*Chapter 2*

# WHY LITTLE MAKERS?

## Libraries are the perfect place to introduce young children and families to making, tinkering, and STEM.

Libraries are free, open to everyone, and offer programs where children and families can attend together. Statistics from the American Library Association (ALA) show that minority and economically disadvantaged families make up a high percentage of groups that visit libraries frequently. Libraries bridge the gap for children who don't have access to expensive daycare facilities, STEM camps, or museum passes.

In 2013, the Institute of Museum and Library Services (IMLS) published *Growing Young Minds: How Museums and Libraries Create Lifelong Learners* with the call to become more intentional about the library's role in early learning and preparing all children for a lifetime of learning and success. The report described 10 ways museums and libraries support young children. Number three directly relates to the Little Makers program and this toolkit: "Supporting development of executive function and 'deeper learning' skills through literacy and STEM-based experiences."[1]

The Little Makers program offers multiple opportunities for children to use the thinking skills of inhibitory control, working memory, and cognitive flexibility, known as *executive functions*. Research shows that executive functions, more than IQ, predict a student's success in school.

STEM and science have been a priority in libraries as far back as 1994, when the American Association for the Advancement of Science (AAAS) and author Maria Sosa published *Great Explorations: Discovering Science in the Library*. Sosa encourages family involvement, noting, "Libraries can help make parents more aware of the importance of

1 Institute of Museum and Library Services. (2013). *Growing young minds: How museums and libraries create lifelong learners.* https://www.imls.gov/publications/growing-young-minds.

science. They can also provide opportunities for families to participate in informal science experiences that provide a strong foundation for learning science."[2]

Further, a family's involvement and attitude are the most important predictors of student success.[3] Research resoundingly points to the importance of libraries engaging families in STEM fields and activities, but little research has been done to show *how* libraries can best do so specifically with very young children.


## Starting Young

Research tells us that children's early experiences build brain architecture and lay the foundation for lifelong thinking skills. Young children are highly receptive to learning from STEM activities. A robust body of empirical research over the past 30 years demonstrates that starting in infancy, children develop and test intuitive theories about the world around them, much like scientists do.[4]

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2 Sosa, M. (1994). *Great explorations: Discovering science in the library.* Washington, DC: American Association for the Advancement of Science.
3 Henderson, A. T., & Mapp, K. L. (2002). *A new wave of evidence: The impact of school, family, and community connections on student achievement.* Austin, TX: National Center for Family and Community Connections with Schools.
4 Gopnik, A. (2012, September 28). Scientific thinking in young children: Theoretical advances, empirical research, and policy implications. *Science 337*(6102), 1623-1627.

Babies enter the world exploring, testing, and evaluating cause and effect. Preschoolers and some verbal toddlers can learn concepts in specific science domains,[5] exhibit reasoning skills for making sense of science investigations,[4] use number sense to estimate and compare quantities,[6] and apply algorithmic thinking to create simple computer programs.[7]

An early introduction to STEM, tinkering, and a maker mindset can develop science vocabulary and fluency, but it can also foster curiosity, leading to a lifetime of learning. In 1993, the National Education Goals Panel (NEGP) suggested that children who start school with "a lack of curiosity are at greater risk of subsequent school failure than other children" and reported that kindergarten teachers believed that curiosity was a more important predictor of school readiness than the ability to count or recite the alphabet.[8] In fact, researchers estimate that preschoolers ask an average of 76 information-seeking questions per hour![9] And we want them to continue asking critical questions throughout their life.

However, typically, parents and caregivers are far more comfortable supporting children's literacy development—reading with and to young children—than they are incorporating STEM learning through everyday experiences. Many adults don't yet recognize the potential of activities, such as building, fixing, crafting, shopping, cooking, gardening, hiking, etc., to inspire children's curiosity and build their STEM content knowledge.

## Making & Tinkering

Think about a time in life when you were curious about how something worked. How did you find out more? Did you read a book? Take it apart? Ask another person? Among the ways we explore our curiosities is by making and tinkering. In this toolkit, we use the terms *tinkering* and *making* interchangeably, but it's worth looking at what these terms mean.

We define tinkering as exploring materials, tools, and ideas, while making refers to the process of using hands-on, interest-driven learning to construct ideas and products. Both are related and contribute to the maker mindset, which promotes that capabilities are continually developed, improved upon, and refined through experiences involving success, mistakes, and persistence.

5 Gelman, R., & Brenneman, K. (2004). Science Learning pathways for young children. *Early Childhood Research Quarterly 19* (Special issue on Early Learning in Math and Science), 150–158. http://ruccs.rutgers.edu/images/personal-rochel-gelman/publications/GelmanBrennECRQ.pdf
6 Clements, D. H., & Sarama, J. (2003, January). Young children and technology: What does the research say? *YC Young Children, 58*(6), 34-40.
7 Bers, M. U. (2008). *Blocks to Robots*. New York: Teachers College Press.
8 National Education Goals Panel (NEGP). (1995, September). *Building a Nation of Learners*.
9 Chouinard, M. M., Harris, P. L., & Maratsos, M. P. (2007). Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development, 72*(1), i-129.

"I really think it was a confidence booster for her just to be able to work with these materials and build something, make something, explore, see what she can do." *—Parent/Caregiver*

This Venn diagram by the National Association for the Education of Young Children (NAEYC) simplifies the concepts and shows their interconnectivity as it relates to the STEM field of engineering.


Through the act of tinkering, children engage in improvisational problem-solving. They learn about material properties and proper tool use, developing fine motor skills along the way. This foundational work leads the way to making even more complex projects. At the core of all making and engineering is the ability to understand materials, use tools, and identify and test possible solutions. Tinkering is the gateway to developing these essential skill sets.

Early childhood is the prime time to explore making and tinkering. Children are constantly using their senses to explore the materials around them. They tinker as they explore how things work by taking things apart or putting them together. Making and tinkering activities that don't come with blueprints tend to encourage and amplify children's creative ambitions and self-directed learning. And many making activities also focus on developing collaborative learning, with an emphasis on learning by doing, building critical social-emotional skills.

## Playful Process

Esteemed child psychologist Jean Piaget famously said, "Play is the answer to how anything new comes about." In other words, play is how we learn. It's natural for children and all animals to play. It's the main way we learn about ourselves, our relationships, and our environment.

When you hear the word play, you might think of creating mud pies in the backyard as a child, making up games with your friends, or building a fort with your siblings out of blankets and pillows. What you might not think about is the variety of skills you gained by participating in these activities, from social-emotional skills, building your imagination and creativity, problem-solving, and so much more! We know that play is one of the most effective ways for children to gain a large suite of skills, including STEM.

> "Play is not frivolous: It enhances brain structure and function and promotes executive function (i.e., the *process* of learning, rather than the content), which allow us to pursue goals and ignore distractions." *—The Power of Play*[10]

Play is at the heart of children's learning, as developmental psychology demonstrates over and again. In a recent article for *The Atlantic*, developmental psychologist and author Alison Gopnik argues that "Play lets the young learn by randomly and variably trying out a range of actions and ideas and then working out the consequences ... The gift of play is the way it teaches us how to deal with the unexpected."[11] And how better to help young children than by preparing them for the unpredictability of life!

Children also, importantly, need to interact with materials and ideas in order to learn.[12] Particularly as children grow and become more aware of and curious about the world around them, interacting with interesting and novel materials, exploring cause and effect, and playing with physical objects all build children's thinking skills. And one of the most authentic ways to engage in this type of exploration is through tinkering. As was

10 Yogman, M., Garner, A., Hutchinson, J., Hirsh-Pasek, K., Golinkoff, R. M., (2018). The Power of Play: A Pediatric Role in Enhancing Development in Young Children. *Pediatrics*, *142*(3), e20182058. https://doi.org/10.1542/peds.2018-2058
11 Gopnik, A. (2016, August). In defense of play. *The Atlantic*. https://www.theatlantic.com/education/archive/2016/08/in-defense-of-play/495545/
12 Hawkins, David. 2002. "I, Thou, It." The Informed Vision: Essays on Learning and Human Nature. 51-64.

mentioned in the previous section, tinkering is defined as the open-ended exploration of materials, where the focus is on the process, the doing, the exploration, and not necessarily on creating a "thing."

Current research suggests that there's a large spectrum of types of play, and each serves a distinct purpose in a child's life. Therefore, free play, imaginative play, tinkering, etc., all have a place. In this toolkit, we lean toward presenting experiences and programs for children and families with a tinkering and exploration lens in mind, not necessarily an end product, since that tends to be an area of growth for many library educators.

## Learning Through Tinkering

For the Little Maker project, we used the Learning Dimensions tool developed by the Tinkering Studio at the Exploratorium to guide the creation of our programming. This tool helped to establish the learning dimensions that are central to each tinkering activity we offered.

| Initiative & Intentionality | Social & Emotional Engagement | Creativity & Self-Expression | Conceptual Understanding | Problem Solving & Critical Thinking |
|---|---|---|---|---|
| • Setting one's own goal<br>• Taking intellectual and creative risks<br>• Working without a blueprint<br>• Complexifying over time<br>• Persisting through and learning from failures<br>• Adjusting goals based on physical feedback and evidence | • Building on or remixing the ideas and projects of others<br>• Teaching and helping one another<br>• Collaborating and working in teams<br>• Recognizing and being recognized for accomplishments and contributions<br>• Developing confidence<br>• Expressing pride and ownership | • Responding aesthetically to materials and phenomena<br>• Connecting projects to personal interests and experiences<br>• Playfully exploring<br>• Expressing joy and delight<br>• Using materials in novel ways | • Controlling for variables as projects complexify<br>• Constructing explanations<br>• Using analogues and metaphors to explain<br>• Leveraging properties of materials and phenomena to achieve design goals | • Troubleshooting through iterations<br>• Moving from trial-and-error to fine-tuning through increasingly focused inquiries<br>• Developing work-arounds<br>• Seeking ideas, assistance and expertise from others |

For our target age group, these learning dimensions manifest themselves in the following ways:

**Social & Emotional Engagement:** The Little Makers program is about co-learning. It's designed to encourage adults and children to learn together by having fun and realizing that you don't have to know all of the answers. These experiences help children develop the skills to interact productively with others.

**Initiative & Intentionality:** Facilitators of the Little Makers program model excitement and provide opportunities for children to apply new skills and prior knowledge through listening carefully, responding to, and taking pleasure in each child's own unique curiosities. Children might also show initiative by planning for future activities or persisting through challenges.

**Problem Solving & Critical Thinking:** Children develop problem-solving skills through opportunities for hands-on discovery, inviting children to use materials in new ways, and allowing children to find their own solutions.

**Conceptual Understanding:** Conceptual understanding isn't about knowing, but rather about understanding. Conceptual understanding is demonstrated when children grasp new ideas and then transfer and use them differently. For this age, this is more visible over a longer period of time.

**Creativity & Self-Expression:** By focusing on the process rather than the product, the Little Makers program encourages children to come up with new ideas and not stress that there's only one right answer. Allowing children adequate time and space for creativity to flourish is important when designing programming.

In this reformulated version of the framework below, the learning dimensions are reiterated at the top. The left side shows indicators of participant agency, from responding to exploring to owning, for each learning dimension. This progression is partially dependent on the developmental stage of the participant, in our case the child attending the programming.

## DIMENSIONS OF LEARNING FOR MAKING AND TINKERING

| Levels of Agency | Initiative & Intentionality | Social & Emotional Engagement | Creativity & Self Expression | Conceptual Understanding | Problem Solving & Critical Thinking |
|---|---|---|---|---|---|
| **Responding** Initial interactions and observations | Initial Engagement | Working Side by Side | Browsing Materials | Noticing the Phenomena | Making Initial Observations |
| | Active Participation | Building Together | Personalizing Projects | Asking Questions | Engaging in Trial-and-Error |
| **Exploring** Probing the problems, variables, and possible solutions | Expressing Intentionality | Modeling for Others | Playfully Exploring | Observing the Variables | Learning Through Failure |
| | Persisting in the Problem Space | Collaborating with Others | Striving to Create a Unique Solution | Seeking Explanations | Honing in On Key Variables |
| | Taking Intellectual and Creative Risks | Mentoring Others | Applying Aesthetic Solutions to Achieve Design Goals | Expressing Tentative Theories | Testing more Focused Solutions |
| **Owning** Taking intellectual risks, applying understanding, and contributing to the community | Shifting Project Goals | Co-Leading Group Activities | Recognizing the Creative Work of Others | Constructing Explanations | Applying Unique Solutions |
| | Planning a New Idea | Creating New Activities | Re-mixing and Re-building | Expressing Conceptual Understanding | Eager to Find a new Problem to Solve |



Through the Little Makers program, we found that the Responding level of agency was age-appropriate for our audience of ages 2 through 6. But remember that even within that age range, you'll still see differences that aren't a reflection of the quality of your program, but rather the developmental stage of the individual child. For instance, working side by side (or "parallel play") is developmentally appropriate for young toddlers, but it's not until ages 4, 5, or even 6 that some children can effectively build together. Using these markers as a guide, library educators can begin to observe learning happening in tinkering and making experiences. We'll refer back to this chart later when we talk about program planning and reflection.

# Designing Developmentally Appropriate Programming

Most resources available—whether they be activities, program ideas, or frameworks—may not have been designed specifically for early childhood or the particular age range you're trying to reach. Therefore, you must always keep in mind the age and developmental stage of the children you serve when designing early childhood programming.

The difference between designing for a 2-year-old and a 5-year-old is vastly different. You can't expect a 2-year-old to be able to rip tape or to sit still for more than about 10 minutes at a time. They just don't have the fine motor skills yet and are still working on building executive function skills like self-control. Children's brains are developing so rapidly during the early childhood years that social skills, fine motor skills, and many others will be vastly different.

Realizing that this age span has so many differentials in demonstrating cognitive understanding, we relied on many resources. The table below highlights the typical abilities and interest levels of various ages based on an article from *Early Childhood Today*.[13]

| | |
|---|---|
| **Age 2–3** | ▪ Ask questions about why things are the way they are and how things work.<br>▪ Observe similarities and differences between objects.<br>▪ Conduct experiments, such as stacking blocks in a new way.<br>▪ Predict cause and effect. |
| **Age 3–4** | ▪ Enjoy sorting and classifying objects.<br>▪ Begin to classify things by their functions.<br>▪ Notice and compare similarities and differences between objects.<br>▪ Use words to describe their observations.<br>▪ Become interested in complex experiments and using new materials in a variety of ways. |
| **Age 4–5** | ▪ Enjoy exploring and using new materials and objects.<br>▪ Use concepts such as height, size, and length to compare objects.<br>▪ Enjoy learning about real-life places and things and how they work. |
| **Age 5–6** | ▪ Engage in long-term science projects, such as growing plants, recording the weather, and collecting and comparing shells.<br>▪ Classify items by a variety of similarities and differences.<br>▪ Have a long attention span for activities that interest them. |

The American Library Association's Association for Library Service to Children (ALSC) and the National Association for the Education of Young Children (NAEYC) can be helpful resources to refer to as you begin to experiment with modifying programming to meet the needs of your particular audience. We touch on more specific things to keep in mind throughout the rest of this toolkit and the Tiny Tips feature.

13 Science Development and Young Children. (2001). *Early Childhood Today*, 15(6), 48.