

STEM LEARNING FOR INFANTS AND TODDLERS



An abundance of research indicates that infants and toddlers are thinking about their surroundings at birth. They naturally explore as they grow and develop. While these young children do not think in terms of STEM fields, nor do adults, their explorations are indeed based on STEM interactions (Boston Children's Museum, 2013; McClure, 2017; McClure et al., 2017; Stacey, 2019).

STEM is an acronym for Science, Technology, Engineering, and Mathematics. The Boston Children's Museum has developed definitions for the four areas in thinking about how it looks when infants and toddlers engage in STEM.

- Science is exploring materials and making predictions based on observations.
- Technology is using tools, being inventive, identifying problems, and building materials.
- Engineering is solving problems, using a variety of materials, designing and creating, and building things that work.
- Mathematics is a way of measuring, sequencing, patterning, and exploring shapes, spaces, volume, and size.

(Boston Children's Museum, 2013).

When we recognize this, we are more able to observe, understand, and analyze what the children are doing and what they may be thinking. Typical infant and toddler activities are full of STEM thinking—banging objects is science (sound); mouthing toys is mathematics (what fits in my mouth—spatial relationships) and science (taste, smell); reaching for something out of reach is engineering problem-solving and technology (using another object to move the goal object). These are just a few of the opportunities to examine STEM relationships for our youngest learners.

Many educators indicate that they are aware of children's actions but have not considered them from the perspective that they are related to STEM thinking. When adults are alert to how infants and toddlers think and learn, both educators and young children will be elevated as learners. In the policy report by the Early STEM Working Group, "Early STEM Matters: Providing High-Quality STEM Experiences for All Young Learners" (Spaepan et al., 2017), the authors suggest that there are four guiding principles to consider as we "do" STEM with young children:

- Children need adults to develop their natural STEM inclinations.
- Representation and communication are central to STEM learning.
- Adults' beliefs and attitudes about STEM affect children's beliefs and attitudes about STEM.
- STEM education is not culturally neutral.



When infant and toddler educators understand what is needed for an inquiry learning environment and what STEM means for young children, many will find that they are already providing science, technology, engineering, and math in their daily activities. With some consideration of the language used to scaffold these activities, re-organizing of the classroom space, increased scrutiny of the visual displays, and the addition of some recycled or inexpensive materials, educators can turn classroom activities into inquiry learning experiences that infants and toddlers will return to again and again. All of this provides the basis for inquiry, analysis, and logical thought. It's how infants and toddlers learn.

HOW DO INFANTS AND TODDLERS LEARN?



We now know that the cognitive abilities of young children far surpass what has been previously attributed to them. Infants and toddlers are able to imagine another person's experiences, understand cause and effect, and begin to construct ideas and theories about how things work in the world (Gopnik, 2010). Thirty years of research has illuminated how infants and toddlers learn best when they are able to establish relationships with trusting adults, and when they have early experiences that take into account their competencies as well as their vulnerabilities. The best early learning experiences are those that involve play. Infants and toddlers use play to develop a systematic collection of information in order to make sense of their world. Adults can witness an infant or toddler engage in inquiry when they observe a child interested in open-ended materials and:

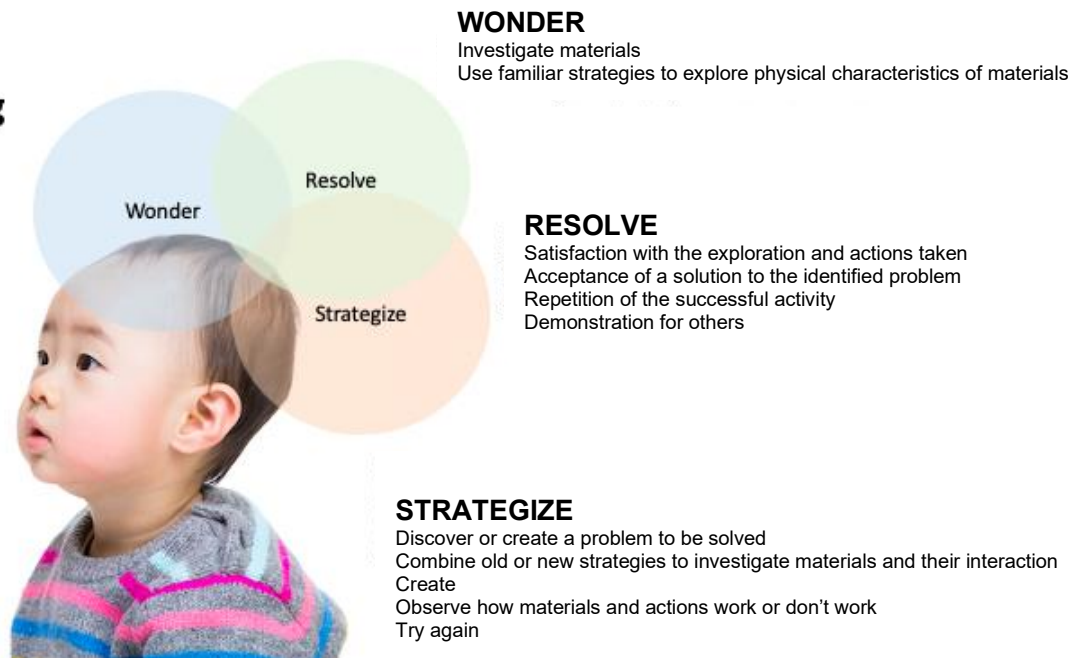
- Performs an action
- Observes what happens
- Repeats (*and repeats and repeats and repeats!*)
- Varies their action.

Sometimes the child's action is accidental, but the child observes the result and then tries to reproduce it. The repetitive action of play allows for their construction of understanding how their world works. Among different children, actions on materials may look similar, but more likely, **actions will vary** from one child to the next based on cultural differences as well as individual learning differences. For inquiry to be successful, adults must accept this seemingly **messy approach** while children are learning. Responsive teachers closely observe infants and toddlers in their play and reflect on their actions. This observation and reflection are vital to understanding the thinking of our youngest learners who cannot yet verbalize the meaning of their actions. These observations are the basis for decisions that are made about every aspect of the infant toddler environment. This awareness about how infants and toddlers learn and the importance of early experiences is the basis for the **Infant Toddler Inquiry Learning Model (ITILM)**, a model developed after many years of observing infants and toddlers in environments where supportive adults invited them to engage with open-ended materials.

INFANT TODDLER INQUIRY LEARNING MODEL

The ITILM describes a kind of **free inquiry** in which infants and toddlers **wonder, resolve, and strategize** as they play. This inquiry process is not linear, indicated by the overlapping circles in the model.

Infant Toddler Inquiry Learning Model



Infants and toddlers move freely among wonder, resolve, and strategize as they engage with open-ended materials. As they handle and explore the materials, they construct physical knowledge and logical-mathematical knowledge and reflect on what they have experienced. They decide whether to repeat an action or try new strategies. They may stop to think for a while, or leave, ignoring the materials altogether. If the child has not accepted the solution to a problem, revisiting that problem with new strategies or materials extends the inquiry process until the child reaches a resolution that is acceptable to them, even if that resolution is to leave the problem behind.

The *Infant Toddler Inquiry Learning Model* is a way to think about how very young children best learn through exploratory experiences as they engage with the world. When adults observe and think about children's actions as they explore, they can more clearly understand how to support their learning.

THE TEACHER'S ROLE

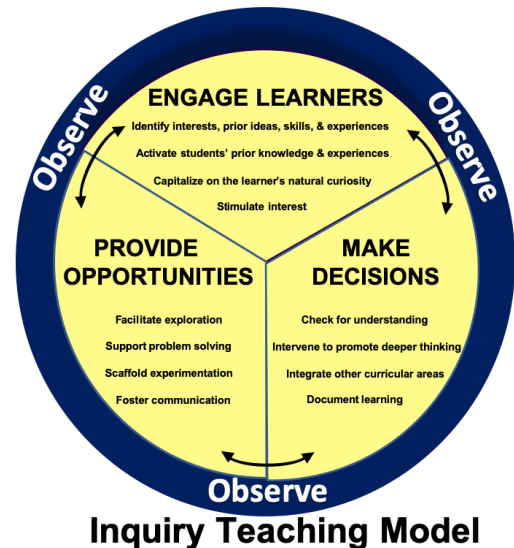
The evidence is irrefutable that for infants and toddlers all learning happens within the context of nurturing and responsive interactions with adults who are important to them. Responsive environments include consideration of children's unique developmental needs, interests, and emerging skills. "Developmentally appropriate practice with infants and toddlers requires the [teacher's] ability to adapt a pattern of care quickly to meet children's rapidly changing needs" (Lally et al., 2005).

The Inquiry Teaching Model (Counsell, et al., 2016) describes how teachers of young children can support inquiry. Adults begin the inquiry teaching process when they **observe** carefully and continuously. Even though infants and toddlers may not be able to verbalize questions they have, they do generate questions as they grapple with understanding how the world works (Greenfield et al., 2017). Careful observations can direct adults to understanding what an infant's or toddler's specific questions may be.

While infants and toddlers engage willingly with any new materials, educators can be intentional by providing materials that invite exploration and encourage learning. Young infants are limited in their ability to explore unless educators place materials within view or reach, while toddlers will use their developing motor skills to explore materials that are available. Educator observation will support understanding of the limits of engagement so they can provide new materials, make comments, or ask questions that stimulate additional explorations.

Providing opportunities and observing the children's actions will provide information about children's struggles to reach their goals, allowing the educator to expand on ideas and scaffold or support explorations while building vocabulary. Using self-talk or parallel talk supports preverbal children in their beginning attempts at language. In self-talk, the educator describes their own actions as they perform them. You may have heard an educator narrate his or her steps as they change a diaper or prepare some materials. In parallel talk, the educator describes the child's actions as they happen. Beyond their simple communication, these strategies also support children's thinking and understanding. Educators also enhance opportunities to learn when they provide supportive comments or ask open-ended questions to support children's explorations.

Observing children's engagement supports adults' **decision-making** about adding materials, providing feedback, or simply noticing what children are doing without interfering. When adults observe that a child is struggling with a problem, their intervention must be based on what they know about how infants and toddlers learn and what they know about the individual child. Simply giving the answer to children does not support inquiry learning or the development of STEM learning dispositions. Educators who want to support inquiry will find strategies to promote problem solving and scaffold learning.



Inquiry Teaching Model

Teaching through inquiry means teaching with intention. When engaged in inquiry teaching, educators are intentionally working to support children's learning through engaging with curriculum and materials and through decision-making about how to proceed. Their actions support the children's construction of both physical knowledge and logical-mathematical knowledge, and when appropriate, educators provide cultural knowledge through their interactions with the children. There are multiple opportunities for enhancing communication skills as educators provide labels for new items, provide encouragement for explorations, and ask questions that guide the children's focus on what happens (Counsell, et al., 2016)



The educator's role is to respond thoughtfully to children's signals, value their interests, support their curiosity, and extend their capacity whether their actions translate to: "Let me try it on my own," or "I need help." As they explore the materials for the first time or for the fiftieth time, the adult's response to them can boost confidence, competence, autonomy, and perseverance, all necessary in the development of life-long learners who feel secure as they find problems and work out the solutions to those problems. "Teachers can create and carry out a classroom culture that either fosters or discourages engaged and active thinkers" (Salmon & Barrera, 2021, p. 60).

DESIGNING AN INFANT TODDLER CLASSROOM ENVIRONMENT FOR INQUIRY

The notion that the environment can be a powerful influence on learning has long been recognized by early childhood leaders, researchers and practitioners. "The environment should suggest a sense of belonging, a sense of well-being, and an invitation for engagement. An early childhood classroom should reflect the community and culture where children live" (Edwards, Gandini, & Forman, 1998). The environment is the context in which all connections are made; this includes connections among the people who inhabit the space and the mental connections that are the basis for learning. An environment that is ready for inquiry is a place where:

- children recognize themselves, their families, and their communities in the artifacts that are selected for display
- children can explore and investigate without interference in a place that is safe and secure
- classroom arrangement and the materials selected for children have been tested by adults to determine if they provide the possibility for inquiry
- children have choices
- centers visible to children are always available
- items intended for adult use are out of reach or behind closed doors
- routines are predictable and schedules are flexible to allow educators to capitalize on children's interests
- children are viewed as competent and have opportunities to connect new ideas to what they already know and can do
- educators support rather than intervene and pay close attention to what children are doing in order to understand
- there is mutual trust - the child trusts the educator to give full attention and the educator trusts the child to solve some of his or her own problems
- adults explain what you can do, not what you can't do.

Environments are powerful. They can welcome children and families by honoring their cultures and communities. They can provide security when children are uncertain. They can inspire exploration by providing spaces that are inviting and materials that are open-ended. And they can be extraordinary places where children thrive and adults are supported in their important work. Nurturing a classroom community that invites inquiry is an ongoing process and requires a commitment from program administrators so that educators of infants and toddlers have opportunities for planning and collaboration. When educators have dedicated time to work collaboratively and grow professionally, they feel valued. This contributes to the healthy climate of the program and of individual classrooms.

SELECTING MATERIALS

The selection of materials that will engage infants and toddlers in inquiry requires careful observation and should be based on children's interests. Observation is the foundation for inquiry teaching and learning. When planning experiences for young children, teachers can ask this question - *What is there in this activity for children to figure out?*

Suggested materials for STEM Focus Areas for Infants and Toddlers:

Blocks

- Selection of blocks with various sizes, weights, textures, & colors (enough so many children can build)
- Soft cloth, vinyl, or foam blocks
- Large interlocking blocks such as MegaBloks or Duplos
- A good set of wooden unit blocks including arches, pillars, ramps, & curves
- Interesting blocks to inspire imagination (window blocks, tree blocks, magna-tiles)
- Materials to support dramatic play (vehicles, block people, trees, trains, tracks)
- Large hollow blocks
- Containers to drop blocks into
- Buckets/baskets/wagons for hauling & carrying
- Boxes of many sizes
- Protected area for building



Contents & Containers

- Muffin tins - at least 2 sizes
- Plastic strainers of various sizes
- Large & small hard plastic balls in 13 cup square container
- Clear plastic container with handle & lid with soft balls
- Clear plastic containers with lids - square (various sizes)
- Colorful plastic balls & water bomb soft balls
- Plastic pitcher with balls - hard, soft, large, small
- Large & small hard plastic balls in 12-cup square container
- Water bomb soft balls, wooden balls
- Colored Scarves
- Nesting Measuring cups
- Plastic bottle with lid
- Salsa Bowls
- Clear plastic round containers with lids - variety
- Clear plastic rectangular containers with lids - variety



Tubes and Balls

- Clear, plastic tubes (sturdy tubes, not flexible) of various diameters (2"-3 1/2") and lengths (12"-36")
<http://www.safespaceconcepts.com>
- Blocks of various sizes (some that will fit into the tubes and some that will not)
- Balls of various sizes and materials (some that fit into the tubes and some that will not)
- Opaque tubes of various diameters and lengths that can be procured from printing shops
- Colored scarves
- Materials found in the classroom that children will add to the center (blocks, stuffed animals, loose parts)



Check the blocks and balls using a choke tube before you give them to the children. Make sure they do not fit into the choke tube. If a choke tube is not available, the adult may use a paper towel tube to check the size.

Water Investigations

- Plastic tubs or dishpans (or small water table made for infants who are sitting and standing)
- Cafeteria trays
- Towels or rugs
- Translucent and transparent beakers, graduated cylinders, measuring cups, and pitchers
- Translucent and transparent plastic containers with lids of varying sizes including sippy cups
- Plastic balls of varying sizes and composition including water balls and nerf balls
- Ping pong balls, small wiffle balls, and golf balls
- Plastic fishing bobbers
- Funnels
- Sponges of varying sizes
- Sieves or strainers
- Soup ladles and slotted spoons
- Plastic cheese, salt, or sugar shakers
- Eye droppers or pipettes
- Plastic water pump that is easy to activate
- Spray bottles



PUTTING IT ALL TOGETHER

Designing an inquiry learning environment for infants and toddlers must be intentional and based on observation, documentation, and consideration of each aspect of the environment. With an ongoing reflective process, educators can achieve the delicate balance between safety and an invitation to explore independently. When infant and toddler educators understand how the environment can support inquiry learning, their natural instincts for selecting and providing high quality early learning experiences will be enhanced and refined. As children acquire new skills and interests, new children join the classroom, or older children move on to new classrooms, educators can modify the environment to accommodate these changes. The educators of these youngest children can support the learning of each and every child by creating spaces filled with a variety of intriguing materials, flexible furnishings, effectively placed lighting, thoughtfully designed displays, and responsive adults with an understanding of the importance of relationships for learning.

Infants and toddlers think like scientists. They explore, hypothesize, try things out, and rethink when their results are not satisfactory. We encourage you to think like scientists in your work. Explore the materials yourself, observe how children use them, hypothesize on what they are thinking and learning, try ideas that support or challenge children's thinking, and then analyze your observations as you rethink what you thought you knew about infants and toddlers.

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