Introduction

Think back to your earliest memories of solving a problem while playing.

Did you

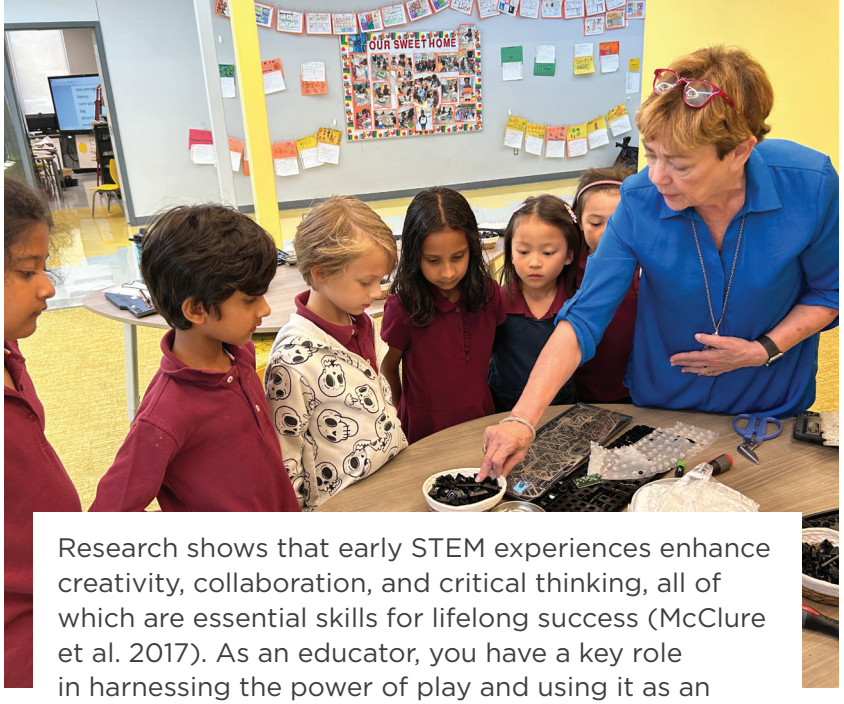
- Figure out an easier way to lift things into a tree house?
- Tape boxes together to create a cool car?
- Build an elaborate fort?
- Use sticks, leaves, or pine needles to create a floor plan for a dream house?
- Adjust ramps to make toy cars go faster?
- Fold and refold paper airplanes so they would fly farther?
- Take apart an old toy and try to put it back together?

How much time did you spend thinking about and doing these activities? Where did the materials you worked with come from? Did you return to your ideas over many days to improve them? How did you feel when you solved the problem?

This is what tinkering, making, and engineering look like for young children.

STEM Learning and Play

Playful early childhood experiences like these combine problem solving, experimentation, and imagination—the same qualities that form the foundation of science, technology, engineering, and mathematics (STEM) learning. These experiences also nurture curiosity and resilience, fostering a mindset that values exploration and innovation. Children start by using their senses to explore the physical properties of materials. They take things apart, put them together, figure out how things work, and attempt to build creations using tools. When faced with a problem, children ask questions, make plans, work together, test their ideas, improve their designs, and share their creations with others. These are the same thinking processes and actions used in science and engineering.



Research shows that early STEM experiences enhance creativity, collaboration, and critical thinking, all of which are essential skills for lifelong success (McClure et al. 2017). As an educator, you have a key role in harnessing the power of play and using it as an entry point for STEM learning. You can guide these explorations—and simultaneously empower children to take ownership of their learning—by offering open-ended materials, creating inviting spaces, and asking thought-provoking questions.

Is It Tinkering, Making, or Engineering?

Tinkering, making, and engineering represent different but related approaches to exploration, creation, and problem solving. Rather than follow a strict hierarchy, children move fluidly among these activities as they discover and innovate.

Tinkering is a playful starting point where exploration and curiosity drive learning. It involves engaging with materials, tools, and phenomena—that is to say, thinking with your hands and learning through doing.

As children tinker, they learn about the physical properties of materials and the capabilities of tools (Boston Children's Museum 2016). They are also developing their fine motor skills. By slowing down and cultivating curiosity about the everyday environment, tinkering fosters a deeper understanding of the world (Bevan et al. 2015). It is inherently open-ended, emphasizing experimentation, testing, and discovery through informal exploration without a specific end goal. Tinkering often begins with simple questions sparked by an interest in objects or processes, such as

- What can I do with this? (Exploring possibilities)
- What happens if I move this? (Experimenting with cause and effect)
- How does this work? (Investigating function and mechanisms)

Making involves turning an idea into a tangible creation. Children use materials and tools to purposefully build something functional, decorative, or expressive. While the terms *tinkering* and *making* are often used interchangeably, making lies somewhere between tinkering and engineering (Boston Children's Museum 2016). Making encourages children to bring their ideas to life while learning through trial and error. Their questions often reflect planning and creativity, such as

- What materials should I use to make this work? (Choosing resources)
- How can I make my creation look the way I imagined? (Considering design and aesthetics)
- What happens if I add this piece? (Iterating and improving)
- Can I make it do something special? (Exploring functionality and purpose)

Engineering focuses on solving specific problems by designing, testing, and improving solutions. STEM professionals solve real-world challenges that often come with constraints, including limited materials, time, and funds to develop solutions. Engineering asks children to create something with certain requirements and goals in mind. Questions often arise from external prompts or real-world challenges posed by educators or the environment, such as

- How can you build a bridge strong enough to hold a toy car? (Addressing constraints)
- What can you change in your creation to make it work better? (Testing and refining)
- What tools do you need to make this happen? (Choosing resources and processes)

Engineering builds on tinkering and making by introducing intentional problem solving and iterative design processes, meaning that children take steps to try, tweak, and refine their ideas over and over again. The engineering design process typically involves components like thinking about the problem, building or creating a solution, trying it out, revising or improving it, and sharing the final product or solution. While different models may use varying terms, the fundamental elements of the process remain the same. These elements will be explored in more detail later in this book, but it's important to recognize that the engineering design process is dynamic and adaptable, reflecting its nonlinear nature.

Although distinct, you can see from these explanations how tinkering, making, and engineering often overlap. A child might begin by tinkering with materials, transition to making a simple structure, and then apply engineering principles to solve a problem. Figure I.1 illustrates their key shared elements:

- **Materials** provide the foundation for creativity and exploration.
- **Tools** enable children to manipulate and experiment with materials.
- **Creativity** inspires innovative thinking and problem solving.
- **Resilience** encourages persistence through trial and error.
- **Problem solving** fosters critical thinking and strategy development.

Together, tinkering, making, and engineering form a powerful pathway into STEM learning, preparing children to tackle challenges with creativity and confidence.

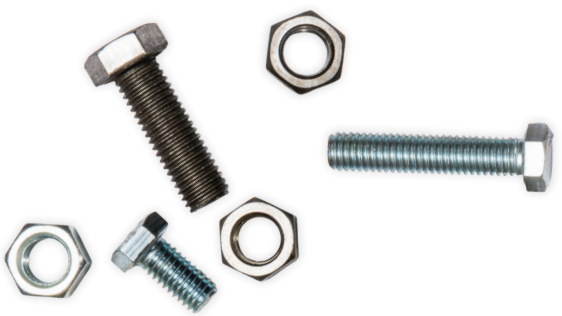


Figure I.1. Common Elements of Tinkering, Making, and Engineering

Adapted, by permission, from Boston Children's Museum, *Tinker Kit: Educators' Guide* (Boston: Boston Children's Museum, 2016), 4.

About This Book

This book is grounded in the belief that young children are natural-born explorers, creators, and problem solvers. Their curiosity, creativity, and drive to figure things out are exactly the qualities that scientists and engineers use every day. This resource offers design challenges for children ages 3 to 8, blending tinkering, making, and engineering into real-world problem solving. The challenges begin at a familiar starting place—the problems faced by characters in picture books. Throughout, teachers are encouraged to engage children in hands-on, minds-on playful learning experiences that move beyond worksheets and not only align with standards related to STEM but also connect to literacy, social studies, and other content areas. Design challenges invite young learners to explore standards in a way that is dynamic, natural, and engaging.

Open-ended explorations are essential for this approach. When children use materials with no prescribed purpose, they are free to experiment, iterate, and discover. They also develop important STEM habits of mind, such as observing, testing, comparing, and revising. The flexibility of these design challenges is inspired by Mitch Resnick's (2017) conceptual framework for learning environments that are accessible to beginners (a low floor), encourage advanced exploration (a high ceiling), and support various approaches (wide walls). Moreover, because of their engaging nature, the design challenges foster a state of flow in which children are fully immersed and motivated to learn, much like professionals experience deep focus and satisfaction in their work (Nakamura & Csikszentmihalyi 2002). By emphasizing STEM, the design challenges encourage the practical application of math and science skills in meaningful projects, moving beyond

Box I.1. Integrating the Arts in STEM

STEM is used throughout this book to align with the growing emphasis on preparing children for success in science, technology, engineering, and mathematics. However, it must be acknowledged that the arts—including visual arts, music, drama, and dance—are integral to many of the design challenges in this resource, transforming STEM into STEAM. The arts enrich early childhood learning by offering unique opportunities to connect science, technology, engineering, and mathematics to creative exploration, innovation, and self-expression. In embracing the arts, this book also honors the cultural traditions that have long inspired creative expression, helping children connect their learning in STEM to the world around them.

By integrating an element of the arts, children are invited to explore STEM concepts in ways that are accessible, meaningful, and fun. Through visual arts, they might draw project plans or craft sculptures from recycled materials, developing spatial reasoning and an understanding of stability. Music-related activities, such as building instruments from everyday objects and composing rhythms, provide an avenue to explore sound vibrations and pattern recognition. When children act out the story that inspires a design challenge or role-play as inventors, drama fosters their skills in problem solving and teamwork. Dance allows for experimentation with the physics of movement (e.g., balance, force, momentum) and natural phenomena like waves and wind patterns. This interdisciplinary approach not only nurtures creativity but also strengthens foundational STEM competencies, helping educators and children alike benefit from richer, more holistic learning.

memorization. They also strengthen executive function skills such as planning, focusing attention, and problem solving. The components of the design challenges in this book and how they encompass these ideas are discussed in more detail in Chapter 4.

When teachers thoughtfully guide learning by asking questions, introducing tools, encouraging collaboration, and prompting reflection, children begin to connect playful exploration to deeper STEM concepts and real-world thinking. This book also offers practical support for teachers, helping you to create environments and experiences that foster joy, engagement, and discovery.

What's New in This Edition

Much has changed in the field of early STEM education since the first edition of this book was published in 2017. In this revised and updated second edition, there is new and expanded content to better support teachers and learners. This includes

- New design challenges as well as favorites from the first edition that have been revised and shaped to make the experiences for children and guidance for teachers more robust.
- An updated collection of books that serve as springboards for design challenges. While the STEM content is always central, the stories matter. These selections were chosen with care to better reflect the diverse experiences, interests, and identities of young children.
- Updated language and structure to reflect current thinking about how children learn through play and exploration.
- Clearer connections among tinkering, making, and engineering, with examples that show how these approaches overlap and build on one another.
- New guidance on how to observe, document, and assess learning during tinkering, making, and engineering experiences.
- Updated safety guidance, new classroom examples, and teaching strategies and tips.
- Stronger support for reaching all learners, with strategies to ensure that every child—regardless of background, ability, or language—can participate in meaningful STEM learning experiences.
- Ideas for creating early learning settings that reflect all children, including ways to draw on family knowledge, cultural traditions, and everyday experiences to make learning more meaningful.

Whether you're brand new to tinkering or a seasoned maker, this book is here to inspire and support you. As you guide children through these experiences, may you find joy in their discoveries and inspiration in the energy and ideas they bring to every challenge.