# Steering STEM education development through play

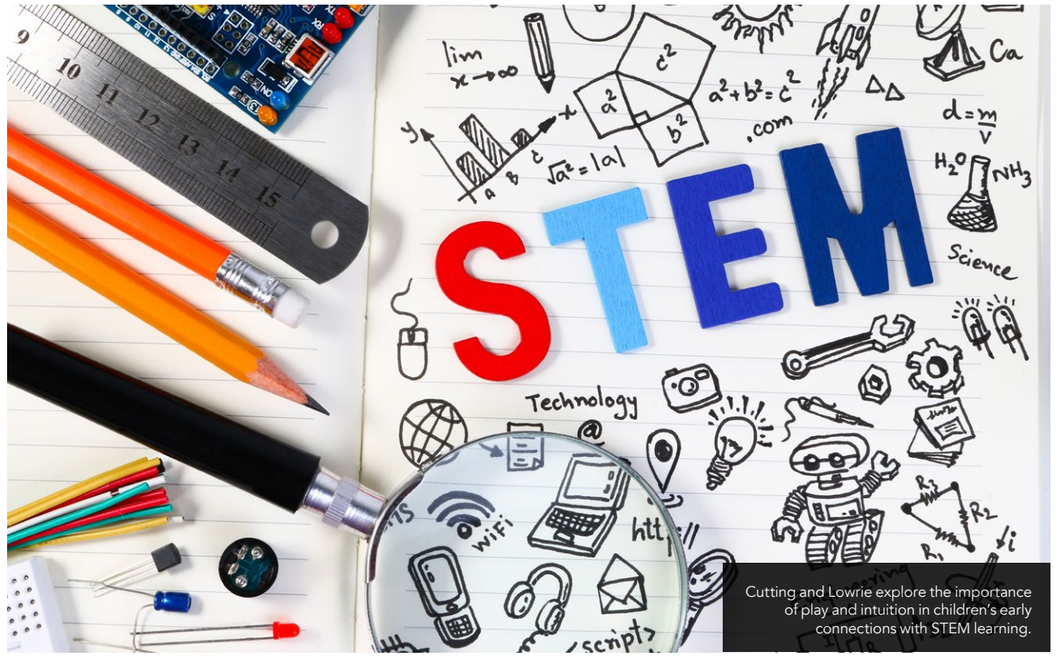
*The growing importance of science, technology, engineering, and mathematics (STEM) for learning at school and beyond is placing increased emphasis on building the framework for their experiences in early childhood. However, designing the learning progressions children experience during this time undervalues a remarkable fact: children's connection with STEM is intuitive. Chelsea Cutting of the University of South Australia's Mount Gambier-based campus, and Professor Tom Lowrie of the University of Canberra's STEM Education Research Centre, have shown how early childhood education can capitalise on this.*

One of the biggest challenges for early childhood educators is assessing children's progression during this particularly free-spirited part of their education. It is a period in their learning that lays the vital groundwork for their educational future. This is especially the case in critical STEM education – science, technology, engineering, and maths. In Australia, as in other countries worldwide, early childhood education practice around STEM is currently geared towards content and assessing children's knowledge of that content. However, two leading Australian STEM education researchers are encouraging educators to rethink how children interact with these subjects by pointing out that it is a crucial component of their play, and that assessing their progression should capitalise on that.

It's easy to watch children at play and be distracted by its seeming frivolity. The reality is that, during play, children develop the necessary foundations to make sense of the world around them. They're learning about what their bodies can do, how to establish and nurture relationships, and, generally, what works and what doesn't. It's a time of great experimentation – if I do this, then what? For Chelsea Cutting of the Mount Gambier based campus of the University of South Australia and Professor Tom Lowrie of the STEM Education Research Centre in Canberra, such developmental play is also the foundation for spatial and logical reasoning – which are critical to how young children develop STEM concepts. With this as their focus, they have developed an innovative approach for investigating and supporting children's learning in early childhood.

## THE 'MESSINESS' OF LEARNING

Childhood education development centres around what are known as 'learning progressions', sometimes called 'learning trajectories' – recognised pathways of how children develop knowledge within a specific domain. Notably, such learning progressions, or LPs, shape instruction and learning design and assessment. This is especially the case in maths and science. Given the nature of these subjects, LPs are usually focused on content – for example, knowing certain basic mathematical ideas by a specific age. Most approaches to developing LPs usually involve cross-sectional, clinical interviews with children, observing the behaviours children may exhibit while doing particular tasks, or the more hypothetical focusing on the tasks that promote children's development within a conceptual domain. However, Cutting and Lowrie argue that the LPs that emerge from such approaches simplify the learning process and undervalue the direct and indirect influences on it – the 'messiness' of everyday, play-based learning.




Cutting and Lowrie explore the importance of play and intuition in children's early connections with STEM learning.

Imagine a group of young children playing, and the focus of their game involves play tools at their disposal. They will sort out a suitable allocation of resources among themselves; it wouldn't be 'fair' or functional for one child to have all the tools, so they will eventually share them. That requires basic mathematics. When they start using the tools, they will realise that certain ones are better suited for specific purposes, digging, say, or carrying water. Those can be considered elements of engineering. When you consider childhood play from that perspective, it becomes increasingly clear how children embrace the central precepts of STEM from an early age. For Cutting and Lowrie, this is critical when developing LPs; it's also more faithful to the fundamentals of early childhood education.

In Australia, educators place significant emphasis on child-led, play-based education during early childhood, underpinned by the Early Years Learning Framework (EYLF). Developed with input from the early childhood sector and early childhood academics, EYLF holds that, far from being vessels for learning, young children are active participants in their education. Furthermore, EYLF is structured around five learning outcomes: children have a strong sense of identity; they connect with and contribute to their world; they have a strong sense of wellbeing; they are confident and involved learners; and they are effective communicators. It's easy to see how the content-focus priorities of STEM education in structuring LPs provide opportunities for disconnect, or at least tension, with the basic principles of EYLF.

***Children explore the basics of STEM, such as patterning, encoding, decoding, problem posing and solving intuitively – they don't have to be taught them.***

## BOUNDED LEARNING PROGRESSIONS

Cutting and Lowrie propose that learning progressions are bounded by the context in which learning occurs. Specifically, when it comes to STEM education in early childhood, such bounded learning progressions, or BLPs, should be learning maps that describe possible pathways of learning that will contribute to achieving connected and meaningful concepts that are developed through spatial and logical ways of thinking.

BLPs emerged from a national play-based learning programme in Australia to encourage children between ages four and eight to explore science, technology, engineering, and mathematics. The programme, ELSA (Early Learning STEM Australia), believes that young children don't make sense of the components of STEM as individual subjects but collectively, via the spatial and logical ways of reasoning. Built upon the work by Lowrie, Fitzgerald, and Leonard, who suggested children do this through a combination of ideas, methods, and values, Cutting and Lowrie propose that it is these that should be the basis for a BLP pedagogical architecture. Problem posing and questioning are examples of *ideas* children will have; they may encode and decode information

Developmental play is the foundation for spatial and logical reasoning, which are critical to how young children develop STEM concepts.

as *methods* and display a clear value for creativity and innovation.

According to the researchers, children explore the basics of STEM, such as patterning, encoding, decoding, problem posing and solving intuitively: yet need to reason logically and spatially to strengthen these foundations. This idea that learning in early childhood is play-based, child-led and supported by responsive and intentional engagement by teachers and educators, is the fundamental philosophy that drives the development of bonded learning progressions Cutting and Lowrie have developed.

**EXPERIENCE, REPRESENT, AND APPLY**

Current LP frameworks usually include an instructional element to the design and assessment of the progressions, and these are typically task-based, especially so with STEM. But that is largely direction-setting rather than responding to the child's self-discovery needs and would be suitable for older children. It is proposed that during play, young children go through continuous cycles of experiencing, representing, and applying understanding as they develop concepts.

***Childhood education needs to embrace a little bit of 'messiness' itself and not be afraid to try new things.***

Through social engagement and language development, children's lived *experiences* become the foundation for developing STEM concepts – educators can draw on this to develop the concepts.

For example, children may be playing with a bundle of blocks, experimenting with different patterns. They experience the mathematical concept of patterning through spatial reasoning. That is, how and where the blocks are placed in relation to one another defines the pattern sequence. Educators can extend children's *experiences* by encouraging them to find different patterns in nature, their environment, or through picture story books.

Once they have done this, educators can help children explore ways to represent their ideas and knowledge. For example, children may use digital and non-digital resources, games, or activities to create images – such as their own patterns, interpret pictures and use symbols to express their understanding. The final phase involves encouraging children to apply their knowledge to unfamiliar contexts – this extends them and allows them to discover the robustness and replicability of the concepts they have learned. An example of the *apply* phase to extend children's understanding of patterns is children use various patterns to create a range of decorations for a classroom celebration. Applied to STEM, this heuristic provides teachers with the pedagogical framework to support learning.

At all points along the process, the focus is not on testing STEM content knowledge, but on developing the central, intuitive STEM concepts of spatial and logical reasoning in a child-led, play-based environment, bounded by the context in which learning develops.

**CAPTURING AUTHENTIC LEARNING**

The bounded approach to developing learning progressions provides a framework for capturing learning in more dynamic, holistic, and authentic ways, encouraging children to explore their intuitive connection with STEM. Like any other innovative learning framework, BLP challenges elements of incumbent pedagogical structures, which doesn't come without a degree of pushback. But as Cutting and Lowrie emphasise, what they're proposing isn't designed to replace current frameworks but to develop future models. If childhood education is to capitalise on the natural energy and exploratory nature of children's early years, it needs to embrace a little bit of 'messiness' itself and not be afraid to try new things.



# Behind the Research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## Research Objectives

Chelsea Cutting and Tom Lowrie explore the importance of play and intuition in children's early connections with STEM learning.

## Detail

**Bio**

**Chelsea Cutting** is a lecturer in mathematics education at the University of South Australia, in the Early Childhood and Primary Teacher education programmes. She is currently undertaking her PhD exploring the role spatial reasoning plays in young children's understanding of early fraction ideas.

**Centenary Professor Tom Lowrie** is Director of the STEM Education Research Centre (SERC) and Program Director for the Early Learning STEM Australia (ELSA) project. Tom's research translation has led to the creation of a commercial learning platform [splatmaths.com.au] that promotes young children's STEM engagement and learning.


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**Collaborators**

- SPLAT-maths splatmaths.com.au

## References


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## Personal Response

***What next steps do you think are necessary to enable future STEM learning frameworks to be embraced into early childhood practice?***

"We hope that our framework will be valuable in supporting educators and teachers to capture learning in ways that respect children's culture and context. From a policy perspective, this includes being able to monitor learning in situations that are play-based and intentional rather than through traditional assessment processes. Teachers should be encouraged to use their professional knowledge and skills to promote authentic and sustained learning engagement, rather than being pressured by 'content achievement' and assessment practices that are at odds with the very nature of early childhood pedagogy. Enabling such agency is critical to promoting and fostering quality educational outcomes."

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