretation, Vygotsky (1978) considered only *pretend play* as 'play', acknowledging it as the 'leading activity' for young children. Socially, emotionally and developmentally pretend play affords rich potential, and for young children some essential requirements are that they are able to freely choose *if, what, how, with whom* and *where* they play, and that their play is *not* planned with specific outcomes in mind. Rich social pretend play enables children to draw on their existing cultural understandings or *funds of knowledge* (Moll et al. 1992), and some of their knowledge will be mathematical and also relate to their interests (Worthington, 2017). In their spontaneous pretend play the children's understandings grow within in their relationships and interactions, within their minds and imaginations.

The subject of mathematics
Mathematics as a subject has been described as a problem solving activity with signs (van Oers, 2001), and it is difficult to conceive why a feature so integral to mathematics *learning* continues to be so neglected in mathematics *teaching*.

Research into children's experiences with mathematical notations over the past fifty years shows that direct teaching results only in superficial learning, lack of understanding and confusion (e.g. Ginsberg, 1977; Hughes, 1986; Carruthers and Worthington, 2006). This makes it difficult 'for children to link mathematical skills and concepts taught only in isolation, since ways concepts are taught in school are frequently very different to their use in everyday life' (Yelland and Kilderry 2010: 93).

Martin Hughes identified the 'gap' that must be bridged, arguing that children need to develop '*ways of translating* – between this new abstract language' and their existing knowledge (1986: 51, emphasis in the original). He suggested that teachers 'build on children's own strategies' and 'respect their invented symbolism' (1986, 176/177). The findings of this recent doctoral research reveal the extent to which *children's mathematical graphics* contribute to *bridging this gap*. At 3–4 years of age the children already knew a considerable amount about the various graphical systems of drawing, maps, writing and mathematics. Using their multimodal signs with confidence to communicate their ideas, they used signs flexibly as they moved towards the increasingly standard abstract signs of mathematics.

Concepts and strategies

For Vygotsky children's social interactions, relationships and dialogue link cultural experiences to support their *spontaneous* (everyday and informal) mathematical concepts, providing foundations for the *scientific* concepts of school (1987). Young children's personal mathematical notations embody many aspects of their early mathematical concepts: these beginnings are very special. Empson and Jacobs observe that,

> '… the kinds of strategies, representations and reasoning used by children often differ from those used by mathematicians and other adults… by saying *children's* mathematics, we imply the existence of a coherent and logical approach to reasoning that differs in important ways from that of mathematicians and other adults' (2008: 260, emphasis in the original).

The cultural foundations of mathematics

The findings from this research highlight the very considerable amount of mathematics that these 3-4 year-old children explored in their *impromptu* and *entirely free* pretend play (Worthington and van Oers, 2016: 63). The children's play mirrored authentic situations of home, their powerful mathematical thinking and meaning making extending their understandings, and establishing confidence and agency in their mathematics.

The cultural knowledge of the children in this study involved their parents' use of construction skills, deliveries, invoices and receipts, shopping, security measures and safes, electricity, preparing meals, menus, ordering food in a café, maps, camping, train journeys and counting the takings from one father's taxi. The research findings showed that:

- These *funds of knowledge* were reflected throughout the children's play episodes.
- Aspects of their cultural knowledge enabled the children to adapt and expand their understandings as they merged reality and invention.
- The children's impromptu mathematical explorations included *all* aspects of the mathematics curriculum.
- References to number, quantities and counting were the most frequent, followed by time and money - perhaps persistent concerns in many families.
- The children's spontaneous mathematical concepts contributed to their joint play in ways that made sense to them.

Isaac's dad had worked in the building trade; he also converted the house in which they live, Isaac often helping with building jobs at home. His dad now runs a microbrewery and Isaac is familiar with deliveries, payments, invoices and counting cash. Isaac shares his dad's interest in maps, a wide range of technologies, motorbikes and trains and they often go camping together. Isaac drew on all this cultural knowledge in his pretence. The following episode shows Isaac and David playing with humour, sharing ideas about large numbers and prices relating to 'bookings for a campsite'.

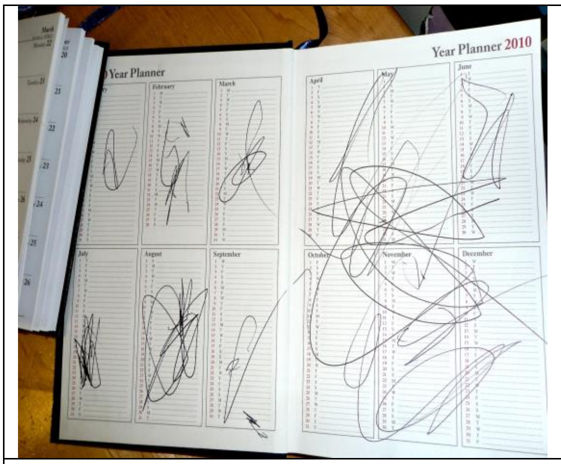

Figure 1: Isaac, **'***I'll put you down for two million nights'.*

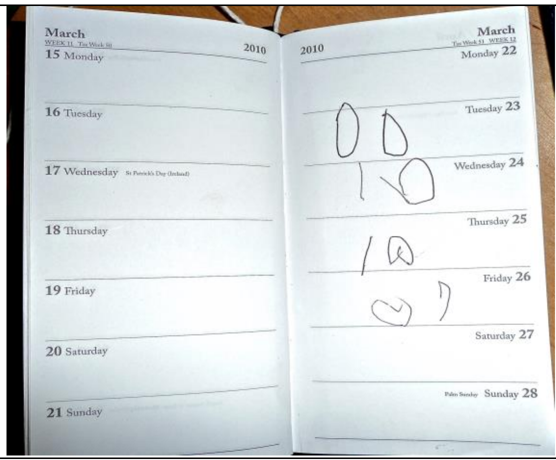

Figure 2: David's bookings.

> Isaac decided to use an old diary as booking book' for a campsite, and explaining that two people were staying, made two marks [not shown here]. Isaac used the phone to take more bookings, telling David *'one hundred million people are staying!'* David replied, *'I want to stay for two nights'.* But Isaac said, *'No. I'll put you down for two million nights, but don't worry – it's only £1.00 a night'.* He then wrote it down, this time making many marks and David also took a diary and made his own signs (circles and vertical lines).

This play episode held personal significance for Isaac, enabling Isaac to draw David into some shared mathematical talk. Figure 1 shows Isaac's 'scribble-marks', a term used to refer to those marks that children appear to use as 'placeholders', allowing their play to continue without interruption (Worthington and van Oers, 2017): they are marks that adults would find difficult to interpret without the child's explanation. Figure 2 shows the signs David made, beginning to represent quantities in his own way. This early exploration with marks and signs will help establish a strong foundation for understanding the abstract symbolic language of mathematics, later including calculations.

Meaning making and children's social literacies

The children's involvement in cultural and social literacy practices at home, and their *interest* and perceived *need* to communicate to further their play revealed their understanding and interest in drawing, maps and writing, using multimodal ways of representing meanings. At 3-4 years of age their texts highlighted a considerable growth of interest in using distinct graphical signs, significant also for mathematics (Worthington and van Oers, 2017: 23). Their *sustained* pretend play was especially rich and complex as the children freely and readily choose to communicate through their graphicacy in a high proportion of play episodes without any adult prompting.

The development of mathematical abstraction in the nursery

Like writing, the symbolic language of mathematics is an abstract sign system and analysis of the children's frequent use of their *mathematical graphics* showed that most had begun to use written numerals, using them only when communicating *mathematical* ideas. Several children used tallies to represent items they counted. They used crosses flexibly, in some instances to suggest 'no' or 'none', and perhaps anticipating 'zero'. The children clearly recognised that quantities can be represented in several ways, although they seldom drew items. They often found personal ways to represent *lots, many and some*. Where writing was appropriate (e.g. for a shopping list) the children wrote standard letters or writing-like marks such as wavy lines. Their sign use moved freely between mathematics and other graphical systems, showing awareness that signs could have different meanings and were dependent on context and what they intended to communicate. During the year the range and quantity of the children's various signs increased, shifting from simple marks to increasing use of signs from the established mathematical system. Their signs and notations increasingly advanced towards the more 'standard' mathematics, their graphics becoming *more mathematical* over time.

Discussion

Pretend play is not the only social and cultural context that has the potential to support such rich mathematical (and literate) thinking. Adult-led groups in which children explore their own mathematical ideas can also provide genuine opportunities for collaborative discussion about aspects of mathematics, and for children to build on their own existing knowledge.

Children's *mathematical graphics* appear to provide strong and effective means for them to express their mathematical ideas with confidence, as they move from their earliest scribble-marks to increasingly mature problem solving. The children's personal ways of representing their mathematical ideas were supported by teachers' and peers' models that augment their growing inventories of signs. Later in school the children will use operators within calculations *with understanding*, and make informed and effective choices about strategies for solving problems (Carruthers and Worthington, 2008).

Young children's developing abilities to master complex graphical sign systems such as writing and mathematics is a considerable achievement. They are served best by supporting children's thinking through natural organic processes - flexible, adaptive and holistic. These processes enable children's powerful understandings and agency to come to the fore.

This is neither a casual or laissez-faire approach but developed through a cycle of practice, pedagogy, research and theory, informed by real children's and practitioners' lived experiences over more than 25 years. Children's mathematics and their *mathematical graphics* are acknowledged in a number of studies including 'the Williams Review' (DCSF, 2008; see also DCSF, 2009). In this nursery school this emergent approach has led to 'open mathematics' (Carruthers, 2017), and year on year the children's mathematics considerably exceed expectations. The nursery school has been awarded 12 'outstanding' awards from Ofsted, including 'outstanding' for mathematics. Together with the findings of this doctoral research and the many studies of *children's mathematical graphics* in which it is rooted, a 'new story' seems possible,

> '… positive and propositional rather than reactive and oppositional… Without such a story nothing changes. With such a story, everything changes' (Monbiot 2017).

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Maulfry is completing her doctorate at the VU University, Amsterdam: she lives in Devon.