STEM in EARLY EDUCATION

A Guide to Integrating Technology

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The International Society for Technology in Education (ISTE) brings together a passionate community of global educators. Our vision is that all students engage in transformative learning experiences that spark their imagination and prepare them to thrive in learning and life. Visit iste.org to find out more.

ASCD empowers educators to reimagine and redesign learning through impactful pedagogy and meaningful technology use. We achieve this by offering transformative professional learning, fostering vibrant communities, and ensuring that digital tools and experiences are accessible and effective. Visit ascd.org to find out more.

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Foreword

Welcome to *STEM in Early Education: A Guide to Integrating Technology*! Here you will find a set of amazing lessons for teachers who are seeking innovative and exciting STEM instructional and curricular resources for early learners, ages 3–8.

The importance of providing high-quality STEM learning experiences to all young learners cannot be overstated. By introducing STEM concepts and practices in the early years, we open up a world of wonder and discovery for our students. We nurture their natural curiosity, creativity, and problem-solving abilities. At the same time, we set them on a path toward lifelong learning and future opportunities. Early STEM experiences can instill positive attitudes toward these subjects and build confidence that can impact educational and career choices far into the future.

ISTE+ASCD has partnered with General Motors to build a future where all young learners have access to transformational STEM learning experiences. This guide represents our shared commitment to providing professional learning resources designed to help educators bring STEM learning into their classrooms in innovative ways.

This guide draws upon the ISTE Standards as a framework for integrating technology and computational thinking into early learning environments. These standards emphasize relationship-centered instruction rather than technology-centered instruction. This approach fosters powerful, developmentally-appropriate learning experiences. The guide demonstrates how educators can leverage digital tools to enhance, not replace, hands-on exploration and social interaction—so vital in the development of young learners.

You'll notice that the lessons align closely with ISTE+ASCD's Transformational Learning Principles. They prioritize authentic experiences, spark curiosity, and ignite agency in young learners. The activities are designed to nurture belonging, ensuring that all children are seen and valued, and that the learning is connected to the learner's world. By framing early STEM education through these principles, we create joyful learning opportunities that set children up for success inside and outside of the classroom.

In closing, we want to acknowledge the incredible work that early childhood educators do every day. Your role in cultivating young hearts and minds is invaluable. This guide will support and inspire you in that important work. We encourage you to approach these lessons with creativity, adapting them to best serve your unique learners and contexts, and adding your own personal touch. Thank you for your dedication to providing high-quality learning experiences. Together, we can spark a lifelong love of STEM in our youngest learners and prepare them for a bright future.

Sincerely,

Joseph South
ISTE Chief Learning Officer
ISTE+ASCD

Introduction

This guide illuminates powerful strategies for early childhood students to learn with and about technology. Educational technologies (edtech)—from digital cameras to web applications to virtual reality to artificial intelligence (AI)—have the capacity to unlock transformational learning experiences for students across subject areas. In fact, you probably already use some edtech tools to enhance teaching and learning!

The information and exemplar lessons included in this guide focus on the context of STEM education. STEM is an acronym that refers to the academic areas of science, technology, engineering, and mathematics. Some of the STEM lessons demonstrate how diverse technology tools and capabilities can empower students to take ownership of their learning, creatively communicate their ideas, and design solutions to problems. These lessons might use interactive games and applications to review concepts or practice skills; they may also provide a medium for creating books, videos, or other media artifacts.

Other STEM lessons in this guide demonstrate how today's technologies work and how to use them appropriately. Some of these lessons even use unplugged (non-tech) methods to explain the inner-workings of advanced technologies, like AI, which is a developmentally appropriate way to build young learner's foundational knowledge about complex ideas. Other lessons use digital coding, tinkering, or play to learn more about the capabilities and limitations of various technologies. Moreover, during these activities, students are encouraged to reflect and think about the impact of technology tools and how to be a good digital citizen while using them.

We hope that the information and lessons in this guide will be a meaningful resource for you, revealing new strategies, activities, and tools that can empower young children and cultivate joy in STEM learning.

Why Focus on Early Childhood STEM?

Young children (ages 3 to 8) are natural discoverers, tinkerers, learners, problem solvers, hypothesis testers, and thinkers. They are inherent STEM explorers. As their cognitive and social skills rapidly evolve, the inclusion of STEM concepts and experiences in engaging, thoughtful, and age-appropriate ways can significantly enhance their problem-solving abilities, computational thinking skills, and curiosity.

Fostering interest, knowledge, and experiences in the wonders of STEM with young children is essential. We emphasize that incorporating STEM learning and exploration when formal education begins is not an "early start," it is actually a critical time to build STEM interest, skills, and knowledge. Negative stereotypes about STEM fields can have a significant effect on students' long-term participation in STEM coursework and careers, and research has shown that elementary students already begin to exhibit stereotypical perceptions about these fields (Google & Gallup 2016; Steffens et al. 2010). Meaningful STEM experiences are too important to our students' futures to delay until they are older. They are ready to learn, grow, and develop deeper knowledge, skills, and interests in science, technology, engineering, and math now. Such experiences lay a firm foundation, allowing students to both transfer and build upon these vital skills in the future.

This guide has been developed for teachers of our youngest learners because all too often early childhood educators must translate materials, instructions, and methods from curricula intended for older children. This guide aims to bridge the gap between theoretical knowledge and practical application, providing both background information and lessons that supply guidance and support to enhance STEM learning specifically with young students. The twelve lessons in this guide provide detailed support for active learning opportunities in STEM, grounded in the ISTE Standards for Students. The lessons encourage computational thinking and problem solving, while providing models of powerful uses of digital technologies in realistic ways. They also include relationship-centered learning approaches and school-to-home connections to extend learning within and beyond the classroom and to help bring families along on the early STEM journey with their children.

It is our hope that this guide provides encouragement and support for you to help your young learners grow into thinkers, dreamers, scientists, engineers, designers, inventors, and problem solvers—independent workers who can also be team players, logical thinkers, and confident explorers of new ideas as they spend their lives creating, living, and leading in a world beyond even our imagination.

Considerations for Developing and Implementing Early Childhood STEM Lessons

This guide provides 12 exemplar lessons that serve as both examples and inspiration for the quality integration of educational technologies in the early childhood classroom. Focused on applications in STEM subjects, the lessons illuminate age appropriate applications of the ISTE Standards for Students. They also highlight computational thinking practices, relationship-centered approaches, and other instruction strategies specific to the early childhood learning environment. Understanding these foundational considerations will support both your understanding and implementation of the lessons in this guide, as well as your own work to design further activities that integrate meaningful applications of educational technologies into your STEM curriculum.

The ISTE Standards for Students

The ISTE Standards for Students are designed to empower student voice and ensure that learning is a student-driven process. Widely recognized and adopted worldwide, they work together to transform education by creating learning environments that ensure students are prepared to thrive in an evolving technological landscape.

The ISTE Standards for Students (shown in Figure 1) emphasize the skills and qualities we want *all* students to develop and are designed for use by educators across the curriculum with students of varying ages, including children as young as three years of age. The full text of the ISTE Standards for Students, their Performance Indicators, and the associated age band articulations of each standard can be found on pages 15–21. While the Performance Indicators provide guidelines for achieving or measuring each of the standards, the age band articulations share modifications to address students' developmental stages. Learn more about the standards here: **iste.org/standards/students**.

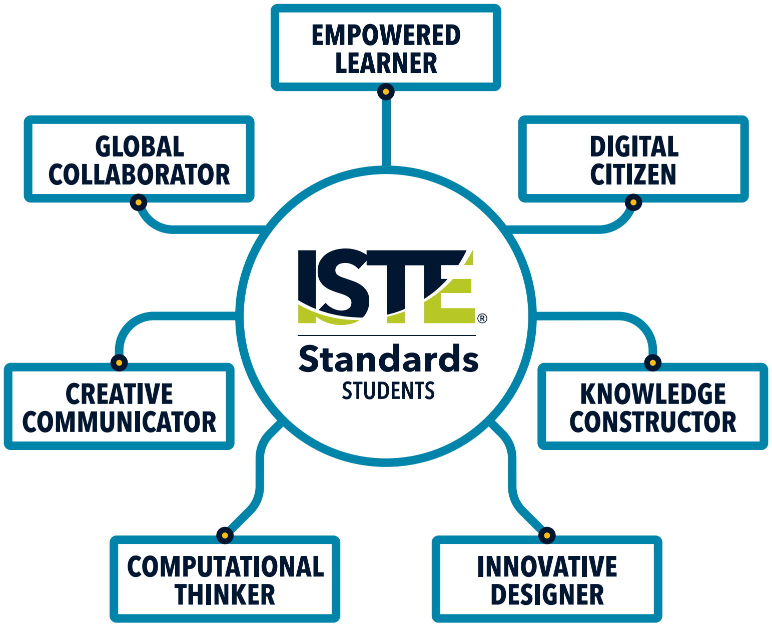

FIGURE 1. The ISTE Standards for Students.

You may find it easy to envision addressing some of the standards with the youngest learners; other standards might seem more challenging. We aim to introduce you to best instructional practices for the use of a wide range of technologies in preschool and primary grades (students ages 3 to 8). Relevant ISTE Standards for Students and performance indicators are cited for each of the twelve lessons, along with appropriate age band articulations for each included standard. The age band articulations are included to expand our collective understanding of how the standards are best applied with early learners through these age-appropriate learning activities.

Our intention is to provide all early childhood educators with meaningful examples of what the ISTE Standards for Students look like in practice with our youngest learners.

Computational Thinking

Computational thinking (CT) is a set of skills for describing and solving complex problems. CT is both a powerful way of thinking and a problem-solving process. With practice, direct teaching, and highlighting of the strategies and kinds of thinking being used, CT develops logical reasoning and problem-solving strategies in even very young learners.

CT is intended to meet the needs of learners who live, work, and play in a rapidly-changing, globally-connected world. CT does not require the use of computers or robots. Instead, it involves logic, problem solving, and rational thinking. While this form of thinking can powerfully enhance students' use of technology, CT skills and habits of mind can also be generalized to most aspects of life. Giving children opportunities designed to grow their CT skills, as well as encouragement to use their CT skills wherever they may apply, will build learners who can apply their thinking skills beyond our observation and reach.

CT is so important to students' overall success that "Computational Thinker" is explicitly named as one of the seven ISTE Standards for Students. This standard and its associated performance indicators and age band articulations can be found in the next section of this Introduction. Here, we unpack the four main pillars of computational thinking, which are problem decomposition, pattern recognition, abstraction, and algorithmic thinking. These four pillars are referred to throughout the lessons included in this guide.

Problem Decomposition

The skill of problem decomposition breaks down problems into smaller, more-easily-solvable components. When decomposing problems, students may start by defining the task, problem, or challenge. Next, they might consider whether the problem could be broken down into smaller, more manageable problems or tasks. Finally, they may determine if there is an important order for solving the tasks and, if so, what order is most efficient, accurate, and useful. They may also determine that some possible steps or tasks are unimportant or unnecessary in ultimately solving the problem at hand.

A simple example might involve the problem of "preparing to go outside at school." At the simplest level, a logical solution could be: "If the door is open, then go outside and play!" But with more careful thought, there are other sub-problems to think about: appropriate clothing (What is the weather? What do I need to wear?); desired toys or other objects (What do I want to do outside? Do I need a ball, a tricycle, a jump rope?); and other competing needs (Do I need to use the bathroom first? Can I get a drink of water before or after I go outside?).

A more technologically-enabled example of problem decomposition could be planning a program, or list of commands, to enable a robot to reach a specific location. In this case, students might consider various sub-tasks such as where to start, how to navigate around objects, or which path would be fastest.

Pattern Recognition

Pattern recognition—being able to create, identify, and extend patterns—is a skill practiced by even our youngest students. Learners experience patterns all around them, in objects, in songs, in activities, in schedules, and in many other situations. Even babies learn that if they do action X (make funny sounds with their mouths) then others will respond by doing Y (laughing or repeating the sound). In early childhood, we should be intentional in discussing patterns, including by naming patterns of objects, by identifying patterns in sequences of behaviors or events (e.g., lunch is always followed by recess), and by calling attention to complex patterns, like the weather. All these examples are important teachable moments.

Using technologies, there are many patterns to explore or extend. When we turn a certain knob, it always makes the volume louder. When we push the longest button on almost any keyboard, it creates a space. When we input a command to a program, it outputs a specific action. Cause and effect is usually very clear when interacting with technology—much more so than with humans!

When we intentionally teach young learners to find patterns, describe the patterns, and extend the patterns, we help them make connections that can transfer to other problems and experiences. Work with pattern recognition supports their growth in CT, enhances the application of prior knowledge and experiences, and becomes a lifelong advantage.

Abstraction

When used in the context of CT, abstraction refers to the process of simplifying complex tasks or ideas, often for greater understandability. Abstraction can make solving problems and completing processes easier and, when done well, abstraction hides complex details without losing the most important steps or tasks.

For example, a parent might tell a young child, "Brush your teeth," abstracting into one simplified phrase the various steps involved: going to the bathroom, getting and using the toothbrush and toothpaste, brushing, and cleaning up. Saying one phrase is much easier than listing all of the steps every time, and the child learns and understands that brushing their teeth involves all of those steps. An abstraction example in programming involves applying a simple, umbrella title ("cross the room") to a complex series of steps (all steps needed to direct a robot from one side of the classroom to another). While early childhood students may not explicitly use the term *abstraction* or fully grasp the scope of applications of this process, they are able to begin applying basic abstraction skills that lead to future learning and applications.

Algorithmic Thinking

Algorithms are sets of step-by-step actions that complete a task or solve a problem. Similarly, algorithmic thinking is the process of developing a step-by-step approach to completing tasks and solving problems. When students use algorithmic thinking, they consider cause and effect, and apply logic and reason.

For example, if your class wanted to surprise a school helper with an appreciation celebration, they could brainstorm to determine the type of celebration, what steps might be needed to plan the celebration, and who could be responsible for the different steps. Such planning and process creation can be documented and re-used by students in other contexts, such as planning a school field trip or class party. Algorithmic thinking can also be implemented by students when using a computer to complete a task.

Encouraging CT in young learners provides them with essential skills for problem solving and promotes cognitive development. It fosters logical reasoning, pattern recognition, and creativity. It also prepares them to strategically tackle the challenges of a technology-driven world. By nurturing these skills early on, we set the stage for lifelong learning and success.

Relationship-Centered Uses of Educational Technology

A relationship-centered learning environment considers the impact of teaching methods, resources, and class activities on students' interpersonal connections. When students learn in an environment that prioritizes teacher-student, student-student, and family-student relationships, they are better equipped for positive social and emotional development, meaningful learning, and academic success (Ferreira et al. 2020).

Looking at the "Early Learning and Educational Technology Policy Brief" (US Department of Education & US Department of Health and Human Services 2016), two of its four guiding principles articulate critical approaches to using technology to enhance young learners' relationships. Guiding Principle #3 emphasizes the potential for technologies to strengthen relationships between young learners and others, while Guiding Principle #4 states that technology use is more effective when young learners are actively engaged with adults or peers.

With these principles in mind, this guide uses a variety of relationship-centered instructional practices to support students' socio-emotional well-being and academic success. These practices aim to enhance face-to-face interactions, instead of replacing them. Practices include:

- Cooperative or collaborative learning experiences, where students work in pairs or small groups to use technology to achieve a task.
- Activities where students co-view and discuss digital media or use technology devices or software with the active involvement of their teacher, their peers, or others.
- Opportunities for students to share their work with their classmates, families, or others in their community.
- Suggestions for providing student choice, as well as flexibility for selecting resources that are culturally relevant and responsive to students, and that cultivate a safe, inclusive, and empowering learning environment.
- Activities that encourage students to think about how their actions when using technology might impact themselves and others around them.
- Recommendations for home connection extensions that encourage students to share or continue their learning beyond the classroom, with parents and guardians, siblings, or friends, thereby strengthening communication and engagement with families.

While the lessons in this guide demonstrate these practices in specific contexts, you can transfer and apply them to a variety of learning experiences to enhance students' socio-emotional skills and strengthen students' relationships.

Other Instructional Approaches and Principles for Integrating Educational Technology into Early Childhood Education

Prior to the COVID pandemic, experts often emphasized the importance of limiting the amount of screen time experienced by youngsters up to age eight. That perception shifted rapidly when, out of necessity, learning environments transitioned from classrooms to online environments during COVID. It became evident that the amount of time spent using a screen was not as important as how tech devices were being used. Now, part of learning how to navigate a post-pandemic world includes identifying how and when use of various technologies is beneficial for educators, parents, and students, and when it isn't. That said, every young person needs device-free time to engage the world directly through play and exploration. Both active learning with technology and active learning without technology enrich learners' development.

In March 2020, the Pew Research Center conducted a survey of parents of children up to age 11. The survey found that watching television was the most common use of digital devices among children ages 3–4 (90%) and ages 5–8 (93%). Regarding use of tablet devices, the survey found the following: 64% of children ages 3–4 and 81% of children ages 5–8, and regarding smartphones the survey found the following: 62% of children ages 3–4 and 59% of children ages 5–8. Tablets and smartphones open up opportunities for active learning, rather than passive entertainment. When we incorporate age-appropriate, positive technology use into learning experiences for all students, we help them learn—with our guidance—to use the technologies they already have at their disposal to their advantage.

When designing technology-supported activities for the youngest learners, keep in mind the following suggestions:

- Identify activities where technology can be used to extend hands-on learning activities. For example, Concrete to Abstract Instruction (Witzel 2005) is a familiar instructional strategy often used with this age group. Students start learning a concept by using concrete manipulatives like beans or popsicle sticks. Next, they demonstrate understanding of the concept by using online virtual manipulatives that represent the concrete objects. Finally, they demonstrate understanding by using numbers and symbols. (Preschool activities typically include just the first two steps in this sequence.)
- Be an active participant when your students use technology. Whenever possible, engage with your students while they are using technology. Talk with them about important concepts, answer questions they may have, and correct misunderstandings about the content.
- Interactive, open-ended activities using technology promote development of critical thinking skills. When students grapple with open-ended questions, they learn strategies for making reasoned decisions (Georgia's Pre–K Program, n.d.). Interactive learning helps children learn how to work with others in group settings, which can also stimulate social interaction.
- Once students understand how to use a technology, include its use as a choice, not a requirement. Since the 1990s, research has shown that the most creative uses of technology emerge when learners are able to decide for themselves if and how they want to use some type of technology to solve a problem or complete an open-ended task (Dwyer et al., n.d.).

The authors' personal experiences in using digital tools with very young learners has shown that students often have unrealistic expectations about the actual capabilities of these technologies. We've learned that it's important to have ongoing opportunities for children to explore how technology works, what it can do, and its limitations. This can be accomplished using activities that are plugged (making use of digital devices) and unplugged (lessons that teach computer science concepts without using a computer). For example, the "Who Am I Online?" lesson in this guide is a plugged activity during which students use digital tools to create an online avatar, while the "How AI Learns through Patterns" lesson helps students understand how AI technologies use pattern recognition to make predictions through unplugged activities.

In its 2018 brief, "Learning through Play," UNICEF calls play an essential strategy for learning. In the conceptual analysis article, "Learning Through Play at School: A Framework for Policy and Practice," Frontiers in Education states, "Researchers have found five characteristics that embody educational play experiences: those that are meaningful, actively engaging, joyful, iterative, and socially interactive."

In the case of students ages 3 to 8, playful learning can be both child-directed and guided or directed by adults. These activities can also be plugged or unplugged. For example, in the lesson, "What to Wear? Dress for the Weather," students participate in adult-directed play when as a class they play a game where they decide how to dress a character for all kinds of weather. An optional extension for this lesson suggests creating an adult-guided learning center where students can continue to play the sorting game introduced during the earlier lesson to practice the skills presented.

Selecting Digital Tools for Early Childhood Education

As a teacher trying to accomplish the worthy educational goals described above, one challenge you may face is determining which edtech tools to bring into the early childhood classroom. Vetting and curating edtech tools for early childhood education must be done intentionally.

To support these efforts, ISTE, in partnership with six other leading edtech organizations, released the Five Edtech Quality Indicators (2024), which should be considered when evaluating edtech products for effective educational use. The more of these characteristics a tool has, the better suited it will be for the early childhood classroom.

Safe

Edtech products for use in the early childhood classroom should be carefully curated to ensure that they provide safe experiences for young children. Such products must establish robust data privacy and security measures to protect student and educator data. Questions to ask:

- Do the terms and conditions of the tool allow for use by students ages 3–8?
- Does the tool require parental permission for student use?
- Does the tool collect students' personally identifiable information? If so, is that data collected securely in compliance with local and federal laws (such as FERPA or COPPA)?
- Does the tool display advertisements or in-app purchasing opportunities to young learners?
- If the edtech tool allows for communication or collaboration, does it allow you to monitor interactions in the classroom and/or limit interactions with those outside the classroom?

Evidence based

Effective edtech products are grounded in rigorous research and evidence-based practices. Even when specific research is not yet available, alignment with key principles of effective early childhood education is paramount to success with young learners. Questions to ask:

- Is there research or evidence that supports the effective use of this tool for the teaching and learning goals I wish to accomplish?
- Does the available research provide any recommendations or limitations about the use of this edtech tool with early learners?
- Does the design and application of this edtech product align with best practices for early childhood education?

Inclusive

Edtech tools used with early learners should be accessible and inclusive. They should provide options that accommodate various student abilities and disabilities. Questions to ask:

- Is the tool developmentally appropriate and accessible for your early learners?
- Does the tool provide visual or auditory cues in addition to any written directions?

- Are there settings, features, or functionalities that can be adjusted to accommodate varying learner needs?
- Does the tool meet industry standards for accessibility, such as Website Content Accessibility Guidelines (WCAG, **www.w3.org/WAI/standards-guidelines/wcag/**) or the CAST Universal Design for Learning guidelines (**udlguidelines.cast.org**)?

Usable

Usability is critical when making edtech tools available to early learners. Consider whether the tool has been intentionally designed to accommodate young learners' cognitive, emotional, and physical needs. Questions to ask:

- Is the interface accessible and intuitive for early learners to use?
- Can the tool effectively achieve the instructional goal it is being selected for?
- As a teacher, is the tool easy for you to set up and use?

Interoperable

Ideally, the edtech tools your students use will work seamlessly with the other technologies that you are running at your school. For early learners, this might include characteristics like single sign-on, so that students can use one ID to log into the various platforms they use, and personalized learning features that securely draw upon data from multiple sources. Questions to ask:

- Does this tool work well (or conflict with) the hardware and software already in use?
- Will students need to log in to use this tool?
- If this tool collects students' performance data, is it easily accessible to me as an educator?

The Edtech Index (**www.edtechindex.org**) is a good resource for exploring edtech products through the lens of these quality indicators. This resource aims to provide a comprehensive directory of information and credible validations through a searchable, educator-friendly platform.

Moreover, this guide provides a variety of examples of edtech products that might support teaching and learning goals in your classroom. Often, we have provided multiple options for accomplishing each task, so that you can weigh their pros and cons to determine which would be best for your unique learning environment and student population.

ISTE Standards for Students

1. Empowered Learner
Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.

- **a.** Students set learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process to improve learning outcomes.
- **b.** Students build networks and customize their learning environments in ways that support the learning process.
- **c.** Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
- **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. Digital Citizen
Students recognize the responsibilities and opportunities for contributing to their digital communities.

- **a.** Students manage their digital identity and understand the lasting impact of their online behaviors on themselves and others and make safe, legal and ethical decisions in the digital world.
- **b.** Students demonstrate empathetic, inclusive interactions online and use technology to responsibly contribute to their communities.
- **c.** Students safeguard their well-being by being intentional about what they do online and how much time they spend online.
- **d.** Students take action to protect their digital privacy on devices and manage their personal data and security while online.

3. Knowledge Constructor
Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

- **a.** Students use effective research strategies to find resources that support their learning needs, personal interests and creative pursuits.
- **b.** Students evaluate the accuracy, validity, bias, origin, and relevance of digital content.
- **c.** Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
- **d.** Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

4. Innovative Designer

Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

- **a.** Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
- **b.** Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.
- **c.** Students develop, test and refine prototypes as part of a cyclical design process.
- **d.** Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

5. Computational Thinker

Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

- **a.** Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
- **b.** Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
- **c.** Students break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem solving.
- **d.** Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

6. Creative Communicator

Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

- **a.** Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.
- **b.** Students create original works or responsibly repurpose or remix digital resources into new creations.
- **c.** Students use digital tools to visually communicate complex ideas to others.
- **d.** Students publish or present content that customizes the message and medium for their intended audiences.

7. Global Collaborator
Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

- **a.** Students use digital tools to connect with peers from a variety of backgrounds recognizing diverse viewpoints and broadening mutual understanding.
- **b.** Students use collaborative technologies to work with others, including peers, experts or community members, to examine issues and problems from multiple viewpoints.
- **c.** Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.
- **d.** Students explore local and global issues and use collaborative technologies to work with others to investigate solutions.

Age Band Articulation: Ages 4–7

1. Empowered Learner
Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.

- **a.** With guidance from an educator, students consider and set personal learning goals and utilize appropriate technologies that will demonstrate knowledge and reflection of the process.
- **b.** With guidance from an educator, students learn about various technologies that can be used to connect to others or make their learning environments personal and select resources from those available to enhance their learning.
- **c.** With guidance from an educator, students recognize performance feedback from digital tools, make adjustments based on that feedback and use age-appropriate technology to share learning.
- **d.** With guidance from an educator, students explore a variety of technologies that will help them in their learning and begin to demonstrate an understanding of how knowledge can be transferred between tools.

2. Digital Citizen
Students recognize the responsibilities and opportunities for contributing to their digital communities.

- **a.** Students practice responsible use of technology through teacher-guided online activities and interactions to understand how the digital space impacts their life.
- **b.** With guidance from an educator, students understand how to be careful when using devices and how to be safe online, follow safety rules when using the internet and collaborate with others.
- **c.** With guidance from an educator, students learn about ownership and sharing of information, and how to respect the work of others.
- **d.** With guidance from an educator, students demonstrate an understanding that technology is all around them and the importance of keeping their information private.

3. Knowledge Constructor

Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

- **a.** With guidance from an educator, students use digital tools and resources, contained within a classroom platform or otherwise provided by the teacher, to find information on topics of interest.
- **b.** With guidance from an educator, students become familiar with age-appropriate criteria for evaluating digital content.
- **c.** With guidance from an educator, students explore a variety of teacher-selected tools to organize information and make connections to their learning.
- **d.** With guidance from an educator, students explore real-world issues and problems and share their ideas about them with others.

4. Innovative Designer

Students use a variety of technologies within a design process to solve problems by creating new, useful or imaginative solutions.

- **a.** With guidance from an educator, students ask questions, suggest solutions, test ideas to solve problems and share their learning.
- **b.** Students use age-appropriate digital and non-digital tools to design something and are aware of the step-by-step process of designing.
- **c.** Students use a design process to develop ideas or creations, and they test their design and redesign if necessary.
- **d.** Students demonstrate perseverance when working to complete a challenging task.

5. Computational Thinker

Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

- **a.** With guidance from an educator, students identify a problem and select appropriate technology tools to explore and find solutions.
- **b.** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories.
- **c.** With guidance from an educator, students break a problem into parts and identify ways to solve the problem.
- **d.** Students understand how technology is used to make a task easier or repeatable and can identify real-world examples.

6. Creative Communicator

Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

- **a.** With guidance from an educator, students choose different tools for creating something new or for communicating with others.
- **b.** Students use digital tools to create original works.
- **c.** With guidance from an educator, students share ideas in multiple ways—visual, audio, etc.
- **d.** With guidance from an educator, students select technology to share their ideas with different people.

7. Global Collaborator

Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

- **a.** With guidance from an educator, students use technology tools to work with friends and with people outside their neighborhood, city and beyond.
- **b.** With guidance from an educator, students use technology to communicate with others and to look at problems from different perspectives.
- **c.** With guidance from an educator, students take on different team roles and use age-appropriate technologies to complete projects.
- **d.** With guidance from an educator, students use age-appropriate technologies to work together to understand problems and suggest solutions.

Age Band Articulation: Ages 8-11

1. Empowered Learner

Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences.

- **a.** Students develop learning goals in collaboration with an educator, select the technology tools to achieve them, and reflect on and revise the learning process as needed to achieve goals.
- **b.** With the oversight and support of an educator, students build a network of experts and peers within school policy and customize their environments to enhance their learning.
- **c.** Students seek feedback from both people and features embedded in digital tools, and use age-appropriate technology to share learning.
- **d.** Students explore age-appropriate technologies and begin to transfer their learning to different tools or learning environments.

2. Digital Citizen
Students recognize the responsibilities and opportunities for contributing to their digital communities.

- **a.** Students demonstrate an understanding of the role an online identity plays in the digital world and learn the permanence of their decisions when interacting online.
- **b.** Students practice and encourage others in safe, legal and ethical behavior when using technology and interacting online, with guidance from an educator.
- **c.** Students learn about, demonstrate and encourage respect for intellectual property with both print and digital media when using and sharing the work of others.
- **d.** Students demonstrate an understanding of what personal data is, how to keep it private and how it might be shared online.

3. Knowledge Constructor
Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

- **a.** Students collaborate with a teacher to employ appropriate research techniques to locate digital resources that will help them in their learning process.
- **b.** Students learn how to evaluate sources for accuracy, perspective, credibility and relevance.
- **c.** Using a variety of strategies, students organize information and make meaningful connections between resources.
- **d.** Students explore real-world problems and issues and collaborate with others to find answers or solutions.

4. Innovative Designer
Students use a variety of technologies within a design process to solve problems by creating new, useful or imaginative solutions.

- **a.** Students explore and practice how a design process works to generate ideas, consider solutions, plan to solve a problem or create innovative products that are shared with others.
- **b.** Students use digital and non-digital tools to plan and manage a design process.
- **c.** Students engage in a cyclical design process to develop prototypes and reflect on the role that trial and error plays.
- **d.** Students demonstrate perseverance when working with open-ended problems.

5. Computational Thinker

Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

a. Students explore or solve problems by selecting technology for data analysis, modeling and algorithmic thinking, with guidance from an educator.
b. Students select effective technology to represent data.
c. Students break down problems into smaller parts, identify key information and propose solutions.
d. Students understand and explore basic concepts related to automation, patterns and algorithmic thinking.

6. Creative Communicator

Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

a. Students recognize and utilize the features and functions of a variety of creation or communication tools.
b. Students create original works and learn strategies for remixing or repurposing to create new artifacts.
c. Students create digital artifacts to communicate ideas visually and graphically.
d. Students learn about audience and consider their expected audience when creating digital artifacts and presentations.

7. Global Collaborator

Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams locally and globally.

a. Students use digital tools to work with friends and people from different backgrounds or cultures.
b. Students use collaborative technologies to connect with others, including peers, experts and community members, to explore different points of view on various topics.
c. Students perform a variety of roles within a team using age-appropriate technology to complete a project or solve a problem.
d. Students work with others using collaborative technologies to explore local and global issues.

How to Use This Guide

This guide offers information and activity suggestions that educators can use—regardless of their own experience and background—to ensure their students are afforded opportunities to engage in meaningful STEM activities and effective uses of educational technology. The guide consists of three parts: Introduction, Lessons, and Appendixes. Let's briefly review each section.

Introduction

The Introduction to this guide includes the following information:

- An overview of the guide
- A discussion entitled "Why Focus on Early Childhood STEM?"
- A description of key instructional principles and considerations for the design and implementation of effective early childhood STEM curricula
- The ISTE Standards for Students and the associated Age Band Articulations for early childhood learners

Lesson Design

This guide includes twelve lessons that are designed to illuminate the principles and standards discussed throughout the introduction. More information about the lessons and tips for implementation can be found on after this Introduction, in a section titled "Explore 12 Exemplar Lessons." For ease of use, every lesson in this guide is designed using a consistent format, as follows.

Lesson Overview

The lesson overview explains what the project is, how it ties to research-based standards, and what students will learn and be able to do as a result of completing the project. Specific sections include a brief overview of the project; the subject(s) addressed, target ages, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students and content-area standards.

Preparation

Preparation provides the information educators need to put the project into action with students. This section includes a list of materials required for project completion; a list of resources for the educator, if applicable; and a list of planning tasks to complete prior to implementation, such as selecting tools and reviewing online resources.

Instructions

Each lesson includes instructions that provide a suggested sequence for the activities for the lesson, and in some instances possible timelines for completing the full lesson. Each activity offers step-by-step directions as well as tips and insights. Prior to planning how you will implement the lesson, read through all the activities, then try out each activity before using it with your students.

While we have provided links to specific resources to support these activities, in most cases, these activities could be successfully implemented with a variety of similar tools. Moreover, new or improved tools may become available in coming years. Consider the tools and resources listed in the guides simply as suggestions.

Additionally, the inclusion of any material is not intended to endorse any views expressed, or products or services offered. These materials may contain the views and recommendations of various subject-matter experts as well as hypertext links to information created and maintained by other public and private organizations. The opinions expressed in any of these materials do not necessarily reflect the positions or policies of ISTE+ASCD. ISTE+ASCD does not control or guarantee the accuracy, relevance, timeliness, or completeness of any outside information included in these materials.

Moreover, prior to using any of the cited resources with students, it is imperative that you check the account requirements for each resource against your school/district student data privacy policy to ensure the application complies with that policy. In addition, some resources' Terms of Service may require parental permission to be COPPA and FERPA compliant for students, especially those younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the lesson to support extended student learning. Each lesson includes one or more ideas for advancing students' work in the classroom, as well as a suggested home connection activity.

Appendixes

Appendix A: Glossary

The glossary includes definitions for key instructional terms found in this guide.

Appendix B: Alignment to ISTE Standards.

This section provides a high-level overview of how the lessons align with the ISTE Standards for Students.

Appendix C: Bibliography

Incorporating educational technology into lessons for young children can be both exciting and challenging. This bibliography offers a curated selection of additional supplemental resources that are not included in the citations throughout the introductory sections, but based on our own experience are good references and/or have been identified in the literature review that was conducted for this project. By referencing these resources, educators can deepen their understanding of some of the specific elements of dynamic and inclusive learning environments that leverage technology to support early childhood education.

Explore 12 Exemplar Lessons

The set of exemplar lessons included in this guide is designed to provide practical early childhood examples for effectively implementing the principles, concepts, and standards described in the introductory section. This is not a comprehensive curriculum, nor a set of lessons designed to be taught in sequence. Instead, this set of lessons provides snapshots of how principles of computational thinking, relationship-centered approaches, and other best practices for early childhood education might be applied across a variety of science, technology, engineering, and mathematics (STEM) contexts and topics. Moreover, these lessons showcase both how early learners can benefit from the use of various types of educational technologies for learning across subject areas, as well as how early learners can benefit from learning about the inner workings of common technologies in their world.

Things to Keep in Mind

Timing. Each lesson plan provides an estimated duration. Remember that these times are simply estimations to help with planning. When implementing the lesson, however, you should move at a pace that is right for you and your students, even if it is much faster or slower than the provided duration.

Flexible Groupings. While each of the lessons provide recommendations for implementation of individual, pair, small group, or whole group activities, please use your discretion to alter these groupings based on the developmental needs and abilities of your students. For example, you may need to provide more guidance or a partner if students are not ready to complete a task independently or individually.

Prerequisites. Each of the lessons provides a list of prerequisite knowledge and skills that students will need prior to completing the lesson. Some of the prerequisites are related to the content area while others relate to familiarity with technology applications.

Advanced Preparation. When applicable, the lesson plans provide a list of important tasks that you—the teacher—should complete *prior* to beginning the lesson, such as preparing materials or selecting technology tools. Performing these tasks will significantly help in creating a smooth and effective learning experience for your students.

Always Work Through the Lesson First. In addition to the list of specific Advanced Preparation tasks, prior to implementation, we recommend that you explore the entire lesson, access all the links and resources, test out the suggested tools yourself, and make any necessary adjustments to the plan for your specific learning environment.

Practicing with the Technologies. When students are learning a new tech tool at the same time as new content knowledge or skills, they can experience cognitive overload. Best practice would be to introduce, review, practice with, and/or play with the suggested edtech tools prior to the lesson, so that during the lesson students can focus on the educational activities, goals, and opportunities rather than the tools themselves.

Make The Lessons Your Own. As you explore each lesson, assume that you will need to make accommodations based on your students' needs, abilities, and interests. As you prepare, look for connections to your other standards and curricula, to your students' cultures and interests, and to the important STEM considerations discussed in the guide's introduction. Also, look and plan for activities where you may need to provide accommodations for language learners or students with varying abilities or disabilities.

LESSON 1

What Comes Next? Repeating Patterns

By Gail Lovely

Patterns are everywhere. The songs we sing, the clothes we wear, items around us, and nature are all full of patterns. Most children really love patterns due to the predictability they can add to their daily life. Knowing that after lunch is quiet time or that before going home is music time are both patterns that children recognize, even if they may not call them patterns.

Patterning is a foundational math skill upon which many mathematical concepts and practices are based. In fact, one of the central skills of Computational Thinking is pattern recognition. The key to teaching about patterns is to help children become aware of patterns and then give them opportunities to notice, name, create, and extend patterns in their world. Students verbalizing and describing their patterns is imperative and can provide meaningful discussions with peers, family members, and others.

This activity, designed for our youngest learners, moves from teacher-led to student-led exploration of patterns, starting with identifying attributes of objects, then describing repeating pattern core units, and finally sharing student ideas and creations related to describing, predicting, and extending repeating patterns. The use of audio and/or video recordings provides opportunities for learners to express their thoughts and ideas in a way that can be captured beyond the moment and returned to for reflection and further exploration. Audio and video files may also be shared with classmates and with family or friends.

This activity supports a variety of secondary skills beyond pattern recognition. For example, students will use the computational thinking skill of problem decomposition to break sequences into parts and identify pattern core units. Further, the discussion and sharing of the description and extension of patterns will provide even very young students with opportunities to practice their creative communication skills with peers—and potentially other audiences.

> My students enjoyed using an app to record a verbal description of their patterns and were very engaged as they explored their patterns on the smart board in a whole group setting. Students eagerly guessed the patterns of their classmates before hearing the pattern-creator's description. This helped students to expand their thinking and value the ideas shared by their classmates.
>
> — Kerry Campbell, Pre-K Teacher, Clinton Elementary School

Lesson Overview

TARGET AGES

3–5 years

SUBJECTS

Math and English Language Arts

ESTIMATED DURATION

45 minutes (in shorter sessions as appropriate for your learners, and in continued exploration via small groups or center exploration)

OBJECTIVES

At the end of this lesson, students will be able to:

- Describe a repeating pattern.
- Extend a repeating pattern.
- With support, use technology to document their own pattern(s) and a description of their pattern(s) to share with others, or revisit themselves.

VOCABULARY

pattern: something that happens or appears in a repeated way

attributes: characteristics or properties of an object or item, also known as **features**, e.g., color, action, size, orientation

pattern core unit: the part of the pattern which is repeated over and over when the pattern is extended (e.g., apple, banana, apple, banana, apple, banana has the pattern core unit of "apple, banana").

generic pattern core labels: Labels for pattern core elements which do not distinguish the attributes involved. For example: an "AB" pattern could refer to "apple, banana" or to "car, truck."

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Ability to detect sameness and difference in objects.
- Ability to name physical attributes of objects (e.g., color, shape, size, orientation).
- Ability to take still photos.
- Ability to record audio or video descriptions, with assistance as needed.

ISTE STANDARDS FOR STUDENTS

Standards and Indicators	Age Band Articulations
1.1. Empowered Learner **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.	**4–7:** With guidance from an educator, students explore a variety of technologies that will help them in their learning and begin to demonstrate an understanding of how knowledge can be transferred between tools.
1.6. Creative Communicator **c.** With guidance from an educator, students share ideas in multiple ways—visual, audio, etc. **d.** With guidance from an educator, students select technology to share their ideas with different people.	**4–7:** With guidance from an educator, students share ideas in multiple ways—visual, audio, etc. **4–7:** With guidance from an educator, students select technology to share their ideas with different people.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.SL. 3.1, 4.1, 5.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.MATH.CONTENT.K.G.A.1. Describe objects in the environment using names of shapes, and describe the relative positions of these objects using terms such as *above, below, beside, in front of, behind,* and *next to*.

CCSS.MATH.PRACTICE.MP7. Look for and make use of structure.

Preparation

MATERIALS

- Classroom objects for creating patterns (e.g., small manipulatives such as math counters, pattern blocks, plastic animals, cars, shoes).
- Digital camera, phone, tablet, or other device(s) that can be used to photograph patterns and record audio or video pattern descriptions.
- A device for displaying the recordings of patterns for the class (e.g., computer screen, TV, projector)
- A tool for easy recording and annotation, such as ChatterPix Kids (**bit.ly/3Zzfi2E**), a free app for iOS and Android mobile devices. This example app does not record student faces, only the photos of their patterns and their voices. Alternatives include Book Creator (**bookcreator.com**) and PowerPoint (**www.microsoft.com/en-us/microsoft-365/powerpoint**).

- A platform for sharing students' recordings of patterns beyond the classroom, such as Padlet (**padlet.com**). Alternatives to Padlet include Seesaw (**seesaw.com**), Google Drive (**www.google.com/drive/**), and Canva (**www.canva.com**).
- Printed or digital instructions for students and adult helpers, as needed.
  - ChatterPix Kids Tutorial (**bit.ly/40TJuaJ**)
  - Padlet Tutorial (**bit.ly/4000pry**)

ADVANCED PREPARATION

- Prepare collections of objects to be used for demonstration and hands-on pattern making.
- Select and set up technology tools and platforms that you will use for the activity (Support for setting up Padlet for this activity: **bit.ly/402PpK7**)
- Prepare a note to families with a link to student-made patterns and a brief explanation about the importance of patterns. Include vocabulary and ideas for pattern activities at home.

SUPPORTING RESOURCES FOR EDUCATORS

- Resource: "Sample Padlet for Sharing Patterns" (**bit.ly/patternsharingpadlet**)
- Article: "Developing Pattern Awareness with Young Children" (**nrich.maths.org/13362**)
- Resource: "Joanne Mulligan on Early Conceptions of Patterns" (**bit.ly/4gk4ywj**)
- Related children's books:
  - *Pitter Pattern* by Joyce Hesselberth
  - *Pattern Bugs* by Judy Harris
  - *National Geographic Kids Look and Learn: Patterns!*
  - *A-B-A-B-A: A Book of Pattern Play* by Brian P Cleary
  - *Zoe's hats: A Book of Colors and Patterns* by Sharon Lane Holm
  - *National Geographic Little Kids Look and Learn: Patterns!* by National Geographic Society
  - *Can You Dance Like a Peacock?* by Rekha S. Rajan
  - *Wings, Waves, and Webs: Patterns in Nature* by Robin Mitchell Cranfield

Instructions

This lesson is best implemented spread over several short experiences, interspersed with pattern-rich books; sorting and classifying items by attributes; and culminating in the sharing of patterns and extended patterns beyond the classroom door. This lesson is intended to be a playful exploration of deep thinking around repeating patterns.

Note: One important reason for the use of technology in this study of patterns can be demonstrated in the following story.

When using animal cookies to create a pattern, a young student made the pattern, shown in Figure 2. The teacher was surprised, and said to me, a visiting teacher, "I really thought Marisol could make a pattern with no problem." The teacher had seen many patterns from other students. Most of these were AB patterns using color or flavor as the attribute of the pattern elements. This one seemed to show vanilla, chocolate, vanilla, chocolate, vanilla, oops!" However, when we asked Marisol to tell us her pattern, she replied, "Going left, going right, going right, going left, going right, going right." Marisol did understand patterns and could articulate her pattern and extend it when asked. If we had only taken the still picture and not heard Marisol's explanation, we might have thought she needed more help, when in fact she was more than ready for more complex patterns. Classrooms are busy places. Adding audio recordings of explanations by students can provide insight to teachers, students, and others by offering a glimpse into student thinking and understanding.

FIGURE 2. A sequence created by a five year old, demonstrating an ABB core pattern unit (going left, going right, going right).

1. Introduce the idea of **attributes**—characteristics or properties of an object or item—using interesting objects.
   - Start by sharing a collection of objects, beginning with objects that have only one attribute difference. As an example, here we will use small toy frogs—some are red and some are blue. This example highlights the attribute of color. You can select any collection of objects of your choice.
     a. Ask, "How are these the same?" Discuss how they are all frogs.
     b. Ask, "How are these different?" Discuss the single highlighted attribute (color or another difference) that sets them apart.
     c. Together, sort the objects into piles or boxes by the highlighted attribute, each time naming the attribute, such as "red" and "blue."
     d. Discuss how some are red and some are blue, but they are all frogs. The color is the attribute that makes them different.
     e. If more exploration is needed, repeat this sequence together, with other items and/or attributes.
     f. Optional: For further exploration, in a station or center, provide additional items for sorting.
2. Explain that a **pattern** is something that happens or appears in a repeated way.
3. Model building a simple AB pattern by selecting one object at a time. For example, create a pattern saying each item as it is placed: "RED frog, BLUE frog, RED frog, BLUE frog," stressing the attribute of difference each time.
4. Pause, and let learners recite the pattern, stressing again the attribute the pattern is based on ("RED frog, BLUE frog, RED frog, BLUE frog"), then pause again.
5. Ask, "What comes next?" Allow students to provide their predictions, then ask, "Why do you think that?" Allow students to explain their reasoning.
6. Repeat steps 3–5 times with color as the attribute, perhaps using different objects or colors. Each time, always say the labels of the items as you place them in the pattern, stressing the highlighted attribute.
7. Next, try patterns with different attributes. Physically obvious attributes, such as size (big and little), are best for learners just figuring out patterns.
   - Other object attributes might be:
     a. Object orientation/directionality: "facing backward, facing forward"
     b. Object type: "frog, car" or "food, not food
   - And non-object attributes might be:
     a. Patterns of actions: "clap, snap" or "hop, stomp"
     b. Patterns of sounds: "cough, sneeze" or "quack, honk"

8. When learners are ready, introduce the idea of **pattern core units**—such as "AB"—and explore other core unit patterns, such as ABB, ABC, and similar. Each time, remember to ask prediction questions like "What comes next? Why do you think that? And what is the core unit of this pattern?" (We often refer to AB patterns or ABB patterns. These are generic terms for the pattern core unit that are free from the specific distinguishing attributes. In addition to using specific pattern core units like "apple, banana," using "AB" allows for mimicking patterns with different items. An AB pattern could be "apple, banana" and also could be "red car, blue car.")
9. Have students create their own patterns. In small groups or as individuals, learners use provided objects to create a simple pattern. Learners should be able to describe their pattern and predict or explain what comes next. Some learners may also be able to describe their pattern core unit (the part that repeats).
10. Have students document their patterns to share with others. Ideally, this would include both a picture of their pattern and a description of their pattern. Sharing and working on articulating their patterns can increase motivation and student interest. Using a digital camera and ChatterPixKids, or other tools of your choice, have learners:
    - Photograph or video their pattern.
    - Record their voice describing their pattern.
    - With assistance, add the video of their pattern to the class Padlet (or other sharing tool). (In keeping with best practices, students should not need to log in to the teacher-created Padlet. Additionally, without parent permission for sharing personally identifiable information in Padlet, students should not add their full names, and their faces should not be shown in the pattern videos they post.)
11. Share the Padlet of all of the students' patterns with other students on a large display with the whole class, with small groups of students, or in a learning center. Encourage students to try to describe the patterns' core units and predict what comes next before hearing the student creator's explanation.

Extensions

Following are three ways to expand students' exploration of patterns both at school and away from school:

1. **Ongoing reinforcement.** In class, continue to notice patterns, name patterns, and extend patterns throughout the day and in the coming days and weeks.
2. **More pattern explorations.** In class and at home, provide wider access to patterning concepts and patterning materials for extended exploration and/or discussion of more complex pattern core units, like those with 3 or 4 elements in the pattern. Add patterns of sounds and motions to the pattern discussions and experiences.
3. **Home connection.** Encourage families to explore and make patterns at home. Provide materials, instructions, and vocabulary for non-school exploration and discussion of patterns.
    - Share the link to the class Padlet of student-created patterns with their families.
    - Provide families with the vocabulary used in class, as well as some key ideas or discussion prompts to support discussion and exploration at home.

- Provide families with small collections of things with which to make patterns and explore at home. These could include outlines of shapes or images to glue to paper in a pattern, small plastic items for building patterns, or ideas for items likely available in homes for building patterns (e.g., shoes, rocks, twigs, pens, pencils, articles of clothing).
- Provide online resources for practicing pattern making, pattern describing, and pattern predicting.
    a. Resource: *Patterns to Explore and Create* ebook (**bit.ly/3P2X6JF**)
    b. Resource: Peep's Feet online game (**bit.ly/49NB9bb**)

LESSON 2

How AI Learns through Patterns

By Nancye Blair Black

Artificial intelligence (AI) technologies have captured the attention of adults and children alike. This unplugged lesson is a great way to teach early-elementary-aged children the basics of how AI works while also reinforcing core science, math, and other curriculum. In the process, students will advance their work with the computational thinking skills of pattern recognition and abstraction. For pattern recognition, students will analyze data sets to find patterns of similar and dissimilar attributes. For abstraction, students will build foundational thinking around simplifying complex characteristics into a single idea. For example, when categorizing animals, they might simplify the checklist of characteristics needed for an animal to be considered an insect (e.g., six legs, three body sections, antennae) into a simpler single question about whether an item is an "insect."

While the examples in this activity span across various subject areas that students ages 6–8 would study, you could also customize the examples to relate to recent units in one or more subject areas, or change the examples to be more culturally relevant to your specific students.

Elementary students who complete this lesson will have a beginners' understanding of how artificial intelligence uses patterns in recognition and classification algorithms. This is a first and simple look at this concept. Extensions are provided for advancing this understanding through both unplugged and digital explorations.

> I'm excited about this lesson because understanding patterns is key to students learning to make predictions, developing logical reasoning, and creating a future foundation for higher math skills. And since AI is going to play a huge role in their lives, even young students need to understand how machines learn so that they can play a part in making sure that the data we use is the best data to give us the best answers to the problems that we need to solve. Just as we introduce math and language to early learners to build foundations, we must introduce artificial intelligence concepts early so students will have a foundation that helps them become ethical, informed citizens of the future.
>
> — Cameron McKinley, Technology Integration Coach, Hoover City Schools

Lesson Overview

TARGET AGES

6–8 years

SUBJECTS

Science, Math, and Artificial Intelligence

ESTIMATED DURATION

60 minutes

OBJECTIVES

At the end of this lesson, students will be able to:

- Recognize patterns of similar attributes.
- Describe how AI technologies use pattern recognition to make predictions.

VOCABULARY

artificial intelligence (AI): a form of human-created computer program that simulates characteristics of intelligence that humans or animals might have

pattern: something that happens or appears in a repeated way

attributes: characteristics or properties of an object or item, also known as **features**

ISTE STANDARDS FOR STUDENTS

Standards and Indicators	Age Band Articulations
1.1. Empowered Learner **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.	**4–7:** With guidance from an educator, students explore a variety of technologies that will help them in their learning and begin to demonstrate an understanding of how knowledge can be transferred between tools. **8–11:** Students explore age-appropriate technologies and begin to transfer their learning to different tools or learning environments.
1.5. Computational Thinker **b.** Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making. **d.** Algorithmic Thinking. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.	**b. 4–7:** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories. **8–11:** Students select effective technology to represent data. **d. 4–7:** Students understand how technology is used to make a task easier or repeatable and can identify real-world examples. **8–11:** Students understand and explore basic concepts related to automation, patterns and algorithmic thinking.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.SL 3.1, 4.1, 5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.MATH.PRACTICE.MP7: Look for and make use of structure.

CCSS.MATH.PRACTICE.MP8: Look for and express regularity in repeated reasoning.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

Describing and extending repeating patterns: In this developmental stage, students should have previous experience with basic pattern recognition and use of prediction to extend the pattern. For example, students might recognize an AB pattern and predict that "square" comes after "circle, square, circle, square, circle." If students do not have this prerequisite knowledge or if it has been a while since they practiced it, then you could do a repeating pattern lesson like Lesson 1 to prepare students for success in this activity.

Preparation

MATERIALS

Writing utensils and paper, or the digital equivalent

ADVANCED PREPARATION

- If you would like to use pattern examples other than the ones provided, prepare those new examples ahead of time.
- Review and select a video and/or book from the list of supporting resources below in order to introduce the concept of artificial intelligence to students at the start of the lesson.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Our Complete Guide to Pattern Recognition in AI" (**bit.ly/3PbQadD**)
- Children's videos related to this lesson:
  - What is AI? | Artificial Intelligence Explained | Super Sema Songs for Kids (**bit.ly/4gwaRMU**)
  - AI & Machine Learning for Kids: Fun & Easy Introduction! (AI for Kids) | AI Courses | ML Education (**bit.ly/4iyT4WW**)
  - What is Artificial Intelligence for Kids | What is AI | AI for Kids | AI explained for Kids |AI Kids (**bit.ly/3D7j8Z4**)
  - ARTIFICIAL INTELLIGENCE FOR KIDS | What is Artificial Intelligence? (**bit.ly/3VCdS67**)

- Related children's books:
    - *Artificial Intelligence for Kids* by Dr. Dhoot
    - *Machine Learning for Kids* by Dr. Dhoot
    - *Supervised Machine Learning for Kids* by Dr. Dhoot
    - *Neural Networks for Kids* by Dr. Dhoot

Instructions

In this scaffolded activity, students will learn about artificial intelligence. Then, they will learn about AI pattern recognition through a series of activities to solve and create pattern puzzles.

1. What is artificial intelligence?
    - Explain to students that artificial intelligence (AI) is a form of human-created computer program that simulates characteristics of intelligence that humans or animals might have AI programs can be used by a robot, on a computer, or even on a phone. Current AI works by making predictions based on patterns.
    - To activate students' prior knowledge of AI and/or build new foundational knowledge, share a short introductory video or book such as those listed in the supporting resources for this lesson.
2. Making predictions from patterns
    - **Direct instruction:** Explain to students that "Instead of just finding one repeating pattern like red, blue, red, blue, AI analyzes data (information) to find many different types of patterns. One type of pattern that AIs might look for is similarities in attributes. Finding patterns of similar attributes is something that human intelligence is also very good at. In fact, this is probably a skill that you use often! You might see a group of students and notice that they are all girls or all wearing blue; you might feel a handful of popcorn and notice that the kernels all rough or slimy from butter; or you might hear several noises outside and notice that they all sound like planes or are all made by nature. AI can use sensors like cameras and microphones to sense the world around it, and then will analyze what it senses to find similar attributes that create patterns."
    - **Activity 1:** Tell students that your class will try noticing some of these similar attribute patterns. For each sample set, show or read the items, then give students time to try to identify what they all have in common. You might even have students write down their observations until all students have had a chance to think and guess. You may also supplement these sample sets with sets of your own creation.
        a. Set 1: 3, 6, 15, 21, 9, 30 = all numbers, all multiples of 3
        b. Set 2: pretty, silly, big, blue = all adjectives or describing words
        c. Set 3: that, cat, scratch, tab = all words with the "short a" vowel sound
        d. Set 4: dolphin, whale, human, hippo = all mammals with various specific mammal attributes (grows hair, breathes air, has a backbone), all mammals that can swim

- **Direct instruction:** Explain to students that "An AI technology does not truly 'understand' what it is sensing. It doesn't understand what a bird or a frog is. But an AI can be programmed to recognize attribute patterns about birds or frogs so that it can correctly predict whether something is related to a bird or a frog. For example, an AI might be able to recognize patterns in bird sounds (tweets, whistles, and songs) versus frog sounds (ribbits and croaks), so that when it "hears" a new bird or frog sound through a microphone, it can tell the difference. When the AI is right, this makes it seem intelligent!"
- **Activity 2:** In this second activity, students try to figure out what each of two categories have in common, then decide which category new examples go into. First, show each of the first two categories and the items inside them. Encourage students to discuss as a whole class or in small groups what attributes they have in common. Then, show students each of the new items to categorize, one at a time, and have them analyze the item's attributes to determine which category it would best fit into, or determine that the item doesn't fit into either category. You may also supplement these sample sets with sets of your own creation, which might include numbers, words, pictures, or even sounds.

  a. **Set 1**

     Category 1: 1, 3, 7, 11 (similar attribute: odd numbers)

     Category 2: 2, 6, 8, 12 (similar attribute: even numbers)

     New items to categorize: 5, 13, 4, 9, 10

  b. **Set 2**

     Category 1: ladybug, ant, butterfly, beetle (similar attribute: insects)

     Category 2: woodpecker, bluejay, ibis, bald eagle (similar attribute: birds)

     New items to categorize: flamingo, bumblebee, stink bug, parrot, elephant (elephant does not fit in either category)

  c. **Set 3**

     Category 1: isosceles, scalene, right, obtuse (similar attribute: types of triangles)

     Category 2: square, rectangle, trapezoid, parallelogram (similar attribute: types of quadrilaterals)

     New items to categorize: acute, diamond, rhombus, equilateral (equilateral fits both categories)

  d. **Set 4**

     Category 1: Texas, Michigan, California, Hawaii (similar attribute: states in the US)

     Category 2: France, Mexico, China, Egypt (similar attribute: countries)

     New items to categorize: Australia, Alaska, New York, Canada, England

- **Discussion:** Are humans and AI always right?
   a. What if the items listed were Siamese, tabby, and domestic shorthair, but then the new item was a lion? Would the AI be correct for classifying them all as cats? Or would it be wrong because the category was domesticated cats? Or what if the new item was a puppy—would it be right because it identified the category as pets? Or would it be wrong because the category was cats? Would having examples of things that do not fit into the category help to clarify what does fit into the category?
   b. What if the categories were vegetables and fruits, but all the vegetables were green, and all the fruits were other colors. If the AI could only make decisions based on what the items look like, how might it categorize a green apple? Would it be right? How could you improve the examples in each category so that the AI would be right more of the time?
   c. Ask students to discuss whether they think that humans or AIs would be right more of the time, and why. Then, ask for their ideas for helping humans or AIs to do a better job at this task. Guide students to understand that both humans and AIs make errors, and that each have strengths and weaknesses. Humans tend to do better with small sets of data and recognizing images, while AI technologies tend to do better with large sets of data and numerical data. The more training a human or AI has at finding patterns correctly, the better they can get at it. This training can include more examples of each category, explicit details about what to look for in each category, or examples of things that don't fit into the category.

3. Attribute pattern puzzles
   - Working individually or in pairs, have students create their own attribute pattern puzzle. Based on time and developmental ability, students can create a Find Our Common Attribute Puzzle like those in Activity 1, or a Pick the Right Category Puzzle like those in Activity 2. In a Find Our Common Attribute Puzzle, students create a list of at least 4 items that have a key attribute in common, and the puzzle player needs to figure out the commonality. In a Pick the Right Category Puzzle, students will create two sets of items lists, one for each of two categories, and provide one or more new items for the puzzle player to correctly categorize.
   - Once puzzles are created, have each student or pair present their puzzle to the class. The rest of the class should act like an AI, analyzing the items to identify patterns in similar attributes and predicting the answer. Finally, students should discuss their experiences in creating and identifying patterns of similar attributes.

Extensions

Following are ways to expand students' exploration of patterns of similarity:

- **Trade pattern puzzles:** If possible, your class could partner with another class in your school or another school who is doing this lesson. Once students create their examples, trade with another class in your school or another school. For an interactive experience, share the puzzles with the other class through a synchronous meeting via a video conferencing platform like Zoom (**zoom.us**), Google Meet (**meet.google.com**), or Microsoft Teams (**teams.microsoft.com**).

- **Advancing understanding of AI pattern recognition:** While this will help students understand how predictive AI recognizes patterns in attributes, students may also enjoy learning about patterns in word repetition to see how it's possible for a generative AI chatbot (like ChatGPT or a customer service bot) to predict which words should come next in a sequence. For example, students might do this with a sentence pattern completion activity that brings this to life. By giving students a text pattern like "A bee makes honey. A beaver makes a dam. A bird …", students can find the text patterns and predict how the sequence should be completed. (In this case, with "makes a nest.")
- **A deeper look at AI and machine learning:** If you would like to foster a deeper understanding of what machine learning algorithms are and how they are trained to find patterns of similar attributes, try the Training Data and Machine Learning project from the free downloadable resource *Hands-On AI Projects for the Classroom: A Guide for Elementary Teachers* by Nancye Blair Black and Susan Brooks-Young (**bit.ly/3Dnq3NO**).
- **Home connection:** Encourage students to share the attribute pattern puzzle they created with their families to see if they can solve them.

LESSON 3

What Makes a Tower Stand or Fall?

By Gail Lovely

Building with blocks is a traditional activity in many learning and play spaces for learners ages 3 to 5 years (and often beyond). This lesson provides opportunities for young learners to explore stability (and indirectly gravity), tower building methodologies, and a simple engineering design process. Through video documentation of their building process, students will be able to deeply discuss: ideas about cause and effect, the design planning process, and the testing of their design improvements. As an optional mathematics practice or extension, students can measure the height of their towers in both standard and non-standard ways (see more in the Extensions section below).

The ISTE Standard for Students 1.5, Computational Thinker, is integrated into this lesson as the children video both the building and falling processes, and then analyze these processes via slow motion replay to determine why their towers fall. Through discussion, learners will also practice the ISTE Standard for Students 1.1, Empowered Learner, using technology to seek feedback that informs and improves their practice. This activity and its uses of technology also support the development of students' speaking and listening skills as they discuss cause and effect regarding their tower's design—and how to build the next tower even taller.

> "This lesson had my students really using their critical thinking and engineering design skills as they were challenged with building a tower with great stability. They enjoyed watching the video of their tower falling, observing why their tower fell, and trying to build it higher using what they learned from the video."
>
> — Jennifer Mayen Pereznegron,
> Pre-K4 teacher, Biomedical Preparatory at UT Southwestern

Lesson Overview

TARGET AGES

3–5

SUBJECTS

Math, Science, and Engineering

ESTIMATED DURATION

30 minutes

OBJECTIVES

At the end of this lesson, students will be able to:

- Build towers and analyze the stability of their towers via video.
- Describe stable construction of a tower in their own words.
- Apply what they learn about stability to building taller towers.
- Describe comparative heights of towers using descriptive language (taller, shorter).
- Use a simple engineering design process to plan, build, and improve their designs.

VOCABULARY

stability: the ability of a structure to maintain balance and stay in one spot

height: a measurement of something from the base (bottom) to the top

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Comparing height: taller and shorter
- Ability to stack objects (blocks) to build a tower, individually and with others
- With or without assistance, video recording others' actions (including holding the camera still)

ISTE STANDARDS FOR STUDENTS

Standards and Indicators	Age Band Articulations
1.1. Empowered Learner **c.** Students use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.	**4–7:** With guidance from an educator, students recognize performance feedback from digital tools, make adjustments based on that feedback and use age-appropriate technology to share learning.
1.4 Innovative Designer **c.** Students develop, test and refine prototypes as part of a cyclical design process.	**c. 4–7:** Students use a design process to develop ideas or creations, and they test their design and redesign if necessary.
1.5. Computational Thinker **a.** Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions. **b.** Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making. **c.** Students break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.	**4–7:** **a.** With guidance from an educator, students identify a problem and select appropriate technology tools to explore and find solutions. **b.** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories. **c.** With guidance from an educator, students break a problem into parts and identify ways to solve the problem.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.SL. 3.1, 4.1, 5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.2.5: Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

CCSS.MATH.CONTENT.K.MD.A.1: Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

CCSS.MATH.CONTENT.K.MD.A.2: Directly compare two objects with a measurable attribute in common, to see which object has "more of" /"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller.

NEXT GENERATION SCIENCE STANDARDS

Crosscutting Concept: Cause and Effect: Events have causes that generate observable patterns.

K-PS2-1 Motion and Stability: Forces and Interactions: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

K-2-ETS1-2 Engineering Design: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Preparation

MATERIALS

- Collection of images of different kinds of towers (**bit.ly/severaltowers**).
- A collection of building blocks: The science and engineering aspects of stability and gravity are best explored with simple wooden or cardboard blocks rather than magnetic or interlocking plastic bricks. If possible, try to include some rounded arches, pyramidal shapes, or irregularly shaped blocks.
- Device(s) for recording video (with slow motion playback capability).
- A monitor or projector to facilitate children's viewing of the slow-motion video.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Benefit of Block Play in Preschool and Beyond" (**bit.ly/49wGG5Y**)
- Research: "Fostering Children's Block-Building Self-Concepts and Stability Knowledge through Construction Play" (**bit.ly/4iy3ZAw**)
- Video: "CDE103 Observation Block Building Towers" (**bit.ly/4iL0QNV**) Reminder: Purpose matters! Sometimes towers are built to be "pretty" rather than tall.
- Related children's books:
  - *Dreaming UP: A Celebration of Building* by Christy Hale
  - *Bigger! Bigger!* by Leslie Patricell
  - *Blocks* by Irene Dickson
  - *Rex Wrecks It!* By Ben Clanton
  - *Crash! Boom!* A Math Tale by Robie H. Harris and Chris Chatterton
  - *Jack the Builder* by Stuart J. Murphy
  - *The Rabbit Listened* by Carol Doerrfeld
  - *Iggy Peck Architect* by Andrea Beaty

Instructions

This lesson can be introduced as a whole-class experience with discussion, and then revisited with small groups in a block or building center on following days. With this age group, repeated exploration of stability and comparison is expected and desired. In terms of gravity, students at this developmental stage should simply be aware that things fall down, instead of floating or falling up, even if they cannot yet conceive of the invisible, abstract force of gravity.

1. Introduce the lesson with a discussion and exploration of towers.
    - Ask learners, "What is a tower?" Activate prior knowledge and explore what they know about towers.
    - Share images of a variety of towers from the collection link provided in the Materials list above, share images of tall buildings in the learners' community (if appropriate), and/or share a book with a variety of buildings/towers (see list in Resources, above).
2. Set the stage for building towers.
    - Set a purpose for building a tall tower (e.g., a lookout tower for a small figure to see over a nearby cabinet or cupboard, a tower tall enough for Rapunzel's hair not to drag on the ground, or a practice tower to improve our building skills) and/or invite students to share purposes for building towers.
    - Ask students, "What do we have in our classroom we could use to build a tall tower?" Children will likely suggest blocks if they are available.
    - Prompt children to consider other materials (e.g., books, shoes, boxes).
    - Discuss the "best" items to build the tallest tower. The "best" items for building a tall tower in the classroom typically have the following attributes: available, stackable, and safe.
    - Help students to choose to make their tall towers with the most available, stable, and safe items, typically blocks.
3. Have the children build a tower.
    - Have each child choose a block to add to the tower.
    - Ask the children to build the tower together, taking turns so all are involved. Do not give them hints about how to build it.
4. When the tower falls, ask "Why did our tower fall?"
    - First ideas will likely swirl around four factors:
        a. Someone bumped it
        b. The way the block was positioned
        c. The way the block was shaped.
        d. It was just too tall.

- Further discuss, and even demonstrate, some of the ideas mentioned. For example:
    a. How can we keep the tower from falling?
        i. When blocks are set crooked on each other they can get wiggly, and we might touch the tower, and it might fall.
        ii. We should carefully take turns so we don't bump the tower.
    b. Stack a few blocks with a big one on top of a smaller one and discuss the "wiggliness" of the blocks. Then stack a few blocks including a curved or pointed block.
        i. Why do these blocks fall?
        ii. When blocks don't touch each other very much, they can be wiggly. They are not very stable.

5. Together, build another tower, keeping in mind the wiggliness (stability) of the tower. When the tower falls, ask:
    - Why did our tower fall? Are you sure?
    - How can we be more sure about how and why it fell? If we took a video as we built the tower, how might that help us know why it fell?
6. Begin building again with someone video recording the building process from the start. When it falls, ask, "Why did the tower fall?" Together, check the video in slow motion to see what the cause of the collapse was. Ask, how did the slow motion video help us? (It showed us exactly what happened so we can do it better next time)
7. Build other towers, continuing to use video documentation to see what happened just before every collapse, and adjusting building practices and materials based on the video information.
8. Conclude the activity with the students.
    - Ask, "When we want to build tall towers, what do we need to think about?" Student answers will vary, but should be based on observations of their experience and may include responses such as:
        a. Be careful when putting the blocks on top of each other.
        b. Don't bump the tower.
        c. Put smaller blocks on top of larger blocks so they are more stable (less wobbly).
        d. Make each block touch the one before as much as possible.
        e. Flat blocks stack better than non-flat blocks.
    - Ask, "How did using technology (video recording) help us build our tall towers?" Answers may include:
        a. We could see what happened before the tower fell.
        b. We could watch it over and over.
        c. If we didn't see it fall "live" we could watch the video to see it fall.

Extensions

Following are two ways to expand students' exploration of the knowledge and skills explored in this lesson:

1. **Measuring towers:** Greater stability and careful building skills can lead to taller towers. This extension provides students with opportunities to measure tower heights and compare them. With your support, students can add the practice of measuring heights of towers using standard measuring tools and nonstandard tools, and then sharing those results. Measuring and documenting the estimated height of each tower just prior to collapse can help in the recall of progress in building and determining which building strategies are working best.
   - **Inquiry:** When building towers with students, ask, "How will we know if this tower is the tallest tower we have made? How will we remember how tall this tower is and then see if a tower we make another time is taller or shorter? (Because we have to take down our first towers to build other towers with our blocks?)"
   - **Measuring tower heights:** Have students use standard measuring tools (e.g., tape measure, meter stick, yard stick) to measure their towers, and make a chart of these measurements (adding images of each tower as it is being built is also desirable). With younger learners, you could use paper strips or paper calculator tape to measure a tower's height, cutting the strip to the tower's height and displaying these strips on a wall or bulletin board. Label the strips with standard measurements, e.g., 32 inches, as well. These strips, along with images of the towers or video of the building of towers, can also be shared as a classroom display for families or others to extend the conversation beyond the moment.
2. **Home Connection:** Provide families or other caring adults with a brief overview of the lesson, its purpose, and the vocabulary. Ask them to build towers of anything (e.g., pillows, boxes, canned goods, books, blocks, rocks). Provide a long paper strip to cut, or tear, to the height of the tower they built. Ask families or older students to write on the back of the paper strip the child's name and what the tower was made of to encourage sharing in the classroom. For extra practice, the measurement of the paper strip can be done in class with a conventional measurement tool and that numerical measurement can be added to the paper strip.

LESSON 4

Shape-Solving Fun with Virtual Tangrams

By Susan Brooks-Young

This activity is multilayered in terms of the skills and standards addressed. The skills involved tie to standards found in the Common Core State Standards for Mathematics, the Next Generation Science Standards, and the ISTE Standards for Students. Beyond these connections to academic content standards, opportunities are incorporated throughout the activity to assist students in transitioning from physical/concrete representations (physical tangram tiles) to visual/pictorial representations (virtual tangram tiles). Successful completion of the activity relies heavily on the use of abstract virtual manipulatives. Students have opportunities to share their thinking using a child-friendly screen capturing tool.

In regard to computational thinking, as students deconstruct existing tangram patterns and use problem-solving skills to create their own patterns, they are encouraged to use a technique called thinking aloud, verbalizing their thought processes. Thanks to the benefits of screen capturing technology, educators and parents are able to gain insight into students' reasoning and use of problem solving strategies by viewing recordings made as students complete activities. This practice has the added benefit of strengthening students' relationships with peers and adults at school and at home.

Students who have no experience using physical tangrams may need to practice with those before progressing to use of virtual tangrams. At the beginning of this lesson, students participate in an activity designed to help them explore manipulating virtual tangrams. Once they are comfortable using virtual tans, students practice making common shapes (e.g. squares or rectangles) using one or more tans. Finally, students engage in activities where they are challenged to complete more complex shape puzzles.

> We have been learning about shapes in our math curriculum and this lesson was a great follow up of that. Plus, it helped me understand what Tangrams are.
>
> — **Emily Stock, First Grade Teacher, Wilmington Area Elementary School**

Lesson Overview

TARGET AGES

6–8

SUBJECTS

Mathematics and Engineering

ESTIMATED DURATION

Four 30-minute activities

OBJECTIVES

At the end of this lesson, students will be able to:

- Make squares, triangles, and parallelograms using one or more virtual tans.
- Work collaboratively with classmates to complete several patterns with interior lines using virtual tans and share their observations about how geometric shapes are used to create different patterns.
- Work collaboratively with classmates to complete several silhouette patterns using virtual tans and share their observations about how geometric shapes are used to create these patterns.

VOCABULARY

tans: The seven geometric shapes that make up a tangram square.

polygon: A general term for a closed shape with three or more straight sides.

triangle: A polygon with three sides and three angles.

square: A polygon with four equal sides and four right angles.

parallelogram: A four-sided polygon with two pairs of equal, parallel sides and four angles.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Previous experience using physical tangrams. (It is common for students this age to transition from use of concrete manipulatives to those that are symbolic. When completing this activity, making that shift will be easier if students have previous experience creating shapes using physical tangrams and pattern cards. If students have not used physical tangrams before, they should use them first before working with the digital tangrams used in this lesson.)
- Familiarity with the vocabulary terms listed in the Vocabulary section above.

ISTE STANDARDS FOR STUDENTS

Standards and Indicators	Age Band Articulations
1.4 Innovative Designer **a.** Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems. **c.** Students develop, test and refine prototypes as part of a cyclical design process.	**a. 4–7:** With guidance from an educator, students ask questions, suggest solutions, test ideas to solve problems and share their learning. **8–11:** Students explore and practice how a design process works to generate ideas, consider solutions, plan to solve a problem or create innovative products that are shared with others. **c. 4–7:** Students use a design process to develop ideas or creations, and they test their design and redesign if necessary. **8–11:** Students engage in a cyclical design process to develop prototypes and reflect on the role that trial and error plays.
1.5. Computational Thinker **c.** Students break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.	**4–7:** With guidance from an educator, students break a problem into parts and identify ways to solve the problem. **8–11:** Students break down problems into smaller parts, identify key information and propose solutions.
1.7. Global Collaborator **a.** Use digital tools to connect with learners from a variety of backgrounds and cultures, engaging with them in ways that broaden mutual understanding and learning.	**4–7:** With guidance from an educator, students use technology tools to work with friends and with people outside their neighborhood, city and beyond. **8–11:** Students use digital tools to work with friends and people from different backgrounds or cultures.

COMMON CORE STATE STANDARDS

CCSS.MATH.CONTENT 1.G.A.1, 2.G.A.1, 3.G.A.1: Reason with shapes and their attributes.

CCSS.MATH.CONTENT.1.G.A.2: Compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half-circles, and quarter-circles) or three-dimensional shapes (cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create a composite shape, and compose new shapes from the composite shape.

NEXT GENERATION SCIENCE STANDARDS

K-2-ETS1-2 Engineering Design: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3 Engineering Design: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online for all whole-class activities.
- Computer(s) or tablet(s) with internet connection for accessing online activities and screen capturing student work. One to four devices in a learning center to be shared by two to three students per device is sufficient.
- Video: "Tangrams: Everyday Learning" (PBS) (**bit.ly/4iyUCQK**)
- At least one virtual manipulative tool. (Check each site listed below before selecting a tool. Some have ads, but do not require a log-in. Others do not have ads but are more difficult to manipulate. Some are subscription-based, meaning they are ad-free if the school has a paid account.)
  - Tangram Builder (**polypad.amplify.com/tangram**)
  - Toy Theater Tangrams (**toytheater.com/tangram/#**)
  - Tangrams (**mathsbot.com/manipulatives/tangrams**)
  - Tangram Browser (**nrich.maths.org/14735**)
  - Tangram Template (**bit.ly/4iuDJa6**)
- Tangram patterns: (The websites listed below are for educator use, not for student use. These websites are sources of tangram patterns that can be downloaded, printed, and given to students. Do not have students visit the sites.)
  - Printable tangram patterns (**education.com/slideshow/tangrams**)
  - Tangram patterns (**makinglearningfun.com/themepages/mathtangrams.htm**)
  - Tangram puzzles (**bit.ly/49wYjm0**)
  - YouTube tangram videos (**youtube.com/user/TangramChannel/videos**). Scroll down to the series of short videos that show a shape for students to replicate with all seven tans and then watch the pattern solution.
- Tool: ScreenPal (**screenpal.com**, free and paid options), or another screen capture tool of your choice that makes it possible to record the computer screen and audio, then share the video.

ADVANCED PREPARATION

- Watch "Tangrams: Everyday Learning" (PBS Video) (**bit.ly/4iyUCQK**), the introductory video to use with students to review tangrams basics.
- Choose the virtual manipulative(s) you want to use for this activity. Each site features different options, so it's worth reviewing them all. Bookmark the sites you select.
- Some, but not all, of the sites listed above include tangram patterns that can be used online or printed for students to refer to while using virtual tans. You may also want to review, select, and print some patterns.

- Review how to use the tool ScreenPal if you want students to record their online work by screen capturing. If needed, the website's How To, Training, and Tutorials (screenpal.com/tutorials) areas offer tutorials showing how to record, edit, and host video using ScreenPal.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Tangrams for Kids: Educational Tips and a Printable Template" (**parentingscience.com/tangrams-for-kids**)
- Article: "Virtual Manipulatives Used by K–8 Teachers for Mathematics Instruction: Considering Mathematical, Cognitive, and Pedagogical Fidelity" (**bit.ly/4gwTf3g**)
- Article: "Think Aloud Strategy" (**teachervision.com/problem-solving/think-aloud-strategy**)
- Related children's books:
  - *Tan's Tile: A Tale of Creative Thought Featuring Tangram* by Dominic Robert Villari
  - *Tangram Book for Kids with Animals, Volume 1* by JeanPaulMozart
  - *Tangram Puzzle Book: The Best Book for Learning Tangrams* (with templates to cut out) by B.K. Math
  - *The Book of Tangrams: 700 Puzzles* by Sam Loyd

Instructions

Each activity in this lesson sequence can be completed all at once, with the entire class, if you have one device for every two students. Otherwise, introduce new strategies to the whole class and have students complete follow-up activities in a learning center.

1. Activity 1: Introduction
   - Whole class activity: Show and discuss the 40-second video "Tangrams: Everyday Learning."
   - Whole class activity: Demonstrate how to use the virtual tangram manipulatives. Use the vocabulary terms listed above during this demonstration.
   - Whole class or learning center: Provide free time for students to experiment with manipulating the virtual tans.
2. Activity 2: Building Shapes
   - Whole class activity: Show students an image of all seven tans arranged to make a square (example image: **bit.ly/4gO5g4P**). Review the three tan shapes: square, triangle, and parallelogram. Ask students to define square. Say that all seven tans can be used to make a square, but it's also possible to make squares with fewer pieces.
   - Whole class or learning center: Challenge students to make a square using 1, 2, 3, 4, and 5 virtual tans. (***Note:*** There is one solution using 1, 3, 4, and 5 tans and two solutions using 2 tans.) Optional: Ask students to take screenshots or photos to document their solutions.

- Repeat the challenge by asking students to create triangles and/or parallelograms using virtual tans.
- Encourage students to share their results in a class discussion.

3. **Activity 3: Deconstructing Patterns, Part 1**
   - Whole class activity: Show students a printed or projected tangram pattern that has interior lines outlining the seven tan shapes used to complete the pattern. Model completing a sample pattern of this type using virtual tans.
   - Whole class or learning center: Ask students to work in pairs or small groups to use virtual tans to complete several patterns with interior lines. Ask them to pay attention to how shapes are used to create the different patterns. This is an opportunity for students to use ScreenPal to record themselves thinking aloud as they explore completing patterns that have interior lines.
4. **Activity 4: Deconstructing Patterns, Part 2**
   - Whole class activity: Show students a printed or projected tangram pattern that is just a silhouette of the shape to be created, with no internal lines. Model completing a sample pattern of this type using virtual tans.
   - Whole class or learning center: Beginning with simple silhouette patterns, ask students to work in pairs or small groups to use virtual tans to complete several patterns with no interior lines. Ask them to pay attention to how shapes are used to create the different patterns. This is another opportunity for students to use ScreenPal to record themselves thinking out loud as they try different strategies to complete these patterns.

Extensions

Following are three ways to expand students' exploration of use of virtual manipulatives:

1. **Creating Tangram Patterns:** Students can extend their learning by creating their own tangram patterns.
   - Whole class activity: Model for students how they can create their own designs with virtual tans, take a screenshot of the pattern, and create pattern cards to share with classmates.
   - Whole class or learning center: Have students work in pairs or small groups to create one or more cards featuring original patterns.
   - Allow time for students to work together to complete patterns created by their classmates.
2. **Other Virtual Manipulatives:** Virtual tangrams are a popular choice among teachers of children ages 6 to 8, but there are many other kinds of virtual manipulatives appropriate for use by children in primary classrooms. Here are a few virtual manipulative collections you can explore and then share with your students:
   - NCTM Illuminations (**bit.ly/3OOgsSX**)
   - Didax Virtual Manipulatives (**didax.com/math/virtual-manipulatives.html**)
   - Math at Home (**bit.ly/3ZNNqZJ**)
   - Pattern Shapes (**mathlearningcenter.org/apps/pattern-shapes**)

(Use the sequence presented in this activity to encourage children to go from free play with the virtual manipulatives, to structured activities you prepare, to opportunities for students to create activities they can share with peers.)

3. **Home Connections:**

   - It is possible to share ScreenPal videos with individual students' parents. Encouraging parents to view their children's think-aloud videos gives them a window on their child's school day. These videos can be viewed on any internet–connected device.
   - If parents have an internet-connected device such as a tablet or computer, teachers can share links to virtual manipulatives as well as activity suggestions they can do with their children at home. For those families who do not have home internet access, consider assembling take-home manipulative kits parents can check out for home use.

LESSON 5

What to Wear? Dress for the Weather

By Susan Brooks-Young

Preschool and kindergarten are the right time for children to begin learning about how weather conditions impact people and their well-being. Appropriate clothing choices can help people stay warm when it's cold outside or cool and comfortable when temperatures rise. This activity is designed to help students increase their awareness of data-driven decisions through the importance of selecting proper clothing for various weather conditions. Additionally, students are exposed to basic best practices for pattern recognition and data analysis by participating in introductory activities designed to demonstrate how data are sorted and organized using rules.

Throughout the lesson, opportunities are incorporated to assist students in increasing their computational thinking skills by gathering data, formulating hypotheses based on those data, and then testing their thinking using online activities. Finally, students are asked to break a series of weather challenges into component parts, extract data, and determine wardrobe selections based on those data.

This lesson includes two activities. In the first, students are given opportunities to think about ways that weather impacts choices people make about a variety of things, including the clothing they wear. In the second activity, students decide what kinds of clothing they would wear based upon various weather scenarios they are given.

> This lesson is appropriate for any Kindergarten unit about weather. My students had lots of previous knowledge to bring to the table. They enjoyed sorting types of clothing and then creating their own outfits for different types of weather.
>
> — Courtney Lipo, Kindergarten Teacher, Wilmington Area Elementary School

Lesson Overview

TARGET AGES

3–5

SUBJECT

Science

ESTIMATED DURATION

Two 30-minute activities

OBJECTIVES

At the end of this lesson, students will be able to:

- Identify common weather conditions (sunny, rainy, stormy, snowy, windy, cloudy).
- Use online activities to test theories about appropriate clothing choices.
- Use their knowledge about common weather conditions to explain how these conditions affect peoples' behavior, including clothing choices.

VOCABULARY

weather: the temperature and other outside conditions (e.g. rain, cloudiness) at a particular time and place

temperature: a measurement of how hot or cold something is

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.3. Knowledge Constructor **d.** Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.	**4–7:** With guidance from an educator, students explore real-world issues and problems and share their ideas about them with others.
1.5. Computational Thinker **b.** Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making. **c.** Students break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.	**4–7:** **b.** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories. **c.** With guidance from an educator, students break a problem into parts and identify ways to solve the problem.

NEXT GENERATION SCIENCE STANDARDS

K-ESS2-1: Use and share observations of local weather conditions to describe patterns over time.

K-ESS2-2: Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Understand that *weather* refers to the temperature and other outside conditions (rainy, snowy, etc.) at a specific time and place.
- Know that *temperature* refers to how hot or cold something is.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online for all whole–class activities.
- Video: "What Is Weather? Young Explorers" (PBS) (**bit.ly/3ZLVZo3**)
- Online Game: "Dress for the Season" (**bit.ly/3ZKoh29**)
- Teacher-created sets of pictures of various individual pieces of clothing that students can use to complete several sorting challenges. See Advanced Preparation below for more directions.
- ***Optional:*** 5 pieces of construction paper, each a different color for each group of 2 to 4 students. *See Advanced Preparation below for more directions.*

ADVANCED PREPARATION

- Review the online game: "Dress for the Season" (**bit.ly/3ZKoh29**). The game will be used in a whole -class activity in which the teacher will use the game to engage students in a discussion about criteria they can use to decide what articles of clothing are appropriate to wear based on the weather.
- Prepare sets of pictures for the What Have We Learned activity. Create enough sets to have a ratio of 1 set for every 2 to 4 students. At a minimum, include individual images of several types of tops, pants, hats, outerwear, and footwear in each set. Ensure you have options for clothing suitable for the following weather conditions: sunny, rainy, cloudy, windy, snowy, or stormy. Sources of royalty-free images include: Flaticon (**flaticon.com**), Pixabay (**pixabay.com**), or Smithsonian Open Access (**si.edu/openaccess**). If you decide to use construction paper to assist students with categorizing pictures, prepare sets of 5 pieces of construction paper for each group of 2 to 4 students. Each set should include the same 5 colors. Students may use the construction paper during the What Will You Wear Today? Part 2 categorizing activity. Have each student group use the same color for each category. For example: all pictures of tops can be placed on a piece of yellow paper while all pictures of bottoms can be placed on a piece of red paper and so on with the remaining three categories.

- Prepare a list of at least five or six sorting challenges for the activity. Different weather conditions can be used more than once. For example:
  - It's dark outside and very cold. Rain is falling and it's windy. What should I wear?
  - The sun is shining, but it's a chilly day. There are no clouds in the sky. What should I wear?
  - It's cloudy and warm. I hear thunder, but it's not raining. What should I wear?

  Note: These are just a few examples. You will need to develop at least a few additional sorting challenges, progressing from simple or obvious scenarios to more complex scenarios. You are also free to adapt the challenge suggestions suggested above to reflect weather conditions your students are familiar with.

SUPPORTING RESOURCES FOR EDUCATORS

- Infographic: "Teaching Children How to Dress for the Weather in Every Season" (**bit.ly/3OO6roR**). While this infographic was published in British Columbia and the temperatures are in Celsius, the chart and tips may be helpful for educators globally.
- Article: "Getting Toddlers to Dress for the Weather" (**bit.ly/3ORBUq7**). The video at the top of the article is not available, but the tips for how parents can help their children make good decisions about what to wear may be helpful to educators.
- Related children's books:
  - *Do I Have to Wear a Coat?* by Rachel Isadora
  - *Froggy Gets Dressed* by Jonathan London
  - *What Will the Weather Be?* by Lynda Dewitt
  - *Different Clothes for Different Weather* by Bruce Larkin
  - *Daniel Plays in the Snow* adapted by Becky Friedman

Instructions

This is a whole-class lesson that can be completed sequentially in one day or split over two.

1. **What Will You Wear Today? Part 1**
   - Show the PBS video (2:16), "What Is Weather?: Young Explorers" (**bit.ly/3ZLVZo3**).
   - When the video ends, ask students to name different types of weather. For example: sunny, rainy, windy, snowy, cloudy, stormy.
   - Explore this topic further by asking students to describe what they know about various types of weather. For example, is sunny weather always hot? Or, does cloudy weather always mean rain is coming? What kinds of storms do they know about? Ask students if they can name any of the ways that weather affects people's behavior (examples: clothing, activities, and transportation). Ask if they think that is true and why.

- Ask children to think about the clothing they are wearing today. How did they decide what to wear? Did someone help them pick their clothes? Are the clothes comfortable? Is there anything else they want to share about their clothes?
- Tell students that as a class, they are going to play a game where they decide how to dress a character for all kinds of weather.
  - **a.** Project the online game "Dress for the Season" (**bit.ly/3ZKoh29**) for all students to see.
  - **b.** Choose a character and a season. Before starting to dress the character, ask students what they know about weather during that season and also ask them to describe the type of clothing that would be most comfortable to wear during that season. (Use this discussion to establish criteria for the type of clothing the class will choose for the character during this round of the game.)
  - **c.** Start to dress the character. Choices will be offered for a top, a bottom, a hat, and an accessory. As you work through the options, remind children of the criteria they identified for appropriate clothing for that season.
  - **d.** Choose one of the remaining four seasons and dress a character for that season, using the same steps described above. Repeat for each of the seasons as time permits.

2. What Will You Wear Today? Part 2

- Lead a class discussion about children's experiences playing "Dress for the Season." What did they like? What didn't they like? What did they learn?
- Give a picture packet to each group of 3 to 4 students. Have them take out the pictures and look through them. Ask the children to tell you what they see. Have children begin by working in their groups to sort the pictures into five categories: tops, bottoms, hats, outerwear, and footwear.
- Explain that you are going to give the class a weather condition description and you want them to talk in their group to decide what kind of clothing a person would need to wear if they were outdoors in those conditions. Remind students about the criteria they identified for making clothing choices based on different types of weather when they played "Dress for the Season."
- Once they have selected the cards that show an outfit appropriate for the weather condition described, check their answer. Depending on the images you've provided, there may be more than one solution. When all groups have created an outfit, ask volunteers to share their answers.
- Repeat this task several times using different prompts.
- Close with a short discussion about what they have learned about clothing and weather.

Extensions

Following are three ways to expand students' exploration of how to choose proper clothing for any weather conditions:

1. **Learning center:** Create a learning center where students can continue to play the sorting game to practice skills presented in this lesson. If available, add a laptop, iPad, or Android tablet students can use individually or in pairs to explore one or more related games. Examples include:
   - "Marco Polo Weather" for iPad (**bit.ly/3BskkG1**) and Android (**bit.ly/3ZyqlJ9**) tablets. This is a self-directed discovery app where students learn about the relationship between weather and clothing through student-led experimentation.
   - "Weather and Clothes" (**bit.ly/4isTDSj**). Educator-created game that may be played on a laptop or tablet. (Prior to using with students, review online games to ensure they are appropriate.)
2. **Daily Practice:** Add a "Dress for the Weather Activity" to your morning calendar routine. Using one of the picture packets you created, take a few minutes during calendar time to identify current weather conditions and then select pictures from the packet to build an outfit for the day. You might want to add an empty clothesline to your calendar display and allow children to pin the chosen images to the clothesline for that day.
3. **Home Connection:** Getting dressed for school presents an opportunity for children to increase their sense of autonomy while making wise choices. Parents can make checking the weather forecast for the next day part of their child's evening routine. They can tell their child what weather conditions are predicted and then help them choose an outfit for the morning. Choosing an outfit the evening before often saves time in the morning and offers opportunities for parents and children to spend time together.

LESSON 6

8-Bit Biome in a Box

By Nancye Blair Black

This lesson is a modern-day version of the traditional "biome in a box" project. Students ages 6–8 are often fascinated with the Earth and take great joy in learning about biomes—or habitats—around the world. This activity allows students to apply what they are learning about various biomes by creating an interactive model that other students can enter and explore within a metaverse environment. While it may sound like a buzzword, a metaverse is simply a digital environment that allows users to interact as avatars as they learn, play, and create. These environments can provide a dynamic platform for immersive learning experiences for students. Plus, research has shown that when students are learning in immersive environments, their engagement, learning outcomes, communication, and understanding of complex ideas and systems all increase (Lin et al., 2024; Maas & Hughes, 2020). This makes an immersive metaverse or virtual reality platform a highly engaging way for students to effectively learn about and demonstrate mastery of ecosystems.

The directions for this activity are given for Minecraft Education (**education.minecraft.net**). This creative platform allows students to build and create, independently or in collaboration with peers. Minecraft Education provides a safe platform for educational use, while providing essentially the same core functionality that early elementary students may be using on computers or mobile devices at home. This platform is used by more than 35 million students in more than 115 countries. Alternatively, you could also facilitate versions of this collaborative activity using 2D background and object images in a platform like Google Slides (**google.com/slides/about**) or using 3D models and environments in another virtual reality platform like MegaMinds (**gomegaminds.com**), which can be accessed on computers, tablets, or VR headsets.

> My students absolutely loved learning about the various biomes and watching video clips that explored each one in detail. The content really captured their interest and sparked their curiosity. However, the excitement truly peaked when I revealed that they would be building in Minecraft. The next day, they came into class with so much energy and enthusiasm—it was as if they couldn't wait to get started! One student even exclaimed, "I could hardly sleep last night because I was so excited to play Minecraft in school!" Their enthusiasm and anticipation were truly contagious, and it was clear that this hands-on, interactive approach to learning had a huge impact on their engagement and excitement.
>
> — Jennifer Toney, Third Grade Teacher, Sharpsville Area Elementary School

Throughout this creation activity, students will serve as innovative designers using a simple design process, as creative communicators crafting digital models, and as global collaborators working with others to create their digital model. They will focus on the computational thinking skills of problem decomposition (dividing the various model-building tasks amongst their team members) and data visualization (representing the information they know about their biome in a visual way that others can understand). Moreover, by working in pairs or small groups, students will build their communication and collaboration skills in this inherently relationship-centered use of technology.

Please note, this lesson activity is intended to be used as a culminating activity for a lesson series or unit on biomes. It provides an opportunity for students to apply and demonstrate their learning about the plants, animals, and geographic features found in various biomes. Since it assumes that students have already learned basic information about habitats through previous lessons, if students will instead need to do this research or learning about biomes as part of this activity, then additional time and resources should be provided to support that. Likewise, the lesson assumes that students have previous experience with various basic creation skills in Minecraft Education, so students will need additional time to experiment with any new Minecraft skills introduced during the lesson as well.

Lesson Overview

TARGET AGES

6–8

SUBJECTS

Science and Engineering

ESTIMATED DURATION

60 minutes

OBJECTIVES

At the end of this lesson, students will be able to:

- Demonstrate their knowledge about the plants, animals, and geographic features that make up a habitat or ecosystem.
- Make observations about different biomes that indicate their understanding that diverse living things reside in diverse living environments.
- Use technology and a design process to create a model that visually communicates complex ideas.

ISTE STANDARDS FOR STUDENTS

Standards and Indicators	Age Band Articulations
1.4. Innovative Designer **a.** Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems. **d.** Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.	**a. 4–7:** With guidance from an educator, students ask questions, suggest solutions, test ideas to solve problems and share their learning. **a. 8–11:** Students explore and practice how a design process works to generate ideas, consider solutions, plan to solve a problem or create innovative products that are shared with others. **d. 4–7:** Students demonstrate perseverance when working to complete a challenging task. **d. 8–11:** Students demonstrate perseverance when working with open-ended problems.
1.5. Computational Thinker **c.** Students break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.	**4–7:** With guidance from an educator, students break a problem into parts and identify ways to solve the problem. **8–11:** Students break down problems into smaller parts, identify key information and propose solutions.
1.6. Creative Communicator **c.** Students use digital tools to visually communicate complex ideas to others.	**4–7:** With guidance from an educator, students share ideas in multiple ways— visual, audio, etc. **8–11:** Students create digital artifacts to communicate ideas visually and graphically.
1.7. Global Collaborator **c.** Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.	**4–7:** With guidance from an educator, students take on different team roles and use age-appropriate technologies to complete projects. **8–11:** Students perform a variety of roles within a team using age-appropriate technology to complete a project or solve a problem.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.W. 1.8, 2.8, 3.8: Recall information from experiences or gather information from provided sources to answer a question.

NEXT GENERATION SCIENCE STANDARDS

K-ESS3-1: Earth and Human Activity: Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. (***Clarification Statement:*** Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.)

2-LS4-1: Biological Evolution: Unity and Diversity—Make observations of plants and animals to compare the diversity of life in different habitats. (***Clarification Statement:*** Emphasis is on the diversity of living things in each of a variety of different habitats.)

2-ESS2-2: Earth's Systems: Develop a model to represent the shapes and kinds of land and bodies of water in an area.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Familiarity with the Minecraft Education platform, including the use of creative mode for building and design, the ability to place blocks and components in the virtual environment, and the ability to join a multiplayer game. Resources for introducing these prerequisite skills can be found here:
    - "Getting Started with Minecraft Education" (**bit.ly/3Dcb5KD**)
    - "Basic Controls in Minecraft Education" (**bit.ly/4g6ufAf**)
    - "Using the How to Play Tutorials in Minecraft Education" (**bit.ly/41sT7O4**)
    - "How to Host and Join a Multiplayer Game in Minecraft Education" (**bit.ly/3ZQ4tKE**)
- Developing understanding about the plants, animals, and geographic features found in various biomes.

Preparation

MATERIALS

- Computer(s) or tablet(s) (one per student or group) with internet connection for accessing tools online and a webcam for interacting with image recognition features.
- Tool: Minecraft Education (**bit.ly/4jt5uQS**)

ADVANCED PREPARATION

- Prior to the lesson, in Minecraft Education, create a new world that you will host for your students. This step will allow all of your students to create and share in the same Minecraft learning environment. The world you set up should be a "flat world" in "creative mode." Directions for creating a host world can be found in the "Minecraft Education Edition Multiplayer Game Guide" (**bit.ly/4jqgFK4**).

- To keep the animals within each of the separate biomes and clearly designate spaces for each group, you can pre-arrange walls, fences, or barrier blocks. For the scope of this activity, student groups should get an area of approximately 16 by 16 blocks. You could also designate which area belongs to which students by adding a wooden sign and writing their names on it. You might place all of these designated spaces around a common shared area or even add walking paths to guide students around the map. While this takes a little more preparation time, it will likely help the activity flow more smoothly.
- Consider providing online research access or classroom materials about the plants, animals, and geographic features found in various biomes.
- Consider providing students with the following wikis or your own lists of animals, plants, and biomes available in Minecraft.
    - Minecraft Wiki: Animal (**minecraft.fandom.com/wiki/Animal**)
    - Minecraft Wiki: Plant (**minecraft.fandom.com/wiki/Plant**)
    - Minecraft Wiki: Biomes (**minecraft.fandom.com/wiki/Category:Biomes**) (***Note:*** This resource is about the characteristics, plants, and animals in the Minecraft specific biomes. If students have a hard time finding specific animals or plants, you could look in this wiki to get an idea of what is available through the platform.)

SUPPORTING RESOURCES FOR EDUCATORS

- Resource: How To Set Up A Multiplayer Game (**bit.ly/4jqgFK4**)
- Resource: Minecraft Education Edition Multiplayer Game Guide (**bit.ly/4jqgFK4**)
- Resource: Minecraft Education Lessons (**education.minecraft.net/en-us/resources/SearchResources**)
- Related children's books:
    - *Habitats of the World* by DK
    - *Many Biomes, One Earth* by Sneed B. Collard III
    - *A Walk in the Deciduous Forest* by Rebecca L. Johnson
    - *A Walk in the Prairie* by Rebecca L. Johnson
    - *A Walk in the Rainforest* by Rebecca L. Johnson
    - *A Walk in the Tundra* by Rebecca L. Johnson
    - *A Walk in the Desert* by Rebecca L. Johnson
    - *A Journey into the Ocean* by Rebecca L. Johnson
    - *A Journey into an Estuary* by Rebecca L. Johnson

Instructions

To create their biome models, students will use a simple, developmentally-appropriate design process of plan, create, improve, and share.

1. For this activity, have students work in pairs or small groups. Assign or have each student group select a biome. You could have students focus on a few biomes that you have specifically covered in previous class lessons, or let them choose from a broader range of biomes that have enough elements for the activity available in Minecraft, which include: plains/grasslands, desert, tundra, swamp, warm ocean/coral reef, cold ocean, freshwater, and various jungles and forests.
2. Introduce the activity to students. Tell students that they will be creating a biome model in Minecraft, working in a small group. Project your screen to show students the host world you created and where their designated areas for building are. Go over the 4-step design process for the activity as well as the element requirements for their biome (listed below).
3. Have students use the design process to create their biome models. Then, provide time for students to present their biomes to the class in the virtual environment and/or to independently explore the various biomes.
    - Plan (10+ minutes): Students should use paper or a digital document to list what they already know about their selected or assigned biome in the areas of plants, animals, and geographic features. Students might also draw a picture to help them plan what they will create in Minecraft. As needed or as time permits, students can also research online or use classroom materials to discover what plants, animals, and geographic features are found in their biome, as well as what is available in the Minecraft platform to bring their biome to life.
    - Create (30+ minutes): The students should work together in Minecraft to create their model, splitting up the work to make sure all elements are included. The more time students have, the more detailed their biome models can be. Required elements should include:
        a. Appropriate geographic features. Update the ground as needed to include substances like dirt, sand, rock, or water and add other geographic features like grassy hills, rocky mountains, or coral reefs.
        b. At least one plant (or living non-animal) found in that biome. (Note: Some of these can be placed, while others may need to be grown in tilled dirt from seeds or saplings. The growing process can be sped up by placing bone meal on them.)
        c. At least one animal found in that biome. (***Note:*** These are added by placing a spawn egg for that animal.)
        d. Other biome elements of your choice (geographic feature, plant, animal, or even a cultural icon that might be found, like a specific type of building, flag, or object).
        e. One or more wooden signs with information to teach visitors about your biome and the elements you included. (Students who are not yet writing confidently may keep these simple and benefit from support from you or their peers to successfully write their signs.)

        Note: You may want to provide master lists of plants and animals that are available in Minecraft, perhaps in alphabetical order. If specific animals or plants that students would like to include in their model are not available, some students might get creative and build models out of other types of blocks. For example, students in California might be excited to repurpose blocks like spruce stairs, spruce fences, and sea pickles to create a Joshua tree in their desert biome, as shown in the video "How to Build a Joshua tree in Minecraft" (**bit.ly/4gfJ3fV**). Students can use a tutorial or come up with their own design ideas to do this.

f. Improve (10+ minutes): Ask students to pretend that they are a visitor to their biome and walk around what they have created. Do they need to make any improvements or changes to make it better for visitors? Do they need to add more signs or details to explain what the various plant, animal, and geographic features are?

g. Share (10+ minutes): Host a virtual gallery walk or field trip so that students can present or independently explore all of the created biome models. If time allows, students can learn a lot about various biomes by visiting each of the models, exploring the terrain, and reading the information shared on signs.

Extensions

Following are three ways to expand students' exploration of the knowledge and skills explored in this lesson:

1. **Discussing Online Collaboration:** Following the lesson, facilitate a discussion with students to find out what they learned about the collaboration process by working with others in a digital space. Ask students: What was challenging about communicating and working together online? What were the best parts about communicating and working together online? Were there things that were harder or easier about working together online versus in the classroom?
2. **Third Grade Extension:** In the standard 3-LS4-3: Biological Evolution: Unity and Diversity (from the Next Generation Science Standards for third grade), students are asked to "construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all." To meet this more advanced standard, students might add related details to signs included in their biome and/or add a follow up activity in the immersive biome learning space to observe and discuss this specific topic.
3. **Home Connection:** Many students are already playing Minecraft at home on their own, with family, or with friends. By sharing this educational experience with parents and guardians, you might encourage them to promote further educational uses of Minecraft at home, as well as to participate in play or a collaborative design process in Minecraft with their children.

LESSON 7

A Class Book of Friends

By Gail Lovely

In this lesson, young learners work together to create a digital book about their classmates while learning and practicing good digital citizenship. In teacher-assigned pairs, students work together to create pages for a digital class "Book of Friends," which celebrates some of the best things about each of the students in the class. Each student will make pages about their partner, seeking information, input, and approval from him or her as the pages are created and finally published for the enjoyment of the entire class. Lessons learned will include the importance of listening to their partner, of seeking approval for content and format from their partner, and of considering who the audience is for the book. The powerful messages of positive information about their friends which will be shared within the class will build relationships and strengthen bonds beyond the moment. Students will need to be familiar with the digital tool(s) chosen prior to beginning this lesson.

> We often make paper class books, and I loved the idea of trying to make one with my students digitally. We also just started our own unit on digital citizenship so it felt like good timing. The students loved taking pictures of one another and asking their friends questions to put in the book. I also personally really enjoyed using Book Creator.
>
> — **Rachel Tarnoff, Pre-K Teacher, Clinton Elementary School**

Lesson Overview

TARGET AGES

3–5

SUBJECTS

English and Digital Citizenship

ESTIMATED DURATION

100 minutes over five or more short sessions

OBJECTIVES

At the end of this lesson, students will be able to:

- Explain that pictures, ideas, and artwork belong to the people who create them as well as to those who are depicted in images—and getting permission to use others' work is important.
- Explain that images of others should be approved by the person or people in them before being shared with others.
- Consider who has access to the things they make and do with technology.
- Describe why their work should be shared only with trusted people.

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.2 Digital Citizen **a.** Students manage their digital identity and understand the lasting impact of their online behaviors on themselves and others and make safe, legal and ethical decisions in the digital world. **c.** Students safeguard their wellbeing by being intentional about what they do online and how much time they spend online.	**4–7:** **a.** Students practice responsible use of technology through teacher-guided online activities and interactions to understand how the digital space impacts their life. **c.** With guidance from an educator, students learn about ownership and sharing of information, and how to respect the work of others.
1.6. Creative Communicator **b.** Students create original works or responsibly repurpose or remix digital resources into new creations.	**4–7:** Students use digital tools to create original works.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.SL. 3.1, 4.1, 5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.W.K.2: Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Ability to take or make digital images.
- Ability to ask questions of peers and capture responses.
- Ability to record audio.
- Turn taking.
- Prior instruction/practice with Book Creator (bookcreator.com).

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing online tools. Students will be working together, but each will be working on different sets of pages of the book. With the youngest learners, this can best be done with small groups and multiple devices, perhaps as a teacher-led station during center time. With more experienced learners, supporting multiple pairs of students will be easier, and sharing devices will be possible.
- Tool: Book Creator (**bookcreator.com**), or another digital tool for creating a collaborative book, such as Google Slides (**google.com/slides/about**), Microsoft Powerpoint (**microsoft.com/en-us/microsoft-365/powerpoint**), Canva (**canva.com**), or Storyjumper (**storyjumper.com**).
- Templated page(s) for the class book. For example: (**bit.ly/4f9tbdr**)

ADVANCED PREPARATION

- Choose a digital tool for the templated book pages.
  - Pre-fill titles of items to be completed by each pair
  - Optional additional information spaces can be included to provide more choice for students who are more independent or who want to add more details.
- Predetermine pairings for students, considering language skills, academic abilities, and other compatibilities.
- Prepare students by allowing them to practice with the tool(s) they will be using to create the book before beginning on the actual book, including skills like adding images, text, and/or sound.

RESOURCES

- Related children's books:
  - *A Friend Like You* by Frank Murphy
  - *Margaret and Margarita/Margarita y Margaret* by Lynn Reiser
  - *The Sandwich Swap* by Queen Rania of Jordan Al Abdullah
  - *A Friend for Henry* by Jenn Bailey
  - *Friends* by Rob Lewis
  - *A Guide to Being a Friend* by Natalie Shaw
  - *Adrian Simcox Does NOT Have a Horse* by Marcy Campbel

Instructions

The goal of this lesson is for students to work together in pairs to create pages of a digital class book that share highlights and information about their partner. These pages will be published as a whole-class book. Along the way students will explore the importance of asking for input, information, and permission from their partners; and of considering the audience for their work. Whole-class discussions, working together with partners, and teacher involvement with students will add to the depth of thought needed to portray partners in accurate and positive ways and listening to the opinions and perspectives of others.

1. Reintroduce the digital tool your students will be using, allowing for exploration, practice and growing confidence in using the tool.
2. Introduce the Book of Friends Project to the class. Include the following points:
   - We are creating a class book with every student featured and every student helping to create the book.
   - The book will be available in the class for the rest of the year. We will all be able to read it as many times as we like.
   - Through the book, everyone in the class will be sharing a little bit of the best things about themselves. Won't it be fun to read?
3. Briefly re-introduce Book Creator or the alternative digital tool(s) you will be using for this project to the students, reviewing how to add images, text, and/or audio. Show students the pre-templated pages that they will be working on, and explain how they will be used.
4. Pair the students.

Note: With very young learners, you may want to stop here and continue at another time.

5. Instruct students to consider the audience of their book. Ask students, "Who will be reading and enjoying our book of friends?" Students' expected answer, "Only our class."
6. Getting started.
   - Instruct students, "As you add your names to the book, think about who will be reading our book, and use the name you would use with the readers of our book. For example, you all call me 'Mrs. Lovely,' so I will add my name as 'Mrs. Lovely,' because you are who this book is for. If I were making this book for my family, I might use my name 'Gail,' or 'Mom.' Remember, when you add your name, that this book is only for our class." (You might model this with examples from the class, such as Richard/Rick or Josefina/Josie.)
   - Have students look at the page template and find where to add their name, as they are the authors. (In the example template, each place to add information is contained in a different colored box, and each item to be entered also has an audio cue as to what goes in that area. These cues can also be translated into other languages.)

- Students will add their name as the author in the allocated space in the template, and then add their friend's name.

    a. With guidance, students type their name as the author in the appropriate place in the template.

    b. Secondly, students add their partner's name. Students ask their partner what name they want to use in the book and make sure they spell it according to their partner's preference. (The teacher may need to help with this step. Spelling names correctly is important!)

Note: This is another natural stopping point in the lesson. At this point, you may decide to continue the work at another time or on another day.

7. Instruct students—independently, in small groups, in pairs, or as a class—to explore and complete the template.

    - Say, "Let's look at the first page we will create about our partners—this is the page you already started with your names. There is a space with a black line around it (or a similar descriptor based on your template). A picture of the subject, your friend, goes in this space."

    - Direct students to follow the instructions below to take pictures for their pages. To bring these instructions to life, you may opt to share some not-so-great pictures of yourself with your students to have a laugh and remind them this book is about the best things about each other. As needed, remind students of the importance of permission and approval before sharing photos of their friends.

    - Taking turns, each pair will complete the following steps:

        a. Take three pictures of your partner. Make sure the pictures are pictures they like, pictures they are comfortable sharing with the whole class; and pictures that show them at their best.

        b. Ask your partner which picture they want you to use in the book.

        c. Add that picture to the book.

        d. Then the students switch roles, with the other partner having their picture taken and having it added into the book.

Note: This is another natural stopping point in the lesson. At this point, you may decide to continue the work at another time or on another day.

8. Depending on your teaching style, student comfort with the tools, and the maturity and independence of your learners, you may continue in this same manner, guiding pairs as they add one or two items at a time to their book pages, or you can walk learners through the entirety of the two-page template and let them work through it all semi-autonomously. (Important reminder: at every step of the way it is critical that the subject gives input, permission, and approval of the work to the author. Authors should also continue keeping the audience in mind.)

9. Once students have completed the book, reinforce principles of digital citizenship.
   - "In summary, making the book together allows all our class friends to share the book and to learn about each other in a fun and safe way. We can share it with our class friends, because we trust each other, and we all worked hard to make our book a celebration of every subject's very best."
   - "We did not put this book online because we cannot decide who looks at our book online. When we share online, we need to be more careful about what we share and who we share it with. This book is special, and we are safe sharing it only in our class."
10. With the book complete, have a book launch celebration and spend time with everyone exploring all the pages about their class friends. Remind learners that they can go back and reread the book, and that they can ask their friends questions or share their ideas related to things included in the book for the rest of the school year.

Extensions

Following are two ways to expand students' exploration of the digital citizenship concepts in this lesson:

1. **Reinforcing Digital Citizenship Principles:** The logical next step in digital citizenship exploration with this age group is repeated overt discussion and decision-making about targeted audiences and open audiences for student work, images, and more. For example, in this particular lesson, the student creations and information are intentionally not shared beyond the classroom walls to reinforce principles of privacy and ownership. Through ongoing discussions with teacher(s) and trusted adults, students can come to realize the importance of choosing with whom, when, and what to share beyond our home and classroom walls.
2. **Home Connection:** Families can be reminded of the dangers of sharing online and about safer online spaces and behaviors for themselves and their children. A template of a similar style of book could be shared with families so that they can create a paper-based Book of Family that highlights the strengths and likes of their family members without sharing it beyond their home.

LESSON 8

Who Am I Online?

By Nancye Blair Black

While students ages 3–5 are often using technology tools to communicate with trusted adults, students ages 6–8 often interact with peers as well. At home, students in this age group may video chat with grandparents, send text communication to their cousins in kid-friendly chatting apps, play multiplayer video games with parents, or even interact with their friends in metaverse worlds like Minecraft or Pokemon Go. At school, these same students creatively share their ideas through digital communication tools like blogs, videos, or learning management systems, and also collaborate through digital tools like cloud-based docs, collaborative whiteboards, and educational metaverse spaces.

In this activity, students will think about their online identity and behavior as it relates to those they interact with, including family, friends, and other trusted individuals. These are a key focus of digital citizenship during this developmental stage. Whereas older students are able to think about digital use and behavior in terms of ethics, students at this age can readily consider ideas about online behavior in terms of safety and kindness. The hands-on avatar creation activity and surrounding conversations prepare students for a variety of relationship-centered technology activities in class and at home.

In addition to illuminating key considerations about digital citizenship, this lesson also reveals a common example of abstraction: using an avatar, symbol, or icon to represent a person or an idea. This early example can be used to support more complex explorations of this computational thinking concept at later developmental stages. This lesson also supports students' development as creative communicators, prompting them to explore multimodal forms of communication for their ideas. This is a skill that will benefit them in both their academic and personal lives.

> My students were highly engaged in the conversation and enjoyed sharing how they use the internet. The highlight of the lesson was the discussion on digital identities, where we explored various scenarios and how to navigate them. It was both thought-provoking and insightful for the students. They also loved creating their own avatars, which added to their excitement."
>
> — **Jennifer Toney, Third Grade Teacher, Sharpsville Area Elementary School**

Lesson Overview

TARGET AGES

6–8

SUBJECTS

Digital Citizenship and English Language Arts

ESTIMATED DURATION

50 minutes

OBJECTIVES

At the end of this lesson, students will be able to:

- Explain the concept of digital identity.
- Analyze online behavior to determine if it is kind and respectful.
- Create an avatar that portrays themselves in the way they want others to see them online.

VOCABULARY

digital identity: the way someone exists online, including information about them, pictures of them, the things they say, and the way they act

online: using a website or app that connects to the internet from a computer, tablet, phone, or other digital device

avatar: images or characters that represent a person online

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.2 Digital Citizen **a.** Students manage their digital identity and understand the lasting impact of their online behaviors on themselves and others and make safe, legal and ethical decisions in the digital world. **b.** Students demonstrate empathetic, inclusive interactions online and use technology to responsibly contribute to their communities.	**a. 4–7:** Students practice responsible use of technology through teacher-guided online activities and interactions to understand how the digital space impacts their life. **a. 8–11:** Students demonstrate an understanding of the role an online identity plays in the digital world and learn the permanence of their decisions when interacting online. **b. 4–7:** With guidance from an educator, students understand how to be careful when using devices and how to be safe online, follow safety rules when using the internet and collaborate with others. **b. 8–11:** Students practice and encourage others in safe, legal and ethical behavior when using technology and interacting online, with guidance from an educator.
1.6 Creative Communicator **c.** Students use digital tools to visually communicate complex ideas to others.	**4–7:** With guidance from an educator, students share ideas in multiple ways—visual, audio, etc. **8–11:** Students create digital artifacts to communicate ideas visually and graphically.

COMMON CORE STATE STANDARDS

CCSS.ELA-LITERACY.SL. 1.1, 2.1, 3.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-appropriate topics and texts, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.W 1.6, 2.6, 3.6: With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.

Preparation

MATERIALS

- Computer(s) or tablet(s) (one per student or group) with internet connection for accessing tools online.
- An age-appropriate AI text-to-image generator that can be used to create a digital avatar, such as Padlet's "I Can't Draw" feature (padlet.com). Alternatives include Adobe Firefly (adobe.com/products/firefly) or Canva's AI Image Generator (canva.com). Each of these tools has pros and cons, so you should select the best one for your learning environment. For example, Padlet does not require an account for students to contribute to a teacher's shared whiteboard. In contrast, Adobe Firefly may produce more accurate images but requires use of an account.

ADVANCED PREPARATION

- Select the digital tool that you will use for the avatar creation activity.
- Learn about and practice with the Padlet "I Can't Draw" feature (**padlet.blog/i-cant-draw**), or the functionality of another selected AI text-to-image generator.
- If selecting Padlet as your tool:
  - Create a shared whiteboard for the lesson ahead of time.
  - Adjust the settings under post fields to allow only "I Can't Draw" as a type of attachment.
  - Adjust the share settings for collaborators, so that visitor permissions are set to "writer" and link privacy is set to "secret." With these settings, the Padlet is accessible only with the direct link, and students who have the link will be able to access and post on the board without logging in.

SUPPORTING RESOURCES FOR EDUCATORS

- Children's books related to this lesson:
  - *The Technology Tail: A Digital Footprint Story* by Julia Cook, illustrated by Anita DuFalla
  - *Nerdy Birdy Tweets* by Aaron Reynolds, illustrated by Matt Davies

Instructions

In this activity, students will first engage in a discussion about their online and offline identities. Next, they will think about how people's behaviors in a variety of situations involving technology reveal information about their digital identities, or who they are. Finally, students will create a digital avatar that can be used to portray and represent themselves in a digital environment.

1. Who am I in real life? Who am I online? (10 min)

- Ask students, "Think about who you are in your class, at home, or in your community. Do you play sports? Are you kind to animals? Are you funny? Are you a big brother or sister?" Have students share up to three characteristics as a whole group or in pairs.
- Ask students, "Now, think about who you are when you are **online**. You're online whenever you are using a website or app that connects to the internet from a computer, tablet, phone, or other device. Do you watch videos or play games? Do you call your family members or chat with your friends? Are you kind, safe, or silly?" Have students share up to three characteristics as a whole group or in pairs.
- Explain to students that their **digital identity** is how they exist online, including information about them, pictures of them, the things they say, and the way they act. It's like your online personality. For example, some people may do, say, and share things online that show they are kind, but other people might do, say, or share things that hurt someone else's feelings. In this lesson, students will have a chance to think about the type of person they are online and the different ways they create their digital identity.

2. **Online Behavior as Digital Identity (20 minutes)**

- Explain to students that one way they show who they are online is by their behavior—by what they do and say.
- Have students consider several scenarios that they might encounter online in digital spaces. For each one, students should discuss (1) how they might feel if they were in the same situation as the main character in the story, (2) what they think the main character in the story should say or do in that situation, and (3) what do all of the characters' online behaviors say about their digital identities? Six possible scenarios have been included below. Feel free to make changes to the details of the stories—such as the names of the characters or the names of specific digital tools or games—to make them more culturally relevant for the students in your class. There is not one single correct answer for each question. In fact, students may respond in very different ways to the same scenarios. For example, in the first scenario below, some children may say that the brother and sister teaming up is unfair and shows that they are not nice, while another child might think it is a clever strategy for playing the game and shows that they are good at video games. The goals of this activity should be to cultivate empathy and open mindedness toward their classmates' points of view, while also guiding students to think about safe and kind ways to behave in digital spaces.

   a. Jamari is playing an online game with his brother and sister. Suddenly, they both team up in order to beat Jamari in the game. How would you feel if you were in the same situation as Jamari? What should Jamari do or say? What do the actions of each character say about their digital identity?

   b. Amy's mom tells her that her grandma's birthday is coming up on Saturday. Amy wants to celebrate her birthday, but she lives far away. Her mom suggests that Amy think about using technology to help her celebrate her grandma's special day. How would you feel if you were in the same situation as Amy? What should Amy do or say? What do the actions of each character say about their digital identity?

   c. While Jin is at his friend's house, they are playing an online game with other players that he doesn't know. One of the players starts using inappropriate language and saying things that make Jin uncomfortable. How would you feel if you were in the same situation as Jin? What should Jin do or say? What do the actions of each character say about their digital identity?

   d. Sam's class is using an online tool that allows them to post comments about the artwork of other students in the class. Sam sees one drawing that they love, but before they can say so, notices that it was made by another student that they don't always get along with. How would you feel if you were in the same situation as Sam? What should Sam do or say? What do the actions of each character say about their digital identity?

   e. Theo and his friend are creating an online presentation together in a class learning center. The rest of the class will get to see the finished presentation. Theo's friend is typing and writes something that Theo thinks is mean and wouldn't want the rest of the class to see. How would you feel if you were in the same situation as Theo? What should Theo do or say? What do the actions of each character say about their digital identity?

   f. Amari's class has been learning about endangered animals, including ones that live in their state. Amari remembers online videos she has seen about other animal topics and wants to do something online to tell more people in the community about how to protect this animal. How would you feel if you were in the same situation as Amari? What should Amari do or say? What do the actions of each character say about their digital identity?

3. Online Avatars as Digital Identity (20 min)

- Explain that words and actions are not the only way that people portray themselves online. Images are another way. In addition to using photos to share about themselves, many people use a variety of digital avatars. **Avatars** are images or characters that represent a person online. They are used to portray yourself the way you want to be seen by others online. They might be used as your image on a media website or for your character in a video game. Using an avatar is also a way to keep yourself safe online by not sharing your real photo, location, or other identifying features. An avatar can appear like a digital version of the real you or have fictional characteristics like an elephant nose or a mohawk. An avatar represents you and your personality, but doesn't have to "be" you. On the flipside, students should not hide behind the anonymity of an avatar to behave badly online. Making good choices with their words and actions still matters, even when using an avatar.
- Students may already be familiar with the concept of avatars from playing games like Minecraft or Pokémon GO, or because their parents create avatars when using tools like Bitmoji. Ask students, "Are you familiar with avatars? Have you or has someone in your family ever used an avatar online? What was it like?"
- Create an Avatar: Using the Padlet "I Can't Draw" feature (or another tool that you selected), support students in prompt writing and creating a personal avatar. If students have their own devices, then they can do this simultaneously as a whole group. If not, this can be done in small groups or in a learning center.
  - **a.** Prompt writing: Have students complete the following sentence to create their first version of their avatar. After seeing the results, students can change or add more details to their prompt to get a result closer to the one they have in their mind. "A _______ style avatar of a _______ year old _______ with _______ hair, _______ eyes, and _______. For the last blank, have students add any detail of their choice, such as "loves Pokemon," "has cat ears," "feels happy," "is good at sharing," or "is dressed up like a king chess piece."
  - **b.** While this sample prompt structure can help students get started, they can also use the technology to express themselves creatively. Students can create an avatar that reflects who they "feel" like they are, not just how they physically look. For example, students may write prompts like these:
    - **i.** "A beautiful avatar of an Asian child with short purple hair and butterfly wings."
    - **ii.** "An avatar that is clever as a fox, fast as a cheetah, and wild as a flower."
    - **iii.** "A dragon that loves and protects its little brother."
    - **iv.** "A cartoon avatar of an 8-year-old boy with brown hair and green eyes that is dressed up like the king chess piece."

    (Students may need to save several images as they go while experimenting with their prompt, then choose the image that they like best.)
  - **c.** Have students post the avatar they like best into the class Padlet, along with a username and the text prompt that they used. Without parent permission, students should not post any personally identifiable information (PII) into the Padlet.
- Share: Share the avatars with the class via Padlet, via SeeSaw (seesaw.com), or via a digital storybook; or by printing them and displaying them in the classroom or on a bulletin board.

Extensions

Following are several ways to expand students' exploration of digital citizenship and digital identity:

1. **Animated Avatars:** Students who want to create a more advanced avatar can use a tool like Voki (**voki.com**) to create an animated avatar. (***Note:*** Paid Voki Classroom accounts do not have paid advertising and do not require student registration.) Students could also use the Chatterpix Kids app (**bit.ly/3Zzfi2E**) to take the AI avatars they already created in this activity and make them speak.
2. **Put Learning into Action:** Expand students' application of the concepts they learned around digital identity and online behavior by facilitating a lesson or activity in which students communicate and collaborate in digital spaces. One possibility would be facilitating a lesson activity like the lesson "8-Bit Biome in a Box" in this book. In that lesson, students use an avatar to portray themselves in a virtual space and work together with other students in a safe and kind way to collaborate around an academic task, specifically creating and exploring habitat models. When working in that activity, remind them what they learned in this lesson about their digital identity and online behavior.
3. **More Digital Citizenship:** Expand students' thinking with other digital citizenship lessons. For example, Common Sense Media provides a series of free lessons for students ages 6–8, including Our Digital Citizenship Pledge (**bit.ly/3Bs20gj**) and This is Me (**bit.ly/3D4d2Zt**).
4. **Home Connection:** Share with parents and guardians that you and your students have been talking about digital identity and online behavior in class, and encourage parents/guardians to have a conversation with their child about safe and kind interactions with others online. If your school shares resources about digital citizenship and online safety, this would be a good time to remind parents and guardians how to access them.

LESSON 9

If You Give a Robot an Instruction, Then Learners Will Be Learning

By Gail Lovely

This math and computer science lesson focuses on using precise language, directionality, mathematical comparisons, and sequencing, while also practicing computational thinking skills such as algorithmic thinking, abstraction, and problem solving. Learners will use inanimate objects, the teacher, and/or real robots, as they learn simple coding skills. Coding is communicating with a computer or robot through a series of instructions or commands. Coding provides exciting ways for even very young children to think systematically through a challenge or problem and to think creatively about how to achieve a solution or goal.

In this lesson, learners will be giving commands—or instructions—to their "TeacherBot," which is their teacher acting as a simple robot. The students will work together to give clear, precise commands to their TeacherBot and, later, to real robots (if available). They will discuss "next" commands while practicing directionality, word order, and other problem-solving skills. Math skills, such as one-to-one correspondence, distance estimations, and shared decision making, will be key as well. Developmentally, some learners may be ready to draw or write an algorithm, a sequence of multiple commands for a robot to follow. Others may need to take it one step or command at a time.

> I found this very valuable because students really had to stop, review, and think with the assistance of the Teacher Assistant and the Teacher Bot. It was a productive struggle.
>
> — Ana Moya, PreK3 Teacher, Biomedical Preparatory at UT Southwestern

Lesson Overview

TARGET AGES

3–5

SUBJECTS

Math and Computer Science

ESTIMATED DURATION

Two 30-minute activities

OBJECTIVES

At the end of this lesson, students will be able to:

- Give precise commands to a "robot"—either "TeacherBot" (teacher as pretend robot), an inanimate object used as a robot, or to real classroom robots.
- Create multi-command algorithms to reach a goal.
- Explain that robots are not alive (though their "TeacherBot" is).

VOCABULARY

robot: programmable machines that move and can do specific things they have been built to do

command: an instruction for an action given to a robot or computer

algorithm: an ordered set of actions or steps needed to solve a problem

coding: communicating with a computer or robot through sets of instructions or commands

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Knowledge of forward and back (directionality).
- Beginning awareness of right and left (even if not consistent).
- Ability to move along a line or path on a floor, a sidewalk, or other surface.
- Counting objects or actions to five (e.g., "Take five steps").

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.5. Computational Thinker **b.** Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making. **c.** Students break problems into component parts, extract key information and develop descriptive models to understand complex systems or facilitate problem-solving.	**4–7:** **b.** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories. **c.** With guidance from an educator, students break a problem into parts and identify ways to solve the problem.
1.7. Global Collaborator **c.** Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal. **d.** Students explore local and global issues, and use collaborative technologies to work with others to investigate solutions.	**4–7:** **c.** With guidance from an educator, students take on different team roles and use age-appropriate technologies to complete projects. **d.** With guidance from an educator, students use age-appropriate technologies to work together to understand problems and suggest solutions.

COMMON CORE STATE STANDARDS

CCSS.MATH.CONTENT.K.MD.A.1: Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

CCSS.ELA-LITERACY.SL. 3.1, 4.1, 5.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade-appropriate topics and texts, building on others' ideas and expressing their own clearly.

CSTA K–12 COMPUTER SCIENCE STANDARDS

1A-AP-11 (K–2): Decompose (break down) the steps needed to solve a problem into a precise sequence of instructions.

1A-AP-12 (K–2): Develop plans that describe a program's sequence of events, goals, and expected outcomes.

Preparation

MATERIALS

- Sticky notes for creating "paths."
- Non-robotic stand-in "robots" for practice, such as small toy animals or cars.
- Optional: Red scrunchies, red ribbons, or a stamp with red ink to mark the right hand of each child. Red = right!

  If you extend the lesson to include real robots, you may want to choose to use a color that matches the buttons on your robot—that is, if the right-turn button is purple on your robots, then use purple scrunchies, ribbons, or stamps.

- Optional: Chalk for drawing paths in outdoor spaces.
- Optional: Extension activities require one or more electronic robots (see below).
- Advanced preparation:
- Optional: Create a set of icon cards for commands (forward, back, turn right, turn left, start, and stop).
- Optional: Print or create the paper tiles for keeping track of the "commands" given to the "robot." Sample tiles for download (**bit.ly/3D7TbZF**).

SUPPORTING RESOURCES FOR EDUCATORS

- Video: Jam Sandwich Algorithm - Primary Computing Lesson Example (**bit.ly/3VDm0Dt**). This video shows an example of a "teacher bot" making a sandwich, revealing the level of precision needed for commands given to "TeacherBot" in the lesson.
- Related children's books:
  - *Robots* by Gail Tuchman (nonfiction)
  - *Robots at Home* by Christine Zuchora-Walske (nonfiction)
  - *Robots, Robots Everywhere* by Sue Fliess
  - *Robot Train's Surprise Birthday Party* by Jen Chiao
  - *Pete the Cat: Robo-Pete* by James Dean
  - *Mechanimals* by Chris Tougas

Instructions

This lesson will provide learners with a beginning understanding of simple robots and the importance of giving clear commands—or instructions—to robots. It is separated into two sessions, which can be taught one after the other, or split across two different days or times.

Note: Several lessons and examples of "teacher-as-robot to be programmed by students" can be found on the internet. Some of these examples involve making sandwiches; others involve moving the teacher-as-robot around the classroom. This lesson uses the strategy of introducing the teacher-as-robot as a way to help our youngest learners begin to think through standardized language, directionality, purposefulness, and distances. One difference built into the lesson here is the very active participation of our young learners as not only "command givers," but also as "learner-robots" who get to practice their own directionality and movements in context of the lesson. Whole-body responses to "what comes next?" as the "robot" is programmed help to reinforce the learning in age-appropriate ways.

1. **Activity 1: Meet TeacherBot**

- Ask students, "What is a robot?" Gather ideas from the students.
- Next, share some correct ideas about robots with the students, such as:
  a. Robots are made and programmed by people to do things.
  b. Some robots use artificial intelligence to move on their own.
  c. Most robots are capable of moving in some way, using wheels, legs, arms, or other moving parts.
  d. Most robots are programmable, meaning what they do can be changed or controlled through programming.
  e. Robots are not alive.
- Introduce yourself to the students as "TeacherBot."
  a. Explain that they are going to be robot programmers of the TeacherBot (you). Position yourself in front of the students, so your right is the same as their right and your forward is their forward.
  b. Share that you are programmed to move in straight lines one step at a time.
  c. Introduce the commands the TeacherBot has been trained to follow:
    i. Forward: Have the group practice one step forward: first pointing forward and then moving one step forward on command)
    ii. Backward: Have the group practice one step back: first pointing back, then moving one step back.)
    iii. Step: A discussion about how big a "step" is will likely be started; for now, one heel-to-toe step will be a sufficient "standardized measurement".
    iv. Combine steps: Show how a series of commands can be given for multiple movements. Have the group practice a combination like step forward, step forward, step backward.
    v. Go: Tell students that the TeacherBot will not start following the commands until they say the word "go." For example, they must say, "forward, go" for the teacher to take one step forward, or "forward, forward, forward, go" for the teacher to take three steps forward.
  d. Ask students to give you instructions to move toward an object or a location that is directly in front of you. (e.g., "Give Teacherbot a command to go to the blue chair" (which is in front of you).
    i. If they only say "go," reply with something like "I cannot follow that command" and stand, awaiting a different command.
    ii. Lead them through trial and error to learn your command syntax.
    iii. Work them through to successful syntax (i.e., What additional commands beyond "go" does the TeacherBot need?)

iv. Tell students that if their commands did not move the TeacherBot far enough, they will need to work through the problem and come up with more commands.

e. Practice the same activity with "back," having Teacherbot move backward to a desired location.

f. Share that TeacherBot is also programmed to turn left and right, and that it always turns a square corner, 90°, like the corner of a standard piece of paper. Stress that when a turn command is given, TeacherBot will *turn*, but not *step* (model and explain if needed).

i. Optional: Provide each child with a red scrunchie, ribbon, or stamp on their right hand to help with directionality. Also mark your own right hand. We usually suggest red to equal right; however, you might choose a different color to match the "right" buttons on the real robots you may later be working with.

ii. Practice *right* turns with the students.

- Have students raise their *right* hands
- Check they have *right* hands raised.
- Ask students to move that hand so it is straight out to their side (pointing *right*).
- Students turn *right*, facing where their hand was pointing.

iii. Practice *left* turns the same way. If your learners are not ready for right *and* left, start with only right turns (until they suggest turning the "other way").

iv. Choose a target for TeacherBot that can be reached with forward or back and right (or left). For example, forward-forward-right-forward-go to reach a chair.

- Work through this program one step at a time.
- After each step, discuss where they want TeacherBot to go next, discussing which direction that is for TeacherBot and then programming TeacherBot to move. With young learners, have them "act out" the actions of the "robot" by moving themselves as well.

v. Tell learners that a list of steps is an algorithm. An algorithm is an ordered set of actions or steps needed to solve a problem or accomplish a task.

vi. Optional: With some groups of children this also can be where you begin to record what commands students have given, visually displaying the algorithm for them to see. This can be done on a whiteboard or with paper. The algorithm can be written out in full words or be "abstracted" by using abbreviations or symbols. Some examples include:

- Forward – Forward – Right – Forward - Go
- FD – FD – RT – FD – GO
- F – F – R – F – G
- ↑↑→↑●
- You could also use images which match the buttons on your physical robots for easier transfer if you will be using those real robots later.

(If your students need more practice, you can continue the guided movement with a PersonBot, using a student as the Bot prior to moving on to Activity 2 and the use of objects as simulated robots.)

2. **Activity 2: Simulated Robots**

- This activity moves beyond humans acting as robots to simulated robots. This is one abstraction level higher for the learners. Simulated robots may be small toy animals, cars, or other objects that can be moved by the teacher and the students.
- In the classroom, create a path of sticky notes where each sticky note represents a single "step" and the path includes only right-angle turns. Have students say and follow commands to move their simulated robots successfully through the path. For those students who are recording their algorithms, also provide a paper or another place for learners to write and keep track of the steps they are programming the simulated robots to take.
- Of course, if you have outdoor spaces, you can create even more paths that can be followed by simulated robots in the form of toy vehicles, tricycles, or other outdoor play objects. Remember to use only right-angle turns at this developmental stage to ensure that students can complete the path without teacher intervention.

3. **Activity 3: IF/THEN/ELSE**

- Once students have mastered providing precise algorithmic sequences of steps, you might add another level of complexity. In this case, you could add IF/THEN/ELSE statements. The structure IF/THEN/ELSE is a conditional statement, which will be very useful as children move into more complex programming and problem solving.
- Start by reviewing the following concepts from Activities 1 and 2.
  a. Commands: forward, back, right, go (and left, if included).
  b. Algorithm: like a recipe, the ordered steps needed to complete a task.
- Advance students' thinking about steps in an algorithm with IF/THEN/ELSE conditionals.

a. To add this element, together as a class or small group, create a sticky note path with multiple branches that lead to a goal.
   i. The path might represent a real-world scenario, like a car driving to a specific place.
   ii. The path should include all straight lines and only right-angle turns.
   iii. The path should provide multiple ways to get from start to finish.
b. Working together, write out the commands to reach the goal and start moving the car or other simulated robot toward the goal.
c. Add to the scenario that one of the road choices is closed, perhaps by adding an obstacle or two to the path. Make sure there is still at least one way to get to the goal.
d. Tell students that you will be using a new programming structure: IF the road is open, THEN we will have our robot go that way, ELSE we need to go another way."
e. Continue programming the simulated robot, stopping to repeat the conditional programming structure when the upcoming road is blocked: "IF the road is open, THEN the robot can continue, ELSE, (the road is blocked and) it must go another way."

- Using basic sequencing and IF/THEN/ELSE command rules, many repeated fun adventures with paths and beginning to keep track of algorithms can be done in whole groups, small groups, or independent centers.

Extensions

Following are two ways to expand students' exploration of algorithms:

1. **Extending to Real Robots:** Using real robots with buttons-on-board (direct programming buttons on the robot) is developmentally appropriate for most of our youngest learners. Some examples of these are Bee-Bot (**bit.ly/4fmbSWY**), Blue-Bot (**bit.ly/4itmlm7**), Robot Mouse (**bit.ly/4gfOw6r**), and Tale-Bot (**bit.ly/40qD8hh**). We recommend not using remote-controlled robots with young learners as it is a much more abstract interface.
   - Introduce a robot to your students. Pass it around, letting each student look at it carefully.
   - Ask students, "What do you notice about the robot?" Possible answers may include: wheels, switches, buttons, lights.
   - Introduce any classroom guidelines about using the robot(s), such as:
     a. Use the robot on the floor only.
     b. Wash your hands before using the robot.
     c. Switch the robot off when finished.

- Review the guidelines by asking students, "What are the rules when using the robot?"
    a. We need clean hands.
    b. We need to work on the floor.
    c. It needs to be turned on. (All robots need energy to work.)
- Shift the conversation to commands and algorithms by asking students, "How do you think we tell the robot what to do? (i.e., How do we program it?)"
- Explore the directional command buttons with the students, and determine what each button does. This will vary with different robots. Some robots have additional command buttons or other features that will be new to the students, such as:
    a. Erase or Clear: Erases the commands entered.
    b. Go or Start: Runs the algorithm.
    c. Sounds: Hearing a sound when the buttons are pushed or the algorithm has been run is helpful for many young learners.
- Work together to program one robot to reach a goal.
    a. Younger students will likely start with one command at a time. For example, they might use "Forward - Go" and then "Forward – Go" until the robot moves to the goal. Other children may estimate how many steps forward, pushing forward that many times and then pressing the Go button.
    b. Practice programming the robot, asking students to notice if the robot takes the same size step each time (it should).
    c. Practice estimating, asking, "About how many steps will it take for the robot to touch the sticky note on the floor, Sam's foot, etc.?" Use a series of "guess and check" practices as students begin to build estimation skills related to the distance.
- Introduce algorithms with real robots. Remind students that an algorithm is an ordered set of commands needed to solve a problem or complete an action. Use the following strategies to build skills around students' algorithmic thinking.
    a. Have students preprogram multiple steps (commands) to create algorithms.
    b. Provide printed icons or tiles to learners (these should show symbols for turns and for moving forward or moving back) to visually represent their algorithms.
    c. Provide a problem or have students set their own problem that can be solved by programming the robot. For example, "What commands do we need to give to the robot in order to have it move from here to a sticky note across the room, without hitting the bookshelves?" Have students record their algorithm by lining up icons or tile cards, or by writing words or drawing symbols on a white board or paper. The algorithm could be made up of arrows, symbols, words, or letters.
- Extend further with more advanced learners by working together to discover how to make a robot move in a square shape or a rectangular shape.

2. **Home Connection:** Share the following ideas or resources with students' parents/guardians.
   - Provide TeacherBot-like exploration ideas for families to explore at home. An AuntieBot, MommaBot, DadBot, SisterBot, or even a ShoeBot could be a fun experience for all involved!
   - Provide vocabulary, justification, and ideas for the use of "paper bots" at home for learners and families to explore.

LESSON 10

Working with AI Automation

By Nancye Blair Black

Even young students can work with block-based coding platforms to create meaningful applications. In this lesson, students will do just that to create a simple app that includes an AI image recognition extension. The outcome is a fun, automated application that displays the user's image via the webcam and continuously responds to the user's movements.

This lesson is an engaging way to bring algorithmic thinking to life for elementary students. Algorithmic thinking is a fundamental computational thinking skill and is emphasized in the ISTE Standards and the CSTA K–12 Computer Science Standards. This lesson illuminates the inner workings of AI-powered image recognition applications that students are likely already encountering in their everyday lives. At the end of the lesson, students will have a better understanding of foundational algorithmic control structures (specifically, sequences and forever loops) and of what AI is, including one way that it can behave "intelligently."

This lesson reinforces positive relationships within the classroom through collaborative coding experiences, and additionally provides a home connection extension that allows students to show the class app to their parents, then "teach" their parents or guardians how their app works or how to create another AI app at home.

> I am always excited to do this activity with my students because I see their faces light up when we get it to work. This activity provides students an opportunity to dive into computational thinking by linking their everyday interactions with technology to hands-on coding experiences. Block-based programming and image recognition in Scratch, not only provides access to tools the students can tinker with, but also gives them an insight on how AI works.
>
> — Michelle Velho, STEAM Director, Hudson Montessori School

Lesson Overview

TARGET AGES

6–8

SUBJECTS

Computer Science and Artificial Intelligence

ESTIMATED DURATION

45 minutes

OBJECTIVES

At the end of this lesson, students will be able to:

- Explain AI image recognition.
- With support, write a simple algorithm that integrates a pre-trained AI model into a program.
- With support, remix an algorithm to customize its functionality.

VOCABULARY

artificial intelligence (AI): a form of human-created computer program that simulates characteristics of intelligence that humans or animals might have

automation: technologies that function on their own with little human direction needed

sequence: series of steps in a particular order

forever loop: an algorithmic control structure that repeatedly runs the blocks found inside for as long as the program is running or until conditions change

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.1. Empowered Learner **d.** Students understand fundamental concepts of how technology works, demonstrate the ability to choose and use current technologies effectively, and are adept at thoughtfully exploring emerging technologies.	**4–7:** With guidance from an educator, students explore a variety of technologies that will help them in their learning and begin to demonstrate an understanding of how knowledge can be transferred between tools. **8–11:** Students explore age-appropriate technologies and begin to transfer their learning to different tools or learning environments.
1.5. Computational Thinker **d.** Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.	**4–7:** Students understand how technology is used to make a task easier or repeatable and can identify real-world examples. **8–11:** Students understand and explore basic concepts related to automation, patterns and algorithmic thinking.

CSTA K-12 COMPUTER SCIENCE STANDARDS

1A-AP-10: Develop programs with sequences and simple loops, to express ideas or address a problem.

1A-AP-14: Debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.

1B-AP-10: Create programs that include sequences, events, loops, and conditionals.

1B-AP-12: Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.

1B-AP-15: Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

Students should have basic familiarity with the Scratch coding language, including dragging coding blocks into the code editor, deleting and inserting sprites, and using the "when green flag clicked" block to run the program.

Preparation

MATERIALS

- Computer(s) or tablet(s) (one per student or group) with internet connection for accessing tools online and a webcam for interacting with image recognition features.
- RAISE Playground (**playground.raise.mit.edu/main**): This coding platform allows students to code in the Scratch programming language without accounts or student data collection. It also includes several custom AI extensions that allow students to code with pre-trained models.

ADVANCED PREPARATION

Practice coding a simple AI image recognition app by using the provided step-by-step walkthrough instructions (**bit.ly/49xCbb7**). Optionally, you can use the app you create during practice for the "I Do" demo portion of the lesson instead of the provided sample.

SUPPORTING RESOURCES FOR EDUCATORS

- Resource: RAISE Playground website (**bit.ly/4gOczJN**)
- Video: "What Do You Tell Your Kids about Automation?" (**bit.ly/4gaFCHd**)
- Resource: Scratch Wiki: Forever (block) (**bit.ly/4g7WFtv**)
- Article: "Gradual Release of Responsibility: I Do, We Do, You Do" (**bit.ly/3OS8s3q**)

- Children's books related to this lesson:
  - *Adi's Perfect Patterns and Loops* by Caroline Karanja, illustrated by Ben Whitehouse
  - *What's a Loop?: A Tree House Adventure! (First Steps in Coding)* by Kaitlyn Siu, illustrated by Marcelo Badari
  - *AI+Me: Big Idea 1—Perception: How AI Sees the World* by ReadyAI
  - *Artificial Intelligence for Kids* by Dr. Dhoot
  - *Robots* (National Geographic Kids Readers, Level 3) by Melissa Stewart
  - *Ultimate Book of the Future: Incredible, Ingenious, and Totally Real Tech that will Change Life as You Know It (National Geographic Kids)* by Stephanie Warren Drimmer

Instructions

In this lesson, students get hands-on with the use of AI image-recognition extensions in Scratch. The lesson activities use an "I Do, We Do, You Do" (Levy 2007) instructional format so you can teach students about AI image recognition and gradually release responsibility and ownership to the students.

1. Activate prior knowledge: Ask students if they have ever seen a photo app that added images or cartoons to their photo. It might put cat ears on the top of their head or make bubbles come out of their ears. If you have example photos of yourself, your students, or their parents that have been created using a photo app filter like this, you could share them with the class.
2. I do: Tell students that it is possible to create your own photo app that adds images or cartoons to a live image. Project a sample Scratch application for the whole class, allowing them to take turns interacting with it to see how it works.
   - Download this sample RAISE Playground Scratch application (**bit.ly/4iuUCS0**), or one of your own creation.
   - Launch the RAISE Playground (**playground.raise.mit.edu/main**).
   - Upload the sample program. This program integrates multiple pre-trained AI machine learning models. Using AI image recognition, the app is able to:
     a. Recognize where the user's hand, body, or facial features are.
     b. Respond to the user's actions.
   - Allow students to take turns trying out the app, sharing their guesses about how it works.
3. Explain to students that:
   - The app uses **artificial intelligence (AI)**. AI is a form of human-created computer program that simulates characteristics of intelligence that humans or animals might have.
   - This AI is able to use a webcam sensor to "see" and uses an AI algorithm to "reason" about the image and recognize body parts, facial features, and facial expressions of its users.
   - The app is an example of **automation** because it functions on its own with little human direction needed. Automation technologies can help perform many types of tasks more quickly.

4. We do: Create an AI image recognition Scratch app together as a class. Walk and talk through the steps in the step-by-step walkthrough instructions (**bit.ly/49xCbb7**) to create a simple AI app together. Explain the purpose of each step and ask students for their observations as you go, especially as it relates to algorithmic **sequencing**, use of the **forever loop**, AI, and automation. If devices are available and time permits, you might want to go through this process twice: once with the whole class contributing to the group app, then once while students code along with you individually, in pairs, or in small groups.
5. You do: Allow students to program an AI image recognition photo app.
   - For first graders or other beginning coders, you could continue as a whole class, creating a new image recognition app based on students' suggestions. Give students agency to direct the collaborative programming activity. They might choose a sprite; select which hand, face, or body part for the sprite to "go to;" and work as a class to "remix" the demo application by making custom adjustments or additions to the code in order to improve the app's functionality (with your support). During this stage, you should provide guidance to keep them moving in the right direction, but also allow them to make mistakes, debug the program together, and learn from those mistakes in the process.
   - For second and third graders, students could work independently or in pairs to program their own application. Depending on the number of available devices and your class setup, students could complete this programming simultaneously as a class or work on this in learning centers.
6. Discuss: Once students have completed all activities, wrap up the activity with a simple discussion.
   - What other things would be helpful for AI to be able to automatically recognize using camera images? What might be done better or faster by automating it with AI image recognition? Possible answers include:
     a. An AI app that recognizes your own pet dog and only opens a doggie door for that particular dog.
     b. An AI app that ties into a bird-watching camera in a tree and takes a photo whenever the app recognizes a particular species of bird.
     c. An AI app that recognizes which LEGO bricks are included in a mixed pile to suggest what builds could be made with those pieces.
     d. An AI app that recognizes shoes, even in a messy room, to help kids find their shoes before school.
     e. An AI app that recognizes recyclable items using a camera over a trash can and makes a buzzing sound if you accidentally put recyclable items in the trash can.
   - What was challenging about coding with the AI image recognition extension? What was your favorite thing about it?

Extensions

Following are ways to expand students' exploration of algorithmic thinking, AI, and automation:

- **Remix:** As time permits, allow students to "remix" their initial AI image recognition Scratch apps. Do this by giving them more time to combine what they learned in this lesson with their prior knowledge about Scratch programming or by tinkering with new blocks with adult support. For example, students might add Motion, Look, or Sounds blocks, or they might change the size or direction parameters for the sprite.
- **Extension for third graders or other advancing coders:** Students can iterate upon this simple AI image recognition app to advance their use of coding control structures to include not just sequencing and a forever loop, but also conditionals with if/then blocks (**bit.ly/3OP7If4**). This extension can address the instructional shift from the CSTA K–12 CS Standard 1A-AP-10 for grades K–2, which states "Develop programs with sequences and simple loops, to express ideas or address a problem" to the CS Standard 1B-AP-10 for grades 3–5, which states "Create programs that include sequences, events, loops, and conditionals." By combining the use of if/then blocks and the Boolean "expressing" and "feeling" blocks from the Face Sensing Extension, students can create AI image recognition apps that respond to smiling, frowning, and other facial expressions and movements.
- **AI image recognition automation in the real world:** Extend students' understanding about the application of AI image recognition in apps by providing hands-on experience with an age-appropriate mobile tool like TapTapSee (**taptapseeapp.com**), which recognizes nearly any object), or Seek by iNaturalist app (**inaturalist.org/pages/seek_app**), which recognizes animals, plants, and other living things.
- **Home Connection:** The RAISE Playground is a free platform that students can access both at school and at home. You can share the step-by-step walkthrough instructions with students' families, so that students can show their parents how to create this basic AI app and share about what they learned.

LESSON 11

Living and Nonliving Things

By Susan Brooks-Young

We typically start teaching children about the similarities and differences between living and nonliving things when they are very young. Why? It's because this discernment helps lay the foundation for basic understandings about life sciences. But in the age of robots, digital assistants, and other interactive technologies, it's also important to help children ages 3–5 to begin to grasp that, despite appearances, these devices are not living things.

Adults, too, often anthropomorphize these devices and computer programs. Think about the terms you use when referring to digital devices and interactive software. Avoid using language that implies that these devices are alive and able to think. Why? Young children often have unreal assumptions about what these machines are actually capable of doing. The language we use when talking about various devices with children will help them develop more realistic expectations. This activity is designed to help students expand their ability to discriminate between things that are living and things that are not living.

Students' computational thinking skills are enhanced throughout this lesson through opportunities designed to help them gather and analyze data using pattern rules based on the characteristics of living things to determine if something is living or nonliving.

> The centers were super engaging for my students who really enjoyed them—especially looking around the room and drawing pictures of living and nonliving things. The activities brought up great discussions about video games. For example, characters eat and drink in the game, but are they actually living?
>
> — Alexandra Schroder, Kindergarten Teacher, Wilmington Area Elementary School

Lesson Overview

TARGET AGES

3–5

SUBJECTS

Science and Engineering

ESTIMATED DURATION

Two 30-minute activities (1 and 3), one learning center with timing based on your schedule (2). Remember that these times are estimations. Move at a pace that is right for your students.

OBJECTIVES

At the end of this lesson, students will be able to:

- Identify at least four characteristics of living things.
- Accurately classify things as living or nonliving.
- Interact with a digital human and engage in a discussion about its characteristics.

VOCABULARY

living thing: something that eats, breathes, grows, and makes more of itself (reproduces)

nonliving thing: something that never has eaten, breathed, grown, or made more of itself

chatbot: a computer program that appears to be able to talk with humans

In the course of this lesson, students participate in several activities to help them distinguish between living and nonliving things. They then have an opportunity to interact with a Digital Human and discuss if this AI is living or nonliving.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Knowledge that things can be alike in some ways and different in other ways.
- Knowledge that things can be grouped using identifying attributes or characteristics.

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.3. Knowledge Constructor **b.** Students evaluate the accuracy, perspective, credibility and relevance of information, media, data or other resources.	**4–7:** With guidance from an educator, students become familiar with age-appropriate criteria for evaluating digital content.
1.5. Computational Thinker **b.** Students collect data or identify relevant data sets, use digital tools to analyze them and represent data in various ways to facilitate problem-solving and decision-making. **d.** Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.	**4–7:** **b.** With guidance from an educator, students analyze age-appropriate data and look for similarities in order to identify patterns and categories. **d.** Students understand how technology is used to make a task easier or repeatable and can identify real-world examples.

NEXT GENERATION SCIENCE STANDARDS

NGSS Science and Engineering Practices: Analyzing and Interpreting Data.

K-LS1-1 From Molecules to Organisms: Structures and Processes: Use observations to describe patterns of what plants and animals (including humans) need to survive.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online for all whole-class activities.
- Computer(s) or tablet(s) with internet connection for accessing online activities. One to four devices in a learning center to be shared by two to three students per device is sufficient. You will also need headsets if children listen to a video picture book read-aloud.
- Video: "Living and Non-Living Things: Science for KIDS!" (**bit.ly/4gugyuO**)
- Online Games:
  - Wordwall: Living and Nonliving Things (**bit.ly/3DayrAh**)
  - Y2 Living or Nonliving? (**bit.ly/4g7WUVr**)
- Digital Human: Sophie (**bit.ly/4g16WYx**)
- Optional: Drawing materials—paper, pencils, crayons, or markers for learning center activity.
- Optional: Teacher-created picture cards of living and nonliving things that students can use to sort. See Advanced Preparation below for more directions.

- Optional: Read-aloud video of one or more picture books about living and nonliving things.
- Optional: Living or Non-Living app for iPad (**bit.ly/3ZMrUVn**)

ADVANCED PREPARATION

- Watch "Living and Non-Living Things: Science for KIDS!" (**bit.ly/4gugyuO**). You will use this introductory video to review with students the basic information about characteristics of living things. The narrator asks questions during the video, at 0:13 and 0:25. Decide if you will stop the video to discuss each question with the class.
- Review the two online games: Wordwall: Living and Nonliving Things (**bit.ly/3DayrAh**) and Y2 Living or Non-living? (**bit.ly/4g7WUVr**). You will use these activities with the whole class.
- Familiarize yourself with Digital Human: Sophie (**bit.ly/4g16WYx**), including authorizing access to the computer's microphone. The Sophie image appears in the lower right hand corner of the screen. To enlarge the image of Sophie, press Ctrl+ (PC) or Command+ (Mac) to Zoom in. You may want to mute the microphone except when asking the digital human a direct question.
- Optional: Assemble drawing materials for the learning center activity.
- Optional: Prepare 30 picture cards (15 living things and 15 nonliving things) for a learning center activity. You may also want to create sorting mats of different colors, e.g., red for living things and green for nonliving things. Be sure to include images of some interactive devices like digital assistants or robots. Possible sources of royalty-free images include: Pics4Learning (**pics4learning.com**), Pixabay (**pixabay.com**), or Smithsonian Open Access (**si.edu/openaccess**).
- Optional: Select read-aloud videos of picture books about living and nonliving things. Search the internet, using sites such as YouTube (**youtube.com**) and Vimeo (**vimeo.com**), to locate read-aloud videos and review each video before using it with students.
- Optional: iPad app Living or Non-Living (**bit.ly/3ZMrUVn**). If you have access to three or four iPads, you may want to include this app in a learning center. Download it, review it, and decide.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Article: Why Chatbots Can't Have Real Human Conversations: The limits of artificial chatting" (**bit.ly/4gwKuGs**)
- Article: "AI Isn't Just Robots: How to Talk to Young Children about AI" (**bit.ly/3Dc1tQd**)
- Article: "How Anthropomorphism Hinders AI Education" (**bit.ly/4gbbBat**)
- Article: "Many Kids Are Unsure if Alexa and Siri Have Feelings or Think Like People, Study Finds" (**bit.ly/3OPOW7D**)
- Related children's books:
  - *Do You Know Which Ones Will Grow?* by Susan A. Shea
  - *Living Things and Nonliving Things: A Compare and Contrast Book* by Kevin Kurtz
  - *Living and Nonliving* by Carol K. Lindeen
  - *What Do Living Things Need?* by Elizabeth Austen

Instructions

The skills required to differentiate between living and nonliving things also help children become more proficient computational thinkers. Learning how to identify similarities and differences, then compare and contrast those similarities and differences to classify things, are skills directly related to understanding algorithmic thinking.

1. **Activity 1: Characteristics of Living Things (Whole Class Activity)**
   - Show the video (1:52), "Living and Non-Living Things: Science for KIDS!" When the video ends, ask students to name the characteristics of living things that are mentioned in the video (0:16). These characteristics are: Living things eat, breathe, grow, and make more of themselves (reproduce).
   - Explore this topic further by playing the two Wordwall online games to give students practice in classifying images of things as living or nonliving. Students can decide if each photo represents a living or nonliving thing by checking it against the list of characteristics identified in the video. If all four are true, the thing is living and if not, it is nonliving.
2. **Activity 2: Living and Nonliving (Learning Center)**
   - Allow students to practice identifying living and nonliving things in a learning center that takes place after Activity 1 and before Activity 3. Provided activities may include:
     - a. Challenging children to find living and nonliving things in the classroom and to draw pictures of them.
     - b. Providing picture cards that children can sort into groups of living and nonliving things.
     - c. Offering a listening center where children can watch a read-aloud video of a picture book about living and nonliving things.
     - d. Allowing children to explore the Living or Non-Living app for iPad.
3. **Activity 3: Interact with a Digital Human (Whole Class Activity)**
   - Tell students you are going to share with them a digital human named Sophie. Explain that this is a chatbot, a kind of computer program that can have conversation-like interactions with humans. It is designed to answer questions that people ask by typing or speaking into the computer microphone.
   - Display and demonstrate Sophie using a large screen. Monitor the language you use when demonstrating Sophie. Avoid referring to the chatbot as "her" or "she." Keep in mind that as a chatbot Sophie cannot think, or see, or hear. Instead, Sophie receives data, processes that information, and generates output.
   - Help the class brainstorm a few questions they would like to ask Sophie. The questions can literally be about anything. Demo asking questions by typing and by using the microphone. Talk with students about what they see and hear. How well does the program work? Do the answers make sense?
   - Discuss with students: Does it seem like they are talking with a living person when a question is asked and answered? How can they tell that Sophie is nonliving? Does it meet any of the four characteristics of a living thing? (Hint: If students are struggling with this, ask the chatbot if it eats, grows, or breathes.) What do they think about this experience?

Extensions

Following are two ways to expand students' exploration of living and nonliving things:

1. **Real World Examples:** If you have access to devices that appear to be living (e.g., a digital assistant, chatbot, personal robot, etc.), share that device with students and discuss if it is living or nonliving and how students can tell.
2. **Home Connection:** Sometimes a video can be more inviting to parents than a packet of materials sent home with written instructions. Consider creating a ScreenPal (**screenpal.com**) video for parents in which you describe and model the activities their children have engaged in related to living and nonliving things. Provide links to online activities and offer suggestions for how to recreate offline activities at home.

LESSON 12

Understanding Digital Helpers

By Susan Brooks-Young

When it comes to digital assistants, a common source of frustration for young students is their tendency to form unrealistic expectations about the capabilities of these devices. Digital assistants are typically designed to emulate human characteristics and behaviors as closely as possible, and this tendency is confusing to children because they tend to anthropomorphize (ascribe human qualities to) nonhuman things. In the age of robots, digital assistants, and other interactive technologies, it's important to help primary-aged students begin to understand that, despite appearances and abilities, these devices and programs are not human.

Adults often anthropomorphize these technologies as well. Think about the terms you use when referring to robots, digital assistants, and other interactive technologies. Consider avoiding the use of language that implies that these technologies are alive and able to think. Why? Young children often have unreal assumptions about what these machines are actually capable of doing. The language we use when talking about various devices with children will help them develop more realistic expectations. This activity is designed to help students understand that digital assistants and other AI agents are simply doing what they've been programmed to do.

In the course of this lesson, students participate in several activities that provide opportunities for them to interact with a Digital Human and discuss if this AI is living or nonliving.The lesson concludes with an activity in which students create a list of attributes of good friends and based on what they have learned about chatbots, determine if humans can befriend chatbots and why.

In addition, opportunities to hone computational thinking skills are incorporated throughout the activity. These are designed to assist students' practice in gathering and analyzing data—using rules based on the characteristics of living things—to determine if something is living or nonliving.

> This lesson helped demystify AI and robots for my students. The discussions about what makes a friend and comparing that to Digital Assistants was eye opening for them.
>
> — **Tracy Andrews, First grade teacher, Wilmington Area Elementary School**

Lesson Overview

TARGET AGES

6–8

SUBJECT

Science

ESTIMATED DURATION

Two 30-minute activities (1 and 3), one learning center with timing based on your schedule (2)

OBJECTIVES

At the end of this lesson, students will be able to:

- Define the terms *digital assistant* and *algorithm*.
- Understand that digital assistants and robots are created by humans and do not possess consciousness or self-awareness.
- Recognize that digital assistants use algorithms to complete tasks such as answering questions.
- Develop guidelines for behaving in positive ways when using a digital assistant.

VOCABULARY

anthropomorphize: to ascribe human form or attributes to something (for example, an animal, plant, or inanimate object)

chatbot: a computer program that has conversation-like interactions with humans.

digital assistant: technology designed to assist users by answering questions and completing simple tasks. (All digital assistants are advanced chatbots, but not all chatbots are digital assistants.)

algorithm: a list of step-by-step directions for completing a task or solving a problem.

PREREQUISITE KNOWLEDGE AND/OR SKILLS

- Ability to identify the attributes of living things (eat, breathe, grow, and reproduce).
- Ability to identify previous experiences they have had with robots, digital assistants, and other interactive technologies.

ISTE STANDARDS FOR STUDENTS

ISTE Standard for Students	Age Band Articulations
1.1. Empowered Learner **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.	**4–7:** With guidance from an educator, students explore a variety of technologies that will help them in their learning and begin to demonstrate an understanding of how knowledge can be transferred between tools. **8–11:** Students explore age-appropriate technologies and begin to transfer their learning to different tools or learning environments.
1.2. Digital Citizen **b.** Students demonstrate empathetic, inclusive interactions online and use technology to responsibly contribute to their communities.	**4–7:** With guidance from an educator, students understand how to be careful when using devices and how to be safe online, follow safety rules when using the internet and collaborate with others. **8–11:** Students practice and encourage others in safe, legal and ethical behavior when using technology and interacting online, with guidance from an educator.

NEXT GENERATION SCIENCE STANDARDS

NGSS Science and Engineering Practices: Analyzing and Interpreting Data

K-LS1-1 From Molecules to Organisms: Structures and Processes: Use observations to describe patterns of what plants and animals (including humans) need to survive.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online for all whole-class activities.
- Computer(s) or tablet(s) with internet connection for accessing online activities. One to four devices in a learning center to be shared by two to three students per device is sufficient. You will also need headsets if children use digital assistants.
- Video: "What Are AI Chatbots?" (**bit.ly/3ZsCvU2**)
- Digital Human: Sophie (**bit.ly/4g16WYx**)
- Writing materials (paper, pencils, pens)

ADVANCED PREPARATION

- Preview the video "What Are AI Chatbots?" (**bit.ly/3ZsCvU2**). Depending on the ages of your students, you may want to simply share the information provided here without showing the video, or you might decide to show snippets of the video, stopping to briefly discuss each idea you think is critical.
- Familiarize yourself with Digital Human: Sophie (**bit.ly/4g16WYx**), including authorizing access to your computer's microphone. The Sophie image appears in the lower right hand corner of the screen. To enlarge the image of Sophie, press Ctrl+ (PC) or Command+ (Mac) to Zoom in. You may want to mute the microphone except when asking the digital human a direct question.
- Assemble writing materials.

RESOURCES

- Article: "Article: Why Chatbots Can't Have Real Human Conversations: The limits of artificial chatting" (**bit.ly/4gwKuGs**)
- Article: "Children & Artificial Intelligence" (**bit.ly/4gaDWxt**)
- Article: "AI Isn't Just Robots: How to Talk to Young Children about AI" (**bit.ly/3Dc1tQd**)
- Article: "How Anthropomorphism Hinders AI Education" (**bit.ly/4gbbBat**)
- Article: "Many Kids Are Unsure If Alexa and Siri Have Feelings or Think Like People, Study Finds" (**bit.ly/3OPOW7D**)
- Related children's books:
  - *How Do Digital Assistants Work?* e-book by Chai the AI Bot (**bit.ly/4ffcUnl**)
  - *Hello, Robot!: Day-to-day life with Artificial Intelligence!* by CosiCosa, illustrated by Ana Seixas
  - *Scholastic Reader Level 2: Robots* by Gail Tuchman

Instructions

This lesson provides students with an opportunity to apply previous learning about living and nonliving things to situations where they are dealing with conversational AI technologies. Many of these technologies are intentionally designed to resemble human beings as closely as possible, which encourages users to anthropomorphize them. As educators, we can bring awareness about the true nature of these technologies to students.

1. **Activity 1: What is a digital assistant? (Whole Class Activity)**
   - Discussion: Open this conversation by asking children to think about and share previous experiences they have had with talking robots or apps like Siri, Alexa, or Google Assistant. Say that in this activity students will focus on AI technologies called digital assistants.
   - Briefly explain the following definitions:
     a. **Digital assistant:** Technology designed to assist users by answering questions and completing simple tasks. Mention that all digital assistants are advanced chatbots. (But, conversely, not all chatbots are digital assistants.)

b. **Algorithm:** A list of step-by-step directions for completing a task.

- Either show the video "What Are AI Chatbots?" or share the information covered there with students.
- Demo Digital Human: Sophie. Point out that students can interact with this chatbot using text and voice. Establish ground rules for exploring the chatbot in a learning center. For example: take turns typing or speaking prompts; do not share personal information. Help the class brainstorm a few questions they would like to ask. The questions can be about almost anything. Walk students through asking—a few questions from their class list. Are the replies what they expected, or were there some surprises?

2. **Activity 2: Exploring a digital assistant (Learning Center):** Provide time for children to work in pairs to further explore the Sophie chatbot. Encourage them to use additional questions from the class list. Monitor their activity during center time.

3. **Activity 3: What makes a person a good friend? (Whole Class Activity)**
   - Debrief with students about their experiences using the chatbot.
   - Distribute writing materials to each student. Ask students to think about this question: What makes someone a good friend? Keeping this question in mind, ask students to write their ideas about what makes a good friend. If children are not yet fluent writers, they can draw their responses to this prompt. When students have finished writing or drawing, ask them to share their responses and why they demonstrate the attributes of good friends. As a class, brainstorm a list of the most commonly mentioned attributes of good friends.
   - Explain to students that some people believe that they can be friends with a digital assistant. Ask students if they think this is true. Review the class list of attributes of good friends. Based on what they have learned about chatbots, ask students if humans can truly befriend chatbots, and why or why not.
   - Ask students to reflect on the conclusions they have come to about whether people can form friendships with chatbots by asking themselves what they have learned about digital assistants, and why it's important to understand that they are not living things.

Extensions

Following are two ways to expand students' exploration of the capabilities of digital assistants:

1. **Interacting with digital assistants:** Some educators and parents have expressed concern that children might decide that, if digital assistants are nonliving, it's okay to be rude or mean when interacting with them. Ask students about this. Is it okay? Why or why not? Challenge students to create several class rules for positive interaction with digital assistants.
2. **Home connection:** Work with students to create a presentation that explains what digital assistants are, how chatbots work, and why humans cannot actually befriend chatbots. Post the presentation on your class website. Encourage parents to watch the presentation and continue conversations about these important topics at home.

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APPENDIX A

Glossary

abstraction: The process of simplifying complex tasks or ideas.

algorithm: An ordered set of actions or steps needed to solve a problem.

algorithmic thinking: The process of developing a step-by-step approach to completing tasks and solving problems.

anthropomorphize: To ascribe human form or attributes to something (for example, an animal, plant, or inanimate object).

artificial intelligence (AI): A form of human-created computer program that simulates characteristics of intelligence that humans or animals might have.

attributes: Characteristics or properties of an object or item, also known as **features**.

automation: Technologies that function on their own with little human direction needed.

avatar: Images or characters that represent a person online.

chatbot: A computer program that appears to be able to talk with humans.

coding: Communicating with a computer or robot through sets of instructions or commands.

command: An instruction for an action given to a robot or computer.

computational thinking: A set of skills for describing and solving complex problems.

digital assistant: Technology designed to assist users by answering questions and completing simple tasks. (All digital assistants are advanced chatbots, but not all chatbots are digital assistants.)

digital identity: The way someone exists online, including information about them, pictures of them, the things they say, and the way they act.

forever loop: an algorithmic control structure that repeatedly runs the blocks found inside for as long as the program is running or until conditions change.

generic pattern core labels: Labels for pattern core elements which do not distinguish the attributes involved. Example: "AB" pattern could refer to "apple, banana" or to "car, truck".

height: A measurement of something from the base (bottom) to the top.

living thing: Something that eats, breathes, grows, and makes more of itself (reproduces).

nonliving thing: Something that never has eaten, breathed, grown, or made more of itself.

online: Using a website or app that connects to the internet from a computer, tablet, phone, or other digital device.

parallelogram: A four-sided polygon with two pairs of equal, parallel sides and four angles.

pattern: Something that happens or appears in a repeated way.

pattern core unit: The part of the pattern which is repeated over and over when the pattern is extended (i.e. apple banana apple banana apple banana has the pattern core unit of "apple banana".

pattern recognition: The skills of creating, identifying, and extending patterns.

polygon: A general term for a closed shape with three or more straight sides.

problem decomposition: The skills of examining problems and breaking them into smaller, more easily-solvable components.

relationship-centered instruction: The use of teaching methods, resources, and class activities to support students' interpersonal connections.

robot: Programmable machines that move and can do specific things they have been built to do.

sequence: Series of steps in a particular order.

stability: The ability of a structure to maintain balance and stay in one spot.

square: A polygon with four equal sides and four right angles.

STEM: An acronym that refers to the academic areas of science, technology, engineering, and mathematics.

tans: The seven geometric shapes that make up a tangram square.

temperature: A measurement of how hot or cold something is.

triangle: A polygon with three sides and three angles.

weather: The temperature and other outside conditions (such as rain, cloudiness, etc.) at a particular time and place.

APPENDIX B

Alignment to ISTE Standards

The following tables provide a big-picture view of how the projects in each lesson align with the ISTE Standards for Students.

LESSON	1	2	3	4	5	6	7	8	9	10	11	12
ISTE Standards for Students												
Empowered Learner	x	x	x							x		x
Digital Citizen							x	x				x
Knowledge Constructor					x						x	
Innovative Designer			x	x		x						
Computational Thinker		x	x	x	x	x			x	x	x	
Creative Communicator	x						x	x				
Global Collaborator				x					x			

APPENDIX C

Bibliography

The list of resources below offers a curated selection of supplemental resources that may support your work with educational technologies and STEM education. When used in combination with the information in this guide and the references, they may help deepen your understanding of related considerations and strategies for leveraging technology to support early childhood education.

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