The abstract symbolic ‘written’ language of mathematics
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1. What are the main difficulties with numeracy and mathematics in the Early Years?

The abstract symbolic ‘written’ language of mathematics is varied and complex (1) and is the area of mathematics that young children find most difficult (2, 3). Without suitable support for this essential aspect children will fail to develop their full potential in mathematics.

Mathematical skills are important, however, emphasising only ‘basic skills’ (2, 4) limits children’s understanding and progression in mathematics and numeracy. In England OfSTED has repeatedly raised concerns, emphasising, It is of vital importance for pupils of all abilities to shift teaching and learning in mathematics away from a narrow emphasis on disparate skills towards a focus on pupils’ mathematical understanding’ (5: p.3).

2. Good practice

Research informed practice: the abstract symbolic language of mathematics

- Young children’s understanding and confidence in numeracy and mathematics are supported by their ability to use signs and symbols flexibly (3, 6, 7), yet there is no official guidance on this.

- Evidence gathered through research throughout England during the past two decades (2) has focused on the educational concept of children’s mathematical graphics in the birth – 8-year age range. Used in personally meaningful ways children’s own representations gradually integrate standard signs of ‘school’ mathematics, highlighting their value for problem solving (2, 8, 9) and wider aspects of the curriculum. Research has also identified children’s informal methods for calculations as of considerable benefit for children in Primary and Secondary schools (10, 11).

- The difference between ‘recording’ mathematics and children’s mathematical graphics is one of quality and depth of thinking (12), children engage in creative thinking, reasoning, problem solving, negotiation and co-construction, using and applying their mathematical understanding.

- This educational concept supports numeracy and all aspects of the mathematics curriculum from birth – 8 years. It has considerable value in establishing strong and effective foundations for written mathematics in the Early Years, building mathematical fluency and confidence.

- Analysis of over 700 examples enabled children’s learning trajectory to be charted, the first time that this has been done (8,13).
• This concept supports all children including those who are gifted or have specific learning needs, and no difference has been found in the willingness of boys or girls to represent their mathematical thinking.

• Teachers’ and other Early Years professionals’ understanding of effective approaches to children’s mathematical graphics has had a positive impact on children’s achievement.

• A major study of mathematics teaching in England gave prominence to children’s mathematical graphics, making a number of recommendations (14). Subsequently Carruthers and Worthington were commissioned to write a publication on Early Years mathematics for teachers and Early Years professionals (15).

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**Doctoral research (1): Maulfry Worthington: VU University, Amsterdam**

• Young children’s learning begins at home (16, 17), and in early childhood play is acknowledged as the ‘leading activity’, providing a ‘bridge’ between spontaneous and scientific concepts (18, 19) and connecting informal representations with the formal written language of mathematics.

• Recent doctoral research was conducted through a longitudinal ethnographic study in a nursery in a Children’s Centre cited in a large city in the southwest of England, in an area designated one of the 30% most deprived in England.

• The research focused on the emergence of children’s understanding and use of early ‘written’ mathematics in various contexts, the findings providing evidence of a high incidence of mathematics within their spontaneous pretend play that spanned the breadth of the curriculum (20).

• A significant finding highlighted children’s growth of graphic symbols between 3 – 4 years of age that underpin symbolic languages such as mathematics (21, 22).

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**Pedagogy**

• The incidence, success and sustainability of children’s mathematical graphics are dependent on the values, beliefs, knowledge and practices of headteachers and staff members in early childhood settings children confidently representing their mathematical thinking in their play, in other child-initiated contexts and in adult-led groups and classes (23, 24).

• Children’s mathematical graphics have contributed to raised standards in mathematics in schools and authorities where this has been a focus of professional understanding.

• Effective pedagogy includes modelling informal and standard mathematical signs and texts for a range of authentic purposes in contexts meaningful to the children (2).
Doctoral research (2): Elizabeth Carruthers: University of Bristol

- A participatory research study of teaching and learning in mathematics with a focus on children’s own problem solving uncovered that reception class teachers were confused about how to introduce calculation and struggled with engaging children in their own problem solving (25).

- The teachers found it difficult, at first, to open up the mathematics and to understand children’s own mathematical notation, signs and symbols (2; 8; 23). However, by the end of the study, the teachers had many narratives of how the children in their class were significantly more challenged in mathematics (26).

- Throughout the study these teachers expressed their concern of the restrictive pressures of the present system in creating a significant barrier to children’s mathematical learning and achievement.

- From the findings of this study it appears there needs to be greater emphasis in mathematics teaching on listening to children’s own mathematics through real contexts and children’s own mathematical graphics that are open and child led.

3. What are the policy solutions that would help solve these problems?

This combined research highlights the need to move beyond ‘basic skills’ – especially regarding the abstract written symbolic language of mathematics: to this end we recommend:

- ✓ An increase in teachers with QTS in all nursery and pre-school settings.
- ✓ Greater clarity on the Foundation stage as a distinct phase, with appropriate mathematical experiences and high expectations.
- ✓ That there is an urgent need to address issues with Reception, acknowledging its position within the Early Years Foundation stage, and emphasising meaningful and challenging learning experiences for mathematics for children of 4 – 5 years of age.

Developing professional knowledge and expertise including:

- ✓ The 30 designated Mathematical Hubs in England are all Primary or Secondary led, and Early Years mathematics is not a focus. We therefore recommend a network of designated Early Years Mathematics hubs 2, by acknowledging the wealth of early educational excellence in maintained nursery schools and developing early mathematical hubs around the

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1 Elizabeth Carruthers is headteacher of Redcliffe Children’s Centre, maintained nursery, National Teaching School and Research Base, Bristol.
2 A major two-year study in England of mathematics continuing professional development (CPD) featured Carruthers and Worthington’s initiative of local children’s mathematics network learning groups (Early Years mathematics hubs), (27; 28; 29).
Nursery School Teaching Schools and other outstanding Nursery Schools (not to be mistaken for nursery classes in Primary Schools).

✓ To develop professional understanding of mathematics in the Early Years, we recommend development of Early Years Mathematics Masters modules - linked to EY Maths Specialists and EY Play Specialists.

References


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3 In 2013 Redcliffe Children’s Centre’s Research Base in Bristol established a successful double EY Mathematics Masters module: it is accredited by Bath Spa University, and repeated in 2014. Several teachers completing these Masters modules are now Specialist Leaders in Education (SLEs) for Early Years mathematics, supporting colleagues and teachers in other settings within their authority, and leading CPD.


Maulfry Worthington and Elizabeth Carruthers are co-directors of the international Children’s Mathematics Network, a not-for-profit organisation with over 1000 members.

Its aims are to enrich children’s mathematical understandings, to share
research and information and to promote effective practice in support of children's mathematical graphics - with all those engaged in early years education including teachers, students, researchers and policy makers. [www.childrens-mathematics.net](http://www.childrens-mathematics.net)

Maulfry Worthington is also an executive member of **TACTYC, The Association of the Professional Development of Early Years Educators.** [http://tactyc.org.uk/](http://tactyc.org.uk/)