

CREATIVE INVESTIGATIONS IN EARLY ENGINEERING & TECHNOLOGY

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Dedication

To my favorite makers and tinkerers, Griffin and Cullen. Thank you for the inspiration!

Introduction

The excitement level is high in Mr. Adams's classroom because the children are anxious to modify—by painting, cutting, and gluing—the found objects they have been collecting during the week. Mr. Adams and his students are working on a long-term project on recycling and reuse. For this part of the project, the children are using discarded objects to create three-dimensional (3-D) sculptures. They have been studying artists who create assemblage art out of natural and man-made materials—*assemblage* is art that is made by putting together dissimilar elements, often everyday objects, found and reinvented by the artist. As a design-based learning project, the assemblage project is an iterative process where the children are actively involved in every step: investigating the context through studying the need for recycling and reuse; learning about the ways in which people, including assemblage artists, reuse discarded objects; deciding what objects can be reused in art; collecting and sharing their found objects; thinking through and drafting designs for their artworks; modifying and assembling objects to create their artworks and reworking any aspect of their designs once they have assembled their artwork.

This marks the beginning of the point in the project where the children must transfer their 2-D drawings of their imagined artwork into a 3-D work using the objects they have collected and modified. The design-based nature of this project encourages the children to try out their ideas and revise or change them as necessary when they run into unexpected challenges. As a first step, Finn has decided to use brass door hinges to create a “robot family.” In his drawing, he has the door hinges making up the torso of the robots. The robots are each different colors, so Finn decides that he must paint the hinges before assembling the robot. Finn carefully chooses colors that match the colors he drew on his robot sketch. As he paints, Mr. Adams checks in and asks Finn how the painting process is going. Finn shares that he is frustrated that the paint isn't drying quickly, so he won't be able to glue his pieces together today. Mr.

Adams pauses to remind Finn that the assemblage artworks don't have to be finished quickly and that he should take the time he needs to paint and put together his robot. "All week?" asks Finn, and Mr. Adams replies, "You can work on it all week and even into next week. Remember the artwork we looked at on the iPad? Those artists worked for months and even years designing and making those sculptures. You have to remember that your robot isn't going to lay flat, so you can see it from all sides." Finn stops painting and picks up one of his hinges; flipping it over, he says, "I'm going to paint the back too. It's the back of his robot shirt." "Right," says Mr. Adams. "Now you've got it; think it through!"



Finn reinvents the door hinges into colorful robot bodies.

As Mr. Adams shared with Finn, design-based learning is typically project based and encourages the students to work on a project over an extended period of time. Project-based work takes time. Ample time is needed so that students are provided the space to think deeply about a topic, problem, or area of interest. Often, in preschool classrooms, we don't provide children with enough opportunities to engage with their thinking at a deep level, but that can be changed when we integrate design-based thinking and project work into our daily routines. Design-based work connects well with content areas of engineering and technology as children engage in cycles of exploration, problem solving, and solution finding.

This book is designed to provide you with knowledge and lesson ideas that scaffold young children's experiences with engineering and technology while also building inquiry and creative thinking skills. You will find information on contemporary creativity and design-based pedagogical practices that early childhood educators can use to implement engineering and technology learning experiences for preschoolers. This book will broaden understandings of the relationship between engineering and technology content, the role of the learning environment, and supportive pedagogical practices for preschool-aged children. Many early childhood teachers are uncertain about whether engineering and technology experiences are developmentally appropriate for preschoolers and when and how they should introduce these topics to their students. When engineering and technology experiences build upon student interests and connect to other areas of content learning—literacy, science, the arts, mathematics, and social studies—young children are able to experience meaningful connections among each content area.

This book stresses the importance of encouraging minds-on learning experiences in the early childhood classroom through guided and independent investigations where every child is actively involved in meaningful ways. Early childhood educators have important roles in early engineering and technology experiences and will act as both guides and facilitators throughout the planning, implementation, and assessment of the creative, design-based experiences presented throughout this book. For young children, technology experiences involve using tools, identifying and acting on problems, being creative and inventive, and making things work. Engineering experiences involve exploring problems, using a variety of materials, and designing and building things that work.

Creative Investigations in Early Engineering and Technology will support your development of creative engineering and technology experiences in the classroom by helping you to:

- understand the links among engineering content, design learning, and project-based learning.

- plan cooperative engineering and technology lessons that will engage all children in your classroom as individuals or when working in small or whole groups.
- implement classroom experiences that support children's engagement with engineering and technology in everyday experiences.
- recognize children's understandings of engineering and technology concepts to build upon their current understandings to support knowledge growth.
- document children's knowledge development with authentic work samples and classroom artifacts.

Playful Learning

Play is an important element for learning in early childhood. Through play, young children learn about themselves, their environment, people, and the world around them. Playful learning encourages children to explore and experiment in situations where they feel comfortable taking risks and delving into the unknown. Children's play in the early childhood classroom can take on many different forms and functions. When children explore, experiment, and cooperate through play, they learn about how the world works. Children need teachers who are supportive of children's play and who work to carefully identify play situations where teacher guidance or involvement are welcome and needed.

Young children use their knowledge and understandings by bringing these ideas into their play to further experiment and clarify their understandings. This process is child driven; the role of the adult is one of supporter, guide, and facilitator. The adult meets each child at his own stage of understanding with intentional pedagogical practices that promote questioning and exploration. Teachers can create early childhood classrooms that honor the ways in which children learn and explore by ensuring that young children have ample opportunities for playful learning and exploration. In the role of supporter, guide, and facilitator, the teacher

- **Posing questions**—questions from children are acknowledged and celebrated by teachers. Teachers’ questions encourage inquiry.
- **Play**—opportunities for extended play periods
- **Immersion**—immersion in a benign environment free from criticism and mockery
- **Innovation**—teachers closely observe evidence of new ideas in student thinking to prompt and encourage
- **Being imaginative**—ample opportunities to meld creative new ideas and curriculum content
- **Self-determination and risk taking**—deep involvement and risk taking are encouraged by both children and teachers

Source: Craft, Anna, Linda McConnon, and Alice Matthews. 2012. "Child-Initiated Play and Professional Creativity: Enabling Four-Year-Olds’ Possibility Thinking." *Thinking Skills and Creativity* 7(1): 48–61.

Promoting Creative, Design-Based Learning with Technology and Engineering

<i>Classroom Components</i>	<i>Supportive Approaches in the Early Childhood Classroom</i>
Physical Environment	<ul style="list-style-type: none"> • Flexible spaces with moveable furnishings that provide room for exploration, display, and storage, and spaces that can accommodate and adapt for small and large groups

<i>Classroom Components</i>	<i>Supportive Approaches in the Early Childhood Classroom</i>
Role of the Teacher	<ul style="list-style-type: none"> • Provide opportunities for children to document their thinking through drawing, writing, and verbal means • Encourage students to share their thoughts with a large/small group • Provide materials that can support student inquiry • Closely monitor student thinking and exploration to scaffold experiences
Peer-to-Peer Relationships	<ul style="list-style-type: none"> • Provide opportunities for children to share their problem-solving experiences and encourage and support children's use of design-based and creative thinking • Provide opportunities for children to ask questions, work out trials/ planning, work in pairs/small groups, and plan experiments
Structure of Technology and Engineering Experiences	<ul style="list-style-type: none"> • Provide opportunities for children to connect technology and engineering to other content areas, work on problems and projects for extended periods of time, and revisit previous experiences and lessons multiple times to encourage mastery and promote confidence
Parent and Community Engagement	<ul style="list-style-type: none"> • Provide opportunities to connect technology and engineering experiences with the community and the children's daily lives • Engage the family throughout the learning process through regular documentation of children's experiences

1

Engineering Design: Force, Motion, and Movement

Young children experience movement throughout their day as they run, jump, slide, crawl, and skip. These gross motor movements serve as a foundation to understanding how and why objects move in different ways. As a child pushes a friend on a swing or pulls open a door, she is applying a force to cause movement. *Motion* is the scientific word used to describe types of movement. Motion can only be applied if there is a push or pull force. There are two types of force—*contact forces* (forces that touch when applied) and *at-a-distance forces* (forces that don't touch when applied). In early childhood, young children can engage with design-based experiences that will help develop their foundational understandings of force and motion.

Experiences with engineering concepts provide creative opportunities for project-based learning by incorporating hands-on design and construction that can promote problem solving with two-dimensional and three-dimensional objects. Design-based engineering experiences can integrate other content areas such as math, science, and literacy to engage students in learning by applying concepts, skills, and strategies to explore real-world engineering and design concepts.

Understanding Motion and Force

Movement is a natural source of interest and exploration for young children, who spend their days in a whirlwind of gross and fine motor play. Motion is an important concept for young children to explore because it affects all of our lives daily. *Motion* is best defined as the change in a position or location of an object. However, objects do not change their locations of their own accord. Force is needed to effect the change in location, and there are numerous categories of force that can help us to understand how motion works.

Action-at-a-Distance Forces

There are three action-at-a-distance forces—gravity, magnetism, and electrical—and these forces do not require direct contact between the objects to enact motion.

- **Gravity:** Gravity is force that pulls two objects with mass toward each other and works the same on all objects unless some kind of resistance gets in the way. A gravitational force can pull objects that are far from each other, such as how the moon's gravity affects ocean tides, or can be felt closer but still at a distance, such as how the earth's gravity pulls a child toward the ground when she jumps off a swing.
- **Magnetism:** A magnetic force can either pull opposite ends of two magnets together or push the matching ends apart from a short distance away from each other. The magnetic field of a magnet can create a magnetic force (attraction) on other objects with magnetic fields, such as a paper clip. The paper clip becomes a temporary magnet for as long as it is touching the real magnet and can be used to attract more paper clips. If the paper clip is removed from the magnet, it will lose its magnetic force.
- **Electrical force:** An electrical force is an attractive or repulsive force between two charged objects. Similar to magnetism, electric forces are attractive when two objects have opposite charges and

are repulsive when two objects have like charges. As an example, static electricity is easy to observe in the winter when children come in from outside and remove their knit hats. As they remove the hats, their hair will stand on end from the attractive force.

Contact Forces

There are six kinds of forces that act on objects when they come into direct contact with each other.

- **Normal force:** A normal force is the support force exerted upon an object that is in contact with another stable object. For example, a bookshelf exerts an upward force upon a book to support the weight of the book.
- **Tension force:** A tension force is the force that is transmitted through a rope or wire when it is pulled tight at opposite ends. The tension force is directed along the length of the wire and pulls equally on the objects on the opposite ends of the wire.
- **Applied force:** An applied force is force that is put to an object by a person or another object—a push or pull motion moves an object.
- **Frictional force:** A frictional force is the force exerted by a surface as an object moves across it or attempts to move across it. For example, if a ball slides across the surface of the floor, the floor exerts a friction force in the opposite direction that the ball is rolling, causing the ball to slow and eventually stop.
- **Spring force:** A spring force is the force created by a compressed or stretched spring upon any object that is attached to it. Depending upon how the spring is attached, it can pull or push to create a force. As an example, a spring in a retractable pen makes the pen tip extend and retract when pushed.

- **Air-resistance force:** An air-resistance force is a type of frictional force that acts upon objects as they travel through the air, such as leaves traveling along on a windy day in autumn.

Movement

The concepts of velocity and inertia are important to understanding the physical movement of objects. An object's *velocity* is how fast it is moving through space in a particular direction. When the object changes direction, such as when turning left or right, the velocity is changed because it is no longer moving in its original direction. Inertia is a property of all objects that is related to the object's own mass. The more mass something has, the more inertia it has and the harder it is to push or pull. *Inertia* is a measure of how difficult it is to change an object's velocity. An object with less mass will require less force to speed it up or down than an object with greater mass.

Engineering experiences with force and motion can take place throughout the day during both free play and planned experiences as children play and work together. Many of the materials you will need to involve your students in force and motion are already used in early childhood classrooms. As you plan activities involving force and motion, consider the guidance from the related *Next Generation Science Standards* from the National Academies Press. While these standards are written to guide K–12 learning experiences, the disciplinary core ideas that they are based upon can be a helpful guide for preschool engineering experiences as you work to help build children's foundational knowledge and creative thinking skills.

Core Ideas in Engineering

Forces and Motion

- Pushes and pulls can have different strengths and directions.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

Types of Interactions

- When objects touch or collide, they push on one another and can change motion.

Relationship between Energy and Forces

- A bigger push or pull makes things speed up or slow down more quickly.

Defining and Delimiting Engineering Problems

- A situation that people want to change or create can be approached as a problem to be solved through engineering.
- Asking questions, making observations, and gathering information are helpful in thinking about problems.
- Before beginning to design a solution, it is important to clearly understand the problem.

Developing Possible Solutions

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

Optimizing the Design Solution

- Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

Source: NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

than Lucas's design. Lucas asks why the size of the loops would matter, and Meghan directs the boys to think about the design of the other paper airplanes, asking "Do you notice any patterns with the front and back of these planes that you fold?" Max responds that the front of the plane is smaller than the back when you fold regular paper airplanes. Lucas agrees that he notices the same thing and states that he is going to make new gliders with loops of different sizes to see if having a smaller loop in the front and a bigger loop on the back will give his plane more power. Ms. Meghan encourages Lucas to think about how the bigger loop might help keep his plane level in the air just like the wings on the paper airplane Max is folding. Before leaving to help another child, Ms. Meghan encourages Lucas and Max to keep track of their plane designs and trials in their planning notebooks so that they can compare their flight results.



Lucas builds his straw plane.

Reflection

Lucas's understanding of aerodynamics and design are deepened after his plane doesn't fly as long as he had hoped, and he has to return to his original design sketch. With assistance from Max and Ms. Meghan, Lucas is able to understand why his built plane was not flying as expected. This analysis will help grow the boys' understanding of how important it is to follow a design exactly.

Motion and Design Across the Curriculum: Planning Tips

Interactions with force and motion can involve many different types of materials and simple machines (lever, wheel and axle, pulley, inclined plane, wedge, and screw) that can be made out of classroom materials. Creating a classroom STEM center or, specifically, an engineering and design center is a good pedagogical strategy for encouraging children to build and explore during independent investigations. Ample space will be a necessary consideration when planning your engineering and design center because children will need space to plan out and build with materials. Such a center can house blocks of various sizes, paper or plastic tubes; small toy cars; balls; building materials such as K'nex, Tinker Toys, and Lego bricks; boxes of various sizes; gears and wheels; straws and craft sticks; tape; rubber bands; sketch paper; and pens.

Questions for Inquiry and Exploration in Motion

The following are a brief listing of questions that can be used to encourage guided-inquiry explorations with motion:

- Do you think it will move fast or slow? Why do you think that?
- Will a light push move the ball the same distance as a big push?
- What can I do to find out which of these will help the ball roll the farthest?
- Will the car roll in a straight line or curved line? Why do you think that?
- What can you do to change the direction the ball is rolling?

Lesson Ideas

The Way I Move Game

Topic:

Motion can be observed, described, and measured

Objective:

Children will identify the different ways an object can move—a straight line, curved line, zigzag, up and down, back and forth, and fast and slow.

Materials:

3 different colors of masking tape

Overview:

This lesson works best if children play in pairs or small groups so that they don't spend too much time waiting and have multiple opportunities to walk a movement line.

Creativity Skills:

Exploration

Visualization

Activity Steps:

1. Prior to playing the game, use masking tape to mark off three lines—straight, curved, and zigzag—that are about five feet in length.
2. Invite the children to take turns walking each line, one at a time.
3. Encourage them to name their movements. If this is their first time playing, assist them in naming their movements.
4. You can also challenge them with suggested movements—Can you move back and forth on the zigzag line? Can you move fast on the curved line?

Documentation:

Take anecdotal notes about the children's ability to name or identify the various movements.

Extension Lesson:

This lesson can be extended by inviting the children to move along with music on the lines. This extension will work best if the lines are extended so that the children will have more space to enact their movements.

Making a Maze Tilt Game

Topic:

Motion and speed

Objective:

Children will create a small maze that will allow them to tilt a platform to move a ball through the game.

Materials:

Loose parts (bolts, nuts, screws, wooden craft sticks, twigs, pipe cleaners, cut straws of varying lengths)

Sketch paper (or STEM journals) and pencils

Tape or adhesive

Small plastic, Styrofoam, or paper tray

Small rubber balls

Creativity Skills:

Exploration

Visualization

Solution finding

Strategic planning

Collaboration

Documentation

Overview:

Children will work in pairs so that there is adequate access to needed materials and cooperation with a peer.

Activity Steps:

1. Begin by asking children if they've ever seen a pinball or a marble maze tilt game. If they have, invite them to talk about their experiences. If not, show them examples and talk about the objective of the game and the movements involved.

TINKER, make, innovate, ask questions, AND EXPLORE... SPARK CURIOSITY!

STEM learning is so important for
today's young learners. *Creative Investigations in*

Early Engineering and Technology, a follow-up to *Creative Investigations in Early Math*, will help you guide your preschoolers' learning as they build structures using basic architectural concepts, learn about computers and the technology behind machines, and so much more. Instead of teaching engineering and technology to preschoolers, you can be their guide as they research, experiment, and investigate in their day-to-day learning.

Teachers will learn practical ideas for intentionally fostering young children's hands-on explorations in the following areas:

- Design concepts
- Force and motion
- Computer coding
- Recording observations
- Understanding measurements

Students will love to learn as they explore on their own and collaboratively to learn about how and why our world works.



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