



Considerations for STEM Education from PreK through Grade 3

This brief draws on research and development supported by the National Science Foundation to highlight important considerations about STEM educational experiences for young children and professional learning for educators who provide those experiences.

What Does STEM Mean?

In this brief, “STEM” is meant to include science, technology, engineering, and mathematics as individual disciplines and as the integration of those disciplines with each other. Because research in mathematics and science education is more extensive, these disciplines receive more attention in the brief.

- » **Science** is the study of the natural world, seen and unseen. Science includes what scientists and children who are doing science learn (concepts and crosscutting ideas) and how they go about learning it (the practices of science).
- » **Technology** involves the application of scientific knowledge for practical purposes, such as to improve productivity, make things, or provide services. It includes all human-made objects—basic and advanced, non-digital and digital—that support us in work and in our daily lives.
- » **Engineering** is the process of designing to meet human needs and wants under various constraints such as time, money, available materials, and the laws of nature. Engineering has strong connections to many other disciplines, particularly mathematics, science, and technology.
- » **Mathematics** is the study of quantity, structure, shape, and change. It provides a foundation for many aspects of daily life, including for much of science, technology, and engineering. The mathematical sciences include more than numbers and arithmetic—they also deal with such topics as geometrical figures and structures, measurement, and logical argumentation. Mathematicians and children doing math use the practices of mathematics to identify crosscutting patterns and structures and to understand and explain phenomena.

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Now is the Time to Increase Children’s Early Exposure to STEM

Quality early STEM experiences provide a critical foundation for learning about these disciplines in ways that facilitate later learning and that are called for by the *Common Core State Standards for Mathematics*, *Next Generation Science Standards*, and *International Standards for Technology in Education*. Early childhood educators

have a unique opportunity to benefit all students by bringing the STEM disciplines into greater balance with literacy, reducing early inequities in access and opportunity to learn STEM, and developing skills and understandings that students can build on as they progress through school and into civic life and the workforce.

A Vision for Early Learning in STEM

Learning in the STEM disciplines, done well, is rich in experiences, problem-solving, and communication. It provides natural opportunities for language development and use. Young children begin the process of developing conceptual understanding through investigating, discussing, reading, and writing about STEM-related ideas and phenomena. They are capable of broad and deep learning in STEM if provided with coherent, consistent instruction over years.



Dedicated time to engage in quality STEM learning in PreK through grade 3.



Curricula that are comprehensive in their treatment of content and mathematical and scientific ways of thinking, and that include opportunities for reading, writing, and speaking.



Teaching that connects to and builds on what is familiar to young children and their families and caregivers; connects the STEM domains to each other and to other domains such as art, literacy, and language; and sustains the cultures of students of color.



Learning environments that integrate the STEM disciplines with literacy development and social and emotional competencies, and that allow for the joy of discovery, including through play.



Supports for teachers to build STEM knowledge and apply effective STEM teaching strategies.

Research Says Early Learning in Science and Mathematics Matters

Early learning in mathematics and science:

- » **Promotes socio-emotional development.** Doing quality STEM leads to social and emotional growth and fewer challenging behaviors.
- » **Supports the development of STEM-related habits of mind.** These habits of mind include curiosity, critical thinking, communication, collaboration, persistence, problem-solving, and positive attitudes toward science and mathematics.
- » **Helps with later learning in all subjects.** Learning and doing science and mathematics contributes to gains in those subjects, supports literacy and language development, and is associated with increased reading comprehension and stronger writing skills. These improvements carry over into subsequent grades, and in mathematics, they can predict later achievement.
- » **Benefits students from all backgrounds.** Children who are non-English speakers, for example, can engage in powerful science explorations that help them build knowledge and understanding in STEM while they are learning English. These experiences can place low language demands on children and provide them with opportunities to hear, gain understanding of, and use common English vocabulary, as well as STEM-specific language (e.g., area, properties, force, pattern), in context.

ALL Young Children Have the Capacity to Learn and Do STEM

Young children and STEM are a perfect match.

- » Young children are curious, inclined to explore, and eager to understand and make sense of their world. They like to build, collect items, organize their collections, take things apart, and put them back together as part of their normal experiences and play.
- » These traits and behaviors are central to the STEM disciplines. They help children to begin to develop STEM understandings, and lay the foundation to learn STEM more formally.

Young children have surprising capabilities in STEM, and they can communicate their knowledge.

- » In mathematics, with high-quality experiences, young children from all backgrounds can:
 - › **Engage in various forms of mathematical reasoning**, including logical reasoning with familiar ideas or situations, and build arguments that explain their mathematical thinking.
 - › **Make sense of measurement and geometry concepts** such as length, area, and volume.
 - › Begin learning to **engage in powerful arithmetic thinking**, even in preschool, including relating addition and subtraction to counting, and composing and decomposing numbers using visual (and other) models.
 - › **Reason in powerful ways about algebraic structure and relationships**, even using important mathematical representations such as variable notations.
- » In science—with high-quality experiences, and teacher and peer support—young children from all backgrounds can:
 - › **Explore scientific ideas**, such as structure and function, cause and effect, and patterns, as they interact with phenomena in classroom science investigations and in the world (e.g., caterpillars turning into butterflies, water evaporating at different rates).
 - › **Engage in the practices of science** (e.g., asking questions, investigating, constructing explanations, designing solutions), which provides a basis for learning scientific concepts and language.
 - › **Reason with representations of physical processes**, such as making sense of simple models (e.g., a wind vane) and using them to help explain phenomena (e.g., wind and speed).
 - › **Begin learning engineering ideas** about form and function (e.g., why different tools are made the way they are, how materials are different) **and scientific ideas** (e.g., systems, growth and development).

- › Communicate their thinking by, for example, talking about their experiences with peers, recording observations in science notebooks, illustrating ideas through pictures and models, and organizing information in charts and tables.

Early Educators Can Support STEM Learning and Discovery

Quality early STEM requires time and scaffolding from teachers.

Self-discovery and sense-making are vital to developing understanding and reasoning ability. Yet, autonomous, discovery-based learning requires scaffolding and support. Strategies for promoting STEM learning and discovery include:

- » Treating all children as STEM learners and providing them with equal opportunities to participate in rich STEM learning experiences.
- » Listening to children and watching what they do as they explore, play, talk to one another, and engage in classroom STEM activities to learn what they understand about STEM concepts.
- » Drawing out children’s prior experiences and ideas about STEM topics (e.g., whether they have seen worms in their yard, how they divide their snacks to share).
- » Making connections to children’s homes and community lives (e.g., cultures and languages).
- » Encouraging children to share and elaborate on their observations and ideas, even if they are “incorrect.”
- » Suggesting further investigation to test children’s emerging ideas.

STEM experiences are natural launching pads for developing literacy and language competencies. In science, for example:

- » Reading fiction and nonfiction books that illustrate a scientific idea can prompt discussion about that idea, and develop knowledge that enables children to further investigate it. This approach develops comprehension and core literacy skills as it builds STEM knowledge.
- » Having children communicate the results of scientific inquiry (e.g., in science notebooks) creates opportunities for authentic literacy activities, even among preschoolers, who are developing pre-literacy skills.

Additional Information, Resources, and References:

<https://go.edc.org/earlylearning-resources>

Families are important partners in building children's early STEM interest.

- » Children's homes and neighborhoods can be rich resources for STEM. To draw on these resources, educators can:
 - » Make connections between children's in-school and out-of-school experiences (e.g., in their backyards, neighborhoods, parks, and libraries).
 - » Include family and community members in early STEM activities and connect them to STEM resources online and in their communities.

Early Educators Need High Quality Supports to Teach STEM Effectively

Broadly speaking, professional learning should address the following general topics (see box for more specific topics):

- » Developmentally appropriate STEM concepts and practices
- » Pedagogical strategies that deepen STEM learning
- » Strategies for inclusiveness and cultural responsiveness, including connections to homes, families and caregivers, and communities

Professional learning for early childhood STEM educators should have the characteristics that are associated with effective professional learning in general:

- » Ongoing
- » Connected to their classroom practice
- » Tailored to and changing with teachers' needs through their careers

Approaches that have been shown to benefit early STEM educators also are worth considering:

- » One-on-one coaching
- » Well-structured professional learning communities
- » Opportunities to rehearse, analyze, and reflect on instructional practice
- » The engagement of teacher-leaders who facilitate early STEM activities and provide a range of supports to their colleagues

Specific Topics for Professional Learning

How young students construct STEM knowledge, and how to engage them in the practices of science, mathematics, and engineering

In math, as an example:

- ✓ Research on early learning of mathematics, including the development of numbers, the importance of counting experiences, and how counting strategies develop into addition and subtraction
- ✓ Learning trajectories for critical topics in mathematics, including the learning goals, levels of thinking, and instruction connected to each of those levels

Connections between STEM and students' everyday play, interests, and explorations

In science and engineering, for example:

- ✓ How to teach ALL areas of science (including physical science and earth and space science) in ways that allow children to explore and investigate phenomena directly
- ✓ How to engage young children in engineering and design by taking advantage of their natural interest in building, creating, and making interesting things happen

Integrating the STEM subjects with each other, and integrating literacy into the STEM subjects

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