Most adults apply mathematics regularly in everyday situations; they may measure how many rolls of wallpaper to buy, order or weigh a specific number of items, compare sizes on clothing labels to decide whether something will fit or not. Yet many lack the confidence to evaluate the probabilistic risk of inoculating their children against a particular disease, or the choice between alternative financial investment opportunities. At a recent workshop, where a discussion about learning maths developed, several attendees said their understanding was limited and that somewhere they "got lost", either in pre-school, primary or secondary school education, and expressed their reasons for a dislike or lack of enjoyment, thus feeling limited in their understanding of mathematics:

"I got lost somewhere at primary school … I was okay at addition, but then I felt I must have missed a chunk of learning somewhere. In a test once I remember drawing a line between the two dots of a division symbol to make it an addition question – honestly, I had no clue when we had been introduced to that symbol and so all my work was wrong."

"I didn’t feel prepared. Now I understand the importance of providing a foundation for maths, I believe that this is probably where it all started to go wrong for me: I don’t recall using specific activities that supported my mathematical knowledge at pre-school."

Children become discouraged when they are presented with challenges that they are ill prepared for. As Dweck (1999) has shown, if this continues children may then develop a ‘helpless’ disposition towards learning and begin to see their problem with a mathematical task in terms of some personal lack of innate capability rather than recognising that they might be successful given further support and encouragement. They may also develop low expectations of success in any future related tasks (Dweck, 1999).

While children engage in prescribed activities in Montessori practice, as their skills advance, they will gain progressively given more freedom of choice and movement along with the time and space to repeat and explore activities. As Montessori (2012) suggested, this leads to enhanced concentration, self-esteem, and refinement of concepts and skills. Indeed, key to her pedagogy is the observation of children engaged in spontaneous activities; recognising that in order to effectively support learning the practitioner must have appreciation of children’s knowledge, interests and skills. Montessori materials are presented to a
child at a time when the educator has observed they will benefit from it. Montessori did not view mathematical learning in the early years as having a glass ceiling and appreciated that we should never underestimate a child’s potential.

Aligning with Montessori, Ryle (in Fisher, 2005) has argued that educators are too focussed on the achievement of basic skills, and that they should be looking instead at developing children’s higher levels of thought, “Present mental ... capacities are only a shadow of what might be” (Fisher, 2005, p iv). It seems worthy of hypothesis that improvements in the early and progressive scaffolding of learning and support might improve mathematical performances significantly.

Yet any more directed approach to mathematics education in the early years is likely to be met with some resistance. If anything, practice might be considered to be moving away from this towards more intuitive, playful and open-ended ‘discovery’ learning through the encouragement of ‘schema’ development.

The increasing emphasis being placed on schema development in pre-schools stems initially from the pioneering analysis and detailed observations of Athey (1990; 2007), who made a significant contribution in applying Piaget’s developmental psychology to early childhood education. ‘Schema practice’ in early childhood education might now be considered to involve the educator in at first identifying and then encouraging the child’s “patterns of repeated behaviour” into which new experiences are then “assimilated and gradually co-ordinated” (Athey 1990, p37). In fact Athey did not just write about schema development, she also discussed the distinction made by Piaget between cognitive ‘schemes’ that provide the child with operational knowledge, and children’s figurative ‘schemas’. Athey (1990, p113-14) noted that research progress was being hindered by an ambiguity in the use of the terms and that the fundamental difference between operative and figurative thinking was “worthy of further study”. But, for the purposes of her continued analysis, in contemporary ‘schema practice’, and in many other contexts, the terms continue to be treated synonymously. It is only in our current in-depth investigation of children’s developing understanding of mathematics that we are beginning to find this distinction useful.

We have found that the best way to understand the issue is to consider schemes and schemas to represent something like ‘two sides of a coin’, or two distinct qualities, one of form and the other of content...
Following the Red Rods activity, Jack had worked with the materials in self-chosen spontaneous activity on four separate occasions. In the following observation Jack appeared to be experimenting with this newly acquired knowledge through another schematic operation, using his whole body:

*SiteA14/03/15/10.15am - Jack walked over to the Sensorial activity shelves in the classroom. He lay down next to the lowest shelf and turned his head to face the ‘Long Red Rods’ activity. He smiled, looked away, brought his legs up to his chest and turned his head again towards the Rods. He remained in that position for a short while then straightened his legs. He smiled, stood up and walked to where a practitioner was with a group of three children talking about Totem Poles. Jack appears to be aligning his body with the Red Rods and adjusting his length by bringing his knees to his chest, suggesting he is developing his ability to compare length.*

*SiteA14/03/2015/10.40am. After leaving the group of three children talking, Jack engaged in a further activity, threading string through toilet rolls in a line. He selected the longest Red Rod, to be a measuring device, which he used to identify a ‘long’ piece of string. This was evidence of a schema; Jack is clearly applying some verbal or non-verbal figurative knowledge of length.*

The indirect preparation for understanding length can be seen to have been supported by the Montessori activity and materials, which appear to be designed with not only the isolation of the sense (visual discrimination), but also operational schemes and supporting schema (figurative knowledge) in mind. The Montessori sensorial materials provide a prescription for understanding later mathematical concepts.

Jack’s case suggests that if we are to improve the scaffolding of learning and support and mathematical performance it will not be enough to simply respond to the observation of the child’s schemes by presenting them with additional schema applications. We may need to consider progression in terms of scheme development as well. Athey (1990, p133) argued evidence of the incremental development is in short supply, and “If more were known about the build-up of co-ordinated schemas and concepts, more would be known about how best to teach some of the key concepts of the curriculum right through schooling.” (Athey, 2007, p114).

The Montessori Red Rods activity that Jack undertook provided schemes and schema which will act as ‘developmental precursor’ for more elaborate mathematical understandings related to length and measurement.

For both Jack and for his educator as well, there is a reciprocal link where knowing facilitates doing and doing facilitates knowing, as Neisser (1976, p56) explains: “The schema is not only the plan but also the executor of the plan. It is a pattern of action as well as a pattern for action.”

The mathematics curriculum is itself an elaborate figurative schema and if educators are to understand what constitutes mathematical learning we need to consider these schemas and not just the children’s most recently acquired schemes. As Wells (2015, p2) argues, “Mathematical & Scientific concepts are acquired as a result of deliberate and systematic instruction”.

In her writings on Spontaneous Activity in Education, Montessori (1965) refers to children’s intelligence in terms of being ‘well versed’ in a subject and, when speaking of culture, she talks about their learning associated with the compositions, and science ‘of the period’. She wrote: “To be able to distinguish, classify and catalogue external things on the basis of a secure order already established in the mind, this is at once intelligence and culture.” (Montessori, 1965, p205)

These are configurative (schema related, such as gaining an understanding of length) ‘orders’, that she refers to, which are progressively represented internally in the mind of the child, and which are also presented in authoritative and established cultural products and texts. The common practice of applying the term schema to child behaviours that both Piaget and Athey clearly regarded to be schemes (such as the process of seriation using the Red Rods) may have served to limit our understanding of children’s learning and, even more crucially, our understanding of how best to scaffold it.

The central task of our continuing investigations will be to test the analytical model further in our observations of children’s learning, and to follow Montessori’s lead by mapping the cognitive related schemes, and in defining progression to support educators in their scaffolding.

The authors are progressing their work in this area with a pilot study at The Gower School, a Montessori setting in North...
London. Funding is being sought to take their research further and to support the development of publications and training materials to support practitioners within and beyond the Montessori community in their scaffolding of young children’s operative schemes and figurative schema.

References:

Lynnette Brock is an MCI tutor and John Siraj-Blatchford in an honorary Professor of Early Childhood Education at the University of Plymouth.