Math and Science in the Kindergarten

• Lisa Gromicko

Steiner-based, early childhood settings abound with rich opportunities for the development of math and science concepts. This may be surprising to some who can easily see the beauty, coziness, and language-rich environment of the Waldorf kindergarten, but not necessarily the mathematical or scientific side. A primary focus of Waldorf early childhood education is on the care and development of the physical body of the child, and that of the child's environment. Considering the "physical" basis of the early years, it then becomes possible to glimpse the natural mathematical relationships. In reality, *all activities* of Steiner-based early childhood education are math- and science-based, including activities of language acquisition and pre-literacy, such as listening and word recognition, patterning, and story sequencing.

How do young children learn fundamental math and science concepts and skills? Concepts are the building blocks of knowledge, accumulated and built upon through experiences and physical movement in the world. Healthy children manipulate concrete materials (including their own bodies) in every situation, collecting "data," and through repeated exposure finding order for that "data." The order the child creates leads to the development of concepts. Young children are naturally astute mathematicians and scientists, learning vast amounts of information daily, as they explore the world and move their bodies. Without needing flashcards or structured lessons, the young child learns the fundamentals of math and science concepts with every sense impression, movement, and action. Research has shown that structured math and science lessons in early childhood are premature and can be detrimental to proper brain development for the young child, actually *interfering* with concept development.

The activity of *play*, especially, provides the child with the most enriched setting for the learning of concepts. "If we observe carefully, child's play is revealed to be excellent unconscious preparation for future education in mathematics and natural sciences, provided this play can proceed freely, and without an adult agenda" (Patzlaff et al., 112). We can see in the young child, the brilliant genius of play in its most scientific essence. Like the archetypal scientist the child is totally absorbed, taking great interest, exploring and playing with the physical world.

Beginning in infancy, the young child is learning concepts. The free exploration of the early years provides the foundation for all future math and science learning. The infant begins to perceive the world and eventually to track the movements of activity in the surroundings, feeling the various textures of objects, the warmth of a caretaker's embrace, that of the sunshine, or the cold wind blowing on the face (*temperature*). The child is also unconsciously living and learning at this time about the powerful rhythms of day and night, the concept of *time sequence*. The child learns about the physical experiences of hunger: how the body feels, what audible expressions are needed to bring a caretaker with nourishment, the comfort in the body of having physical and emotional needs met.

Then, physical movement begins. One day, the child becomes aware of his limbs, and this begins the long process of discovering how to grasp objects. The child investigates every object within reach: tasting, turning over, rattling, biting, dropping objects to the ground. Concepts such as weight, texture, hardness, shape, taste, sound and temperature are all registered continually at this age through primarily *naturalistic* experiences, led by the child. These spontaneously initiated experiences are the primary mode of learning in the early years, and continue to be valuable for older children as well. An interesting and rich natural environment, with adults engaged in purposeful activity, provides the child with endless opportunities and motivation for interacting with the surroundings.

Mobile toddlers learn multiple concepts about *spatial* relationships with the world in their tireless efforts to stand up and walk, and then fall down

and get up again. Becoming upright and mastering movement through the three planes of space is a monumental accomplishment and informs all future concepts of spatial understanding. Activities such as crawling over and under, climbing, walking, running, and jumping naturally provide the essential bodily basis of geometry and physics. The child will now endlessly sort objects, pick them up, carry them, place them inside a container and then dump them out again, developing the concepts of *one-to-one correspondence* and *cause and effect*. It is very interesting (and fun!) to bang on pots with wooden spoons, drop food on the floor, build with blocks, and pick up the tiniest objects visible on the ground. Toddlers explore the concept of *weight,* especially that of "heavy." They also experiment with throwing objects into the air. Being in water provides another "laboratory," where this fluid medium allows for the experience of buoyancy.

Healthy physical development of the child is a critical prerequisite for proper mathematical and scientific education. Plenty of movement and opportunities for play provide physiological, neurological, and experiential foundations for learning about the physical world (Marxen). The young child needs tremendous amounts of movement (often under-estimated today), sleep, and a healthy diet rich in essential fats, in order to support the proper myelinization of the brain, which is required for the successful development of sensory, motor, and cognitive functions, in preparation for academic readiness.

> *His consciousness slowly awakens to grasp the qualities of space and time, of quantity, number and geometric laws in correspondence to his physical development. That is why the healthy formation and maturation of the sensory organs and their functions, as well as the movement organism, are a top priority of preschool and kindergarten education, extending into the first few grades of elementary school.*
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> *Through their activities the children come to know the properties, qualities and patterns of their environment. For example, coming to stand upright and learning to walk are experiences of gravity and spatial dimensions. Later, similarly, the child bodily experiences momentum and buoyancy, gravity, centrifugal force, friction, and so forth, when he jumps rope, plays on the swings, merry-go-round, teeter-totter or slides. He can comprehend these principles and transpose them into his play, when, for example, he lets chestnuts roll down the slope of a wooden board or when he builds runways for marbles or bridges and towers. In this process he also explores the laws of leverage, stasis and balance* (Patzlaff et al., 113).

All young children delight in participating in concrete, everyday activities, all of which support math and science concept development. Those of the home or kindergarten environment are especially accessible at this age: taking the compost out to the garden, digging and preparing the garden, watching the plants grow, caring for pets, sweeping the floor, setting the table, chopping vegetables, serving food, dusting the furniture, woodworking, picking up toys and putting them away (*ordering*), sorting the onions from the potatoes (*sets and classifying*), sorting laundry, putting the boots by the front door in order, baking.

Singing together and playing live (unrecorded) music allows for proper development of the inner ear, forming musical and acoustical foundations for math and science. Movement in play and circle/ring time provides many opportunities for learning body geography. This also helps develop balance, spatial awareness and orientation, and vestibular, proprioceptive, and kinesthetic integration, all of which provide critical foundations for mathematics. Playing with logs, stumps, boards, bricks, ropes and so on allows for mechanical learning that can include levers, fulcrums, and pulleys.

Dramatic play includes dressing up, "house" building, and the imaginative (representational) use of objects. For example, a piece of wood may be used as an iron or telephone, or a puppet used as a character to tell a story, which provides the neurological foundations for the later use of abstract *symbols* (numbers and letters) to represent ideas. Cooking allows for learning the concepts of *measurement, parts and wholes, chemistry, volume.*

Preschool and kindergarten-aged children learn about the concept of *counting* by counting napkins, birthday candles, how many chairs are needed at the table? They enjoy rhythmic, repetitive language in storytelling and with counting, clapping, songs and verses, which support mathematical foundations. They love to sort toys, shapes, colors, animals, which develops the concept of *classifying*, a pre-algebraic skill.

Order, *patterns*, and *sequence* become very

important at this age as the young child begins to organize these concepts and have beginning capacities for abstract thought. The earlier acquired concept of *one-to-one correspondence* in infancy and toddlerhood is foundational for the concepts of this stage. Examples of this concept for the young child include: one mitten for each hand, one shoe for each foot, one hat for each head, one coat hook for each coat, one seed for each hole in the planting row, one chair/cup/bowl for each person, etc. According to the National Council of Teachers of Mathematics (NCTM), *one-to-one correspondence* is a focal point for *number and operations* at the pre-kindergarten level (Charlesworth and Lind, 118).

The development of math & science "concepts and skills" from birth to age seven follows a developmental sequence (Charlesworth and Lind, 3). Several standard concepts are listed below, with examples of activities that may occur in a Steiner/Waldorf early-childhood setting or at home. In addition, young children naturally acquire standard science process skills, such as questioning, analyzing, reasoning, communicating, connecting, representing, investigating, and organizing through plentiful daily opportunities for cooperative and/or solo free play and practical activities.

From birth to age two (continuing to develop throughout childhood):

Observation
Watching the leaves fluttering on the trees, investigating toys, watching a caregiver, ants moving on the ground, reflections in the water, plants growing in the garden, seeing the rainbow or the stars. Is it day or night? Raining or snowing? Filling the bird feeder and watching the birds. Wet-on-wet watercolor painting.

Problem solving
Crawling or walking over and around objects, carrying objects, eating, stacking, filling up and dumping, picking up heavy objects. Building "houses" or other structures in play. Having enough of something to go around. Cracking nuts, sawing wood, buttoning or zippering a coat, tying shoelaces and tying/untying knots. Sewing. Finger-knitting.

One-to-one correspondence
"One for you and one for me," putting on shoes/hat, lids on pots, one little bear in each boat, sitting on a chair, planting one seed in each hole, one ticket for each train passenger, taking turns "one at a time." Each puppet represents one character in the puppet play. Playing catch with a ball or beanbag. Hammering nails. Serving food to others.

Number
Three apples, two shoes, one kitty, one kiss, one baby, four children, one cake, three candles, and so on.

Shape (Development of tactile sense, pre-geometry and basis for learning concepts of sorting and "sets and classifying")
Experiencing objects in the environment: ball, block, feather, soft blanket, chair, table, toy car, pinecone, rock, pencil, cup, mud, pillow, ice cube, mother or father's skin. Hard/soft, smooth/rough, wet/dry. Playing in the sand and mud, playing in the water. Polishing shoes or wooden toys. Oiling cutting boards. Building with blocks. Blowing bubbles. Washing clothes with a washboard. Finger-painting. Crayoning. Manipulating playdough, bread dough, beeswax. In circle/ring time: making a circle, spiraling in and out of the center, expanding and contracting.

Spatial Sense (Activities that develop orientation and awareness of one's own body in space, facilitating brain development and left/right hemispheric processing)
Circle/ring time, "Movement Journeys" (Blanning and Clark), obstacle courses. Crawling under, walking around, sitting on, stepping over, behind, next to, above, on top of. "Zoo exercises" (McAllen), "Jack be nimble, Jack be quick, Jack jump over the candlestick," "The Curly House of Snail." Building and then playing inside of a "house" or "fort." Building with blocks. Playing "The Hokey Pokey." Eurythmy. Walking on logs, stumps, river stones, a balance beam. Bean-bag games. Finger-plays. Sweeping the floor (crossing the midline).

From two to seven years:

Sets and classifying (pre-algebra)
Sorting: laundry, buttons, seeds, carrots from potatoes, spoons and forks, toy cars from trucks, wooden animals. Grouping objects by color, use, etc. Collecting autumn leaves, stones, seashells, and other objects.

Comparing
Bigger/taller than, smaller/shorter than, "The Three Billy Goats Gruff," "The Three Bears." Heavy or light, color differences, taste, smell. Hot and cold.

Speech variation in storytelling, nursery rhymes. Does an object sink or float? Light and shadow. Loud and quiet, hard and soft, giant steps and tiptoe steps, yelling and whispering. "Breathing" in and "breathing" out. Contrast of rest and movement becomes a foundation for music.

Counting
How many carrots do we need so that each rabbit will get one? How many crackers are on the plate? "The Three Little Pigs." Songs such as: "Five Little Ducks," "This Old Man," "Baa Baa Black Sheep."Verses such as: "1 2 3 4 5, Once I Caught a Fish Alive," "I Have Ten Little Fingers," "One, Two, Buckle My Shoe."

Parts and Wholes (Preparation for fractions in grade school)
Slicing a loaf of bread, cutting apples in half (to see the "star"), chopping vegetables for soup. Playing the game "The Farmer In The Dell," where part of the group goes into the center and part stays in the outside circle. Peeling potatoes. Acting out stories. Cooking. Grinding wheat, rolling oats. Pizza slices.

Language
Communication during work or play, describing ideas or observations. Naming activities. Cooperative-play discussions among children. Storytelling, verses, nursery rhymes.

Ordering, seriation, patterning (logic, pre-algebra)
Daily, weekly, yearly rhythms; predictable daily events. Seasonal festivals. Circle games. Storytelling, poetry, verses—rhythm of language. Rhythmic clapping. Putting toys away into their places after playtime. In play: lining up cars, blocks or train cars in order of size, color. Stacking toys. Experimenting freely with materials to create a pattern, such as making tissue-paper "stained glass windows" or stringing beads.

Informal measurement: weight, length, temperature, volume, time, sequence
Measuring ingredients for cooking and baking, pouring tea, filling the bird feeder, growth charts (how tall am I?). Is it cold outside or hot? Ironing. Digging in sand and filling buckets, pouring water at a water table or bathtub (filling and dumping). Playing on a teeter-totter or using a balance scale: who/what is heavier? Planting seeds and watching seedlings grow. Sequential stories and nursery rhymes: "The Gingerbread Boy," "Hickory Dickory Dock," "Little Louse and Little Flea," "Henny Penny," "Jack and Jill," "Little Jack Horner," "Brown Bear, Brown Bear." Dipping candles.

Graphing (representational)
Daily chores list, growth charts, Advent calendar, birthday calendar. Pictorial "graphs" that show information, such as drawing pictures of what came to the bird feeder today.

Higher level skills:

Number symbols
Using numerals (symbols) to represent the amount of a group of things. "I am six years old." My phone number is _____." Recognizing number symbols.

Groups and symbols
Matching a symbol to a group or a group to a symbol. Child takes play money, or a group of objects to represent "money," and goes to the play store to "buy" things. Shopping at a children's holiday market, such as the "Winter Faire" in many Waldorf schools. In the sandbox, a child makes a "birthday cake," puts six candles on it, and may write the number "6" or have an adult write it.

Concrete (real objects) addition and subtraction
A child has two seashells and finds two more seashells – two and two make four. Giving away two seashells to a friend leaves two. "Bartering" play. Handing out party favors to friends at a party. Collecting and using tokens in a game.

Each day in the kindergarten, the wheel is "re-invented" in multiple ways. All physical laws are worked with unconsciously in play, as children test and discover new ways of working with the physical world around them. It is an exciting and innovative "flow" environment, where every idea is possible and each child is an inventor. The enormous "research" of early childhood in play and movement forms the essential physical basis for math and science.

> *The connections and associations that the child experiences through play, through experiments with the play materials, and through the use of his entire body coalesce into a still-unconscious physical-kinesthetic intelligence. This builds the foundation for the exacting, mathematical and scientific thinking and understanding in later life* (Patzlaff et al., 114).

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