An introduction to supporting early maths in ECE

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ECE resources

Children are surprisingly motivated and able to engage in mathematical thinking and problem-solving before they even begin formal schooling. They explore maths on their own through free play and during informal social interactions with their teachers and peers. Children are thought to already understand some mathematical concepts intuitively from birth, such as comparing set sizes and doing simple arithmetic with groups of objects. Other concepts, such as learning the names of numbers and written numerals, how they map onto their respective groups of objects, and how numerical symbols compare in magnitude and can be combined arithmetically, require more experience and explicit instruction from teachers, other adults and more advanced peers. Early childhood teachers can support preschool children's developing mathematical knowledge through a combination of free play and guided play techniques such as games.

This guide describes some foundational maths skills that children are ready to learn and demonstrate in early childhood, how to tell when children are practising these skills on their own during play, and ideas for ways to incorporate supportive guided and unguided maths learning into the day. The intention is not to advocate for formal or routine maths instruction in ECE settings, but to suggest ways that teachers can notice and respond to children's emerging interest in and understanding of maths by supporting them to further develop those interests and understandings through play.

Numeracy skills

Numeracy refers to the ability to reason and to apply simple numerical concepts. Basic numeracy skills include the ability to identify and understand numbers, to perform simple arithmetical operations (such as addition and subtraction) and to compare numerical magnitudes.

Non-symbolic relations and combinations: Humans and even some animals have the capacity to think about numbers non-symbolically from birth as they are able to distinguish and compare the relative magnitude of one set of objects to another. In infancy, children demonstrate an early concept of number as they can differentiate representations of small quantities quite precisely, can approximately distinguish between larger quantities varying in number, and even recognise basic concepts of arithmetic with small sets of items. The precision of these abilities sharpens over a child's development and is predictive of later maths achievement.

Recognising and identifying symbolic representations: In the toddler and preschool years, children in countries with formal number systems transition to representing numbers in more exact ways through their acquisition of the symbolic number system. They learn to say numbers ('four') and to write them ('4'). They can count sequentially ('1, 2, 3') and begin to recognise their first written numerals. As they get older, children are increasingly able to recognise and name written numerals, both small (1-3) and large (4-10) and extend the range of their count word list.

Connecting symbolic and non-symbolic representations: As they approach the age of five, children develop the ability to link together symbolic and non-symbolic representations of number. For example, they begin to associate the number words they first learned in toddlerhood with the specific sets of visible objects they represent. In learning this skill, children of this age are working on one-to-one

correspondence, or the ability to assign individual count words to single objects in a set. However, when asked to label the set size of the objects, they may fail to identify the last number in their counting sequence as the set size, or produce the appropriate number of objects upon request (the cardinality principle). They will also inaccurately judge the appropriateness of certain counting strategies that may lead to the correct answer but are unconventional (such as counting objects from right to left).

Another critical component of connecting symbolic and non-symbolic number knowledge is the importance of children's ability to understand Arabic numerals, called digit or **numeral knowledge**. This understanding entails the ability both to recognise written numerals (and associate them with the appropriate verbal number names) and to link the numeral symbols directly to their respective quantities. Preschool children approaching the age of five learn to link those symbols to corresponding non-symbolic sets of object arrays (or objects arranged in rows and/or columns). Numeral knowledge acquisition is thought to be the last critical step in the transition from reliance on non-symbolic number representations to competency in representing numbers entirely symbolically. Further, it is predictive of children's success in maths in early to late primary school.

Symbolic relations and combinations: The final aspect of number development in early childhood involves the advanced ability to solve symbolic number problems. It is in this area that children demonstrate their conceptual understanding of numbers, as they are able to move beyond answering the conventional 'how many' question and apply their foundational knowledge to more novel situations. For example, they may be able to determine which of two number words or written numerals is larger, or solve for the sum or difference of two numbers (addition and subtraction). In order to solve these problems, children must keep in mind the magnitude of the numbers involved, their order in the counting sequence, and, in the case of arithmetic, how two numerical magnitudes can be combined to create a new, larger number. Studies have shown that developing these skills in the preschool years is important because they are highly predictive of children's later achievement in maths.

Encouraging number exploration during unguided play

There are many ways that teachers can support children to develop these foundational numeracy skills through play. For example, using toy balance scales can help children in comparing the magnitudes of sets of objects. Dramatic play, arts and crafts, and block areas can also promote children's exposure to different set sizes of objects, particularly as children are keenly attuned to the amount of toys and materials other children have in relation to their own supply. Simply providing activities involving large numbers of objects will encourage children to make these comparisons on their own. Further, the redistribution of toys and materials that often results from conflict over unequal toy distribution is an opportunity to experience non-symbolic arithmetic.

Young children rarely need prompting to count objects. In fact, they will seek out items in their environment to quantify, whether those items were intentionally provided or not. But children's play can benefit from exposure to large quantities of small objects that differ in perceptual features like colour and shape (such as **lacing and stringing bead sets**). Children often like to sort objects by similar characteristics and then count those groups of objects, so having a variety of objects will increase counting opportunities.

Children can also be exposed to written numerals in many kinds of play. Playing 'shops' with toy money and cash registers provides exposure to numerals in culturally meaningful contexts. This supports numeral knowledge by motivating children to associate those numerals with prices for and specific quantities of food items. Children can also be exposed to modified playing cards with dots and their respective quantities either on the same card or differing cards. Children can practise matching the

number and dot cards (if they are separate) or exploring the connection between the numbers of dots and the numerals on the same cards. Number puzzles and 100's charts that display numerals in order also support children to learn the magnitudes of numerals by helping them to compare different numerals to each other.

Spatial skills

Spatial skills are thought to be necessary for mathematical reasoning and problem solving and research shows that young children's spatial skills predict their later maths achievement. This is because they help children to mentally visualise information (which is helpful for doing arithmetic) and learn mathematical concepts (for example, watching and tracking set-size transformations such as adding to a group of objects). In particular, spatial visualisation (transforming mental images of objects) is a particularly sophisticated skill that begins to develop during the preschool years and is the spatial skill most consistently and strongly associated with concurrent and later mathematical knowledge. Visual–spatial working memory skill (remembering and reproducing sequences of locations of objects) also develops during early childhood and relates to concurrent and later mathematical knowledge.

Encouraging spatial exploration during unguided play

Young children are naturally drawn to building and shape play—two activities that are fundamental to spatial development. Children can be provided with model pictures or preassembled constructions to recreate or left to create their own structures. Preschoolers enjoy using regular wooden blocks, which require consideration of how to keep the structure stable, as well as toys like **Magformers** or Lego that can be connected to each other. Playing with Tangram/pattern blocks and model pictures encourages children to identify shapes and fit them into the appropriately shaped spot on the pictures. Children can also assemble the tangram blocks together without relying on the model pictures. These activities emphasise important shape properties and require planning as well as trial and error to position the shapes in the correct spots on model pictures, or, in the case of tangram blocks, in a way that allows different shapes to fit together.

Pattern skills

Pattern skills are thought to support finding and generalising rules and regularities that are core to mathematics, and research shows that preschool children's pattern skills predict their later maths achievement and numerical knowledge. Patterning is considered to be important for mathematical thinking because it supports how children learn rules about numbers (for example, the next number in the count sequence is one more than the previous number, and if a number appears after another in the count sequence, it must be larger in magnitude). Pattern skills for young children focus on repeating patterns or linear arrays that have repeating units such as **ABB**ABBABB. Around the age of three, children begin to develop explicit knowledge of repeating patterns and are able to recognise examples (such as the stripes on a shirt). As they get older, preschool children develop increasingly sophisticated pattern skills. They first master fixing patterns (filling in missing items) and duplicating or copying model repeating patterns. They then become adept at extending patterns (continuing an existing pattern by at least one unit of repeat, such as ABCABC**ABC**), and abstracting patterns (recreating a model pattern using a different set of materials, such as ABBABB to CDDCDD using red/yellow and blue/green blocks). Eventually, children are able to verbalise and demonstrate what makes a sequence a repeating pattern (by identifying the core unit that repeats in a pattern).

Encouraging pattern exploration during unguided play

Children often enjoy identifying and creating patterns using everyday objects. Children can make beaded necklaces in either repeating or symmetrical patterns using lacing and stringing bead sets or other arts and crafts materials such as buttons or pompoms, or make patterns from blocks that vary in colour and shape. If sample pattern designs are already displayed (such as an actual necklace or a picture of different symmetrical or repeating bead or block designs), children can copy those patterns using the same or different materials (if intentionally provided with materials that do or do not match the model), or make their own patterns. Materials can also be set up so that children can extend patterns of objects using beads or blocks (such as providing a partially created beaded necklace pattern secured with a knot that can be built upon on the remaining string).

Further reading

Rittle-Johnson, B., Zippert, E.L., & Boice, K.L. (2019). The roles of patterning and spatial skills in early mathematics development. Early Childhood Research Quarterly, 46, 166-178.

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Zippert, E.L., & Ramani, G.B. (2017). Parents' estimations of preschoolers' number skills relate to at home number related activity engagement. Infant and Child Development, 26(2).

Zippert, E.L., & Rittle-Johnson, B. (2020). The home math environment: More than numeracy. Early Childhood Research Quarterly, 50, 4-15.

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