Hands-On
AI Projects
for the Classroom

A Guide for Elementary Teachers

ISTE

GENERAL MOTORS

Hands-On
AI Projects
for the Classroom
A Guide for Elementary Teachers

About ISTE

The International Society for Technology in Education (ISTE) is a nonprofit organization that works with the global education community to accelerate the use of technology to solve tough problems and inspire innovation. Our worldwide network believes in the potential technology holds to transform teaching and learning.

ISTE sets a bold vision for education transformation through the ISTE Standards, a framework for students, educators, administrators, coaches and computer science educators to rethink education and create innovative learning environments. ISTE hosts the annual ISTE Conference & Expo, one of the world's most influential edtech events. The organization's professional learning offerings include online courses, professional networks, year-round academies, peer-reviewed journals and other publications. ISTE is also the leading publisher of books focused on technology in education. For more information or to become an ISTE member, visit **iste.org**. Subscribe to ISTE's YouTube channel and connect with ISTE on Twitter, Facebook and LinkedIn.

Related Resources

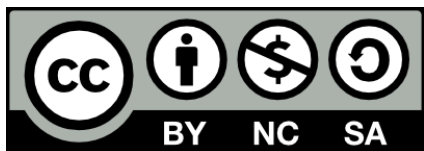**Teaching AI: Exploring New Frontiers for Learning** by Michelle Zimmerman

ISTE online course, *Artificial Intelligence and Their Practical Use in Schools*

To see all books available from ISTE, please visit **iste.org/books**

To see all courses available from ISTE, please visit **iste.org/isteu**

ISTE | **GENERAL MOTORS**

Contents

Hands-On AI Projects for the Classroom: A Guide for Elementary Teachers

foreword

Welcome to the *Hands-On AI Projects for the Classroom* series, a set of guides for teachers who are seeking instructional and curricular resources about artificial intelligence (AI) for various grade levels and across a range of subject areas.

We know that the jobs of the future will increasingly demand knowledge of how to leverage and collaborate with AI as a tool for problem-solving. Unfortunately, most students today are not on a trajectory to fill those jobs. To prepare students, all educators need to understand the implications, applications, and creation methods behind AI. After all, teachers are the most important link in developing the new generation of AI-savvy learners, workers, and leaders.

That's why ISTE has partnered with General Motors (GM) to lead the way regarding AI in education. Over the past three years, we have teamed up with GM to create scalable professional learning experiences to help educators bring AI to their classrooms in relevant ways, and to support students' exploration of AI-related careers.

These guides are an extension of our work and feature student-driven AI projects curated from educators in the field, as well as strategies to support teachers in implementing the projects in a variety of K–12 classrooms. The projects engage students in both unplugged and technology-infused activities that explore key facets of AI technologies.

The *Hands-On AI Projects for the Classroom* series is just one of the resources ISTE is creating to help educators implement powerful AI projects to prepare students for their futures.

We are convinced that the language of future problem-solving will be the language of AI, and that educators must accelerate their understanding of AI in order to guide the next generation. We are here to help you make that happen!

Joseph South
ISTE Chief Learning Officer

Introduction

What Is AI?

AI pervades learning, working, and living in the modern world. In fact, AI technologies are being developed and applied across all fields of study—from science and government to language acquisition and art. We believe that, in order to be successful in school and in life, *all* K–12 students need a foundational understanding of what AI is, how it works, and how it impacts society. AI education is important across *all* subject areas, not just computer science classes.

Yet, even if we believe that, most of us as K–12 educators and education leaders have not had much education in AI ourselves. You might even find yourself wondering: What exactly is AI? And if you are, you are not alone. In fact, even professionals in the field of AI do not always agree on the answer. Nevertheless, it is important to know what we mean in this guide when we refer to AI.

According to John McCarthy, who first coined the term, artificial Intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, J., 2007)[1]. A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using that data to make predictions and decisions.

In fact, the autonomous decision-making nature of AI technologies is part of what helps us to distinguish technologies that are and are not AI. For example, autonomous decision-making separates the non-AI automatic doors at your grocery store—which do use sensors to perceive, but open in response to simple if-then conditional statements—from AI-powered, self-driving cars that use sensors to perceive and analyze visual data, represent that data as a map of the world, and make time-sensitive, life-and-death decisions about which direction to move in next, and at what speed.

At their best, AI technologies accomplish tasks that are difficult or impossible for humans to accomplish by themselves. While early AI made decisions based on a preprogrammed set of data and actions, many newer AI technologies use machine learning to improve based on novel data as it is presented. When trained well, AI software is able to efficiently and effectively process, recognize patterns in, and extrapolate conclusions from large data sets across various fields of study. Similarly, robots powered by AI have the potential to complete tasks that are physically complicated, demanding, or even dangerous for their human counterparts. The projects in this guide and in the other volumes of the *Hands-On AI Projects for the Classroom* series reveal these capabilities to K–12 students across various subject areas and grade levels.

You can learn more about AI and access supporting resources in **Appendix A: Unpacking Artificial Intelligence**.

---

1 McCarthy, J. (2007). What is artificial intelligence? Retrieved from jmc.stanford.edu/articles/whatisai/whatisai.pdf
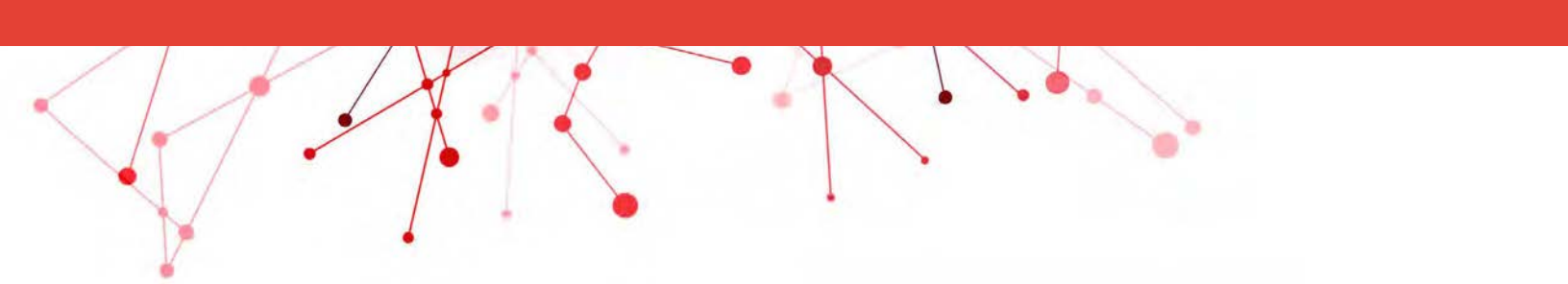
Why Is It Important to Teach About AI in Your Courses?

Think about articles you may have read related to the use of AI in K–12 education. Odds are the majority of them are focused on two general areas: automating administrative tasks, such as taking attendance and grading assignments, or increasing student performance through AI-supported assessment, personalized learning, and increasing engagement in typically mundane rote learning. Yes, AI can be used in these ways. However, strategies of this kind barely scratch the surface when it comes to AI's potential for impacting students' lives—not only in the classroom but throughout their daily activities. The driving purpose of this guide is to look beyond the kinds of strategies mentioned above to consider not only how AI makes life easier at a superficial level, but also what students need to know and understand about AI to ensure they become thoughtful users and even creators of these powerful tools.

This guide is for educators who teach grades K–5. Why devote a guide to elementary education? Once the stuff of science fiction, AI now permeates nearly every facet of our lives. Many children are aware of tools like voice-activated assistants or navigators, but we may not recognize the importance of helping even our youngest students begin to understand that they are interacting with AI-supported tools and devices, and how these AI agents work. For example, we can help students realize that:

- AI does some things very well, such as image/speech recognition, but other tasks like discerning emotions or making ethical decisions are currently done better by humans.

- AI robots are able to interact with the environment around them because they have sensors that mimic animal senses.

- AI navigation systems are trained to analyze different ways to get from one place to another and make independent decisions regarding the shortest or fastest route to a destination.

- There are basic best practices for data collection for machine learning, including how data are gathered, classified, and organized using rules.

The beauty of AI-supported tools and devices is that they blend often seamlessly into our lives; we can employ them without having to give much thought about how they work. This is obvious to adults who grew up in a pre-AI world, but AI may appear to be mysterious or magical to children. They need to be explicitly taught that AI agents can be trained to imitate human intelligence, but they are not human. Awareness at this level does not require specific technical expertise. Educators with little or no prior experience with AI may still help their students become more informed about AI technologies. They can help by identifying instances of AI use, exploring the ethics of machines influencing the decisions we make, and understanding AI concepts enough that they can remind students that AI is a tool created by humans.

Until recently, conventional wisdom has suggested that K–5 students are too young to learn about AI due to the technical content. In reality, students in these grade levels have been taught skills that lead to an early understanding of how AI works: pattern recognition, sequencing, categorization, sorting, navigation skills, map reading, and even knowledge of animal senses are just a few of the competencies educators can leverage to help youngsters understand how AI works. The projects in this guide offer educators insights into ways they can frame these skills to help their students better understand AI.

Considerations for Developing and Implementing AI Projects

This guide provides student-driven projects that can directly teach subject area standards in tandem with foundational understandings of what AI is, how it works, and how it impacts society. Several key approaches were taken into consideration in the design of these projects. Understanding these approaches will support both your understanding and implementation of the projects in this guide, as well as your own work to design further activities that integrate AI education into your curriculum.

Our Student-Driven Approach
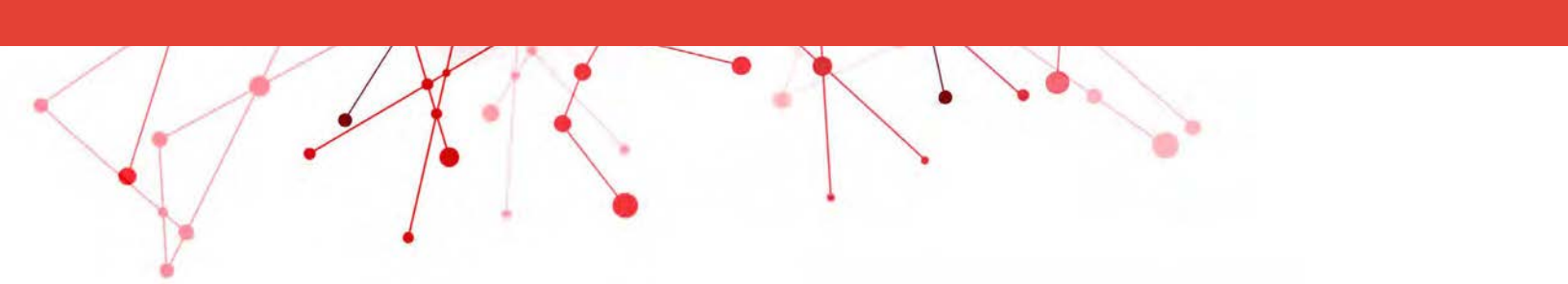
The projects in this guide use a student-driven approach to learning. Instead of simply learning *about* AI through videos or lectures, the students completing these projects are active participants in their AI exploration. In the process, students work directly with innovative AI technologies, participate in "unplugged" activities that further their understanding of how AI technologies work, and create various authentic products—from presentations to designing an AI robot—to demonstrate their learning.

Each project's student-driven activities are divided into three sections: Getting Started, Take a Closer Look, and Culminating Performances.

Getting Started activities hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

Take a Closer Look activities develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject-area content. Students will learn key vocabulary, discover and analyze how real-world AI technologies work, and apply AI tools as they relate to subject-area problems.

Culminating Performances challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they have learned.

Moreover, in this guide, students' exploration of AI is framed within the standards, concepts, and depth that would be appropriate to for students in grades K–5. Depending on the level of your students and the amount of time you have available, you might complete the entire project from Getting Started to Culminating Performances, you might pick and choose from the listed activities, or you might take students' learning further by taking advantage of the additional extensions and resources provided for you. For students with no previous experience with AI education, exposure to the guided learning activities alone will create an understanding of their world that they likely did not previously have. And for those with some background in AI, the complete projects and resources will still challenge their thinking and expose them to new AI technologies and applications across various fields of study.

In addition to modifying which project activities you implement, you can also modify the projects themselves as needed to support learning at various grade and ability levels. You might provide simpler explanations and vocabulary definitions; assign students to work as individuals, small groups, or a whole class; or adjust the output of the Culminating Performance to better suit their abilities. For example, the Training Data and Machine Learning project can be completed by students in any K–5 grade level; however, instruction regarding datasets and classification should deepen for older students. Early and repeated success with these and other AI learning activities can encourage students to continue their exploration into important field-relevant AI applications in the future.

Frameworks and Standards

When making decisions about what to teach about AI in K–12 classrooms, we recommend considering related educational standards and frameworks. In terms of frameworks for teaching AI, this guide references the Five Big Ideas in AI (shown in Figure 1).

The Five Big Ideas in AI serve as an organizing framework for the national AI in K–12 education guidelines developed by the **AI4K12 Initiative**. These guidelines articulate what all K–12 students should learn about AI. Each of the projects in this guide illuminates one or more of the first four foundational concepts—perception, representation and reasoning, learning, and natural interaction—as well the societal impact that the concept has in the context of the project.

Additionally, the ISTE Standards and Computational Thinking Competencies can help frame the inclusion and development of AI-related projects in K–12 classrooms. The **ISTE Standards for Students** identify the skills and knowledge that K–12 students need to thrive, grow, and contribute in a global, interconnected, and constantly changing society. The **Computational Thinking Competencies for Educators** identify the skills educators need to successfully prepare students to become innovators and problem-solvers in a digital world. Together, the standards and competencies can give us a language and lens for understanding how these AI projects fit into the greater goal of teaching all students to become computational thinkers. Each of this guide's projects will indicate alignment points with both the ISTE Standards for Students and the Computational Thinking Competencies.

Finally, another way to think about technology use in these student-driven projects is with the SAMR model developed by Dr. Ruben Puentedura. This model classifies the use of technology into four categories: Substitution,

THE FIVE BIG IDEAS IN AI
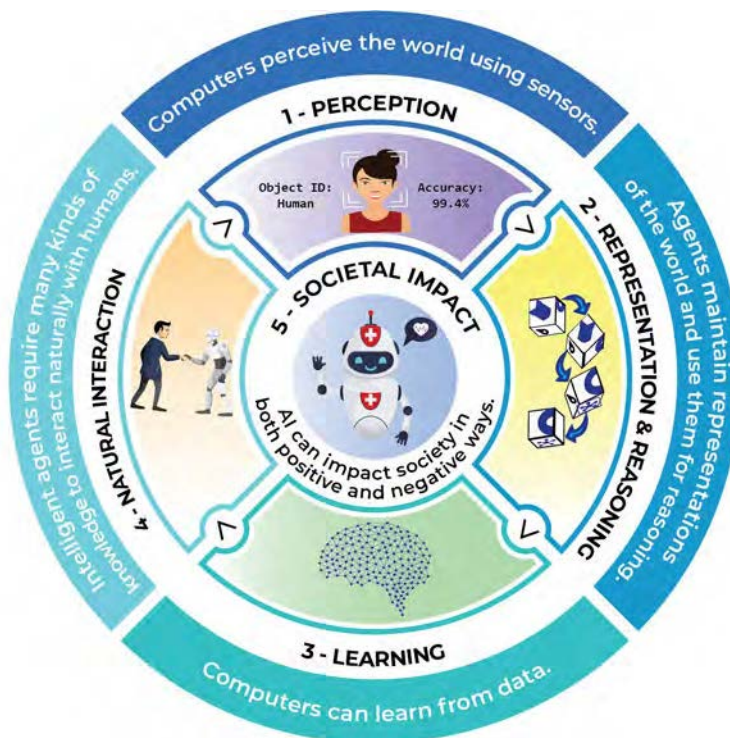
FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Augmentation, Modification, and Redefinition. While uses of technology at the substitution and augmentation level might enhance learning or the performing of tasks, uses at the modification and redefinition level transform the learning experience or task into something that was previously inconceivable, difficult, or even impossible. Many of the activities in this guide will push students' use of technology to the modification and redefinition levels. And while other activities might have students engage with AI technologies conceptually through unplugged activities, or work with AI technologies at the substitution or augmentation level of SAMR, each of the new understandings students walk away with will empower them to understand, use, and possibly even create AI technologies that will fundamentally redefine the way humans live and work.

How to Use This Guide

There are many courses, workshops, seminars, and other learning opportunities both online and offline that focus on the fundamentals of AI. There are also resources that target very tech-savvy educators who have backgrounds in AI concepts and the programming skills necessary to teach students how to code AI-based projects. However, when it comes to the educators who are themselves in the early stages of learning about AI, very little is available to help them transfer what they are learning into meaningful, student-driven classroom activities. That's where the *Hands-On AI Projects for the Classroom* series of guides comes in.

Each guide in this series 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 activities related to AI. Each guide consists of three parts: Introduction, Projects, and Appendices. Let's briefly review each section.

Introduction

Each of the guides in the *Hands-On AI Projects for the Classroom* series is directed toward a specific group of educators: elementary, secondary, teachers of electives, and computer science teachers. In addition to this How To section, the introductory section of each guide includes the following information:

- An overview of the Hands-On AI Projects for the Classroom series
- A discussion entitled "What Is AI?"
- An explanation of how AI fits into the context for that guide
- Considerations for designing and implementing AI-related projects

Project Design

For ease of use, every project in each of the guides is designed using a consistent format, as follows.

Project Overview

The project overview offers an explanation of 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, target grades, and estimated duration of the project; objectives for the project; and a listing of relevant standards addressed, such as the ISTE Standards for Students, ISTE Computational Thinking Competencies, AI4K12 Five Big Ideas in AI, and content-area standards.

Preparation

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

Instructions

Each project includes instructions for:

- Getting Started activities that hook students' interest, activate prior knowledge, and introduce them to the project's objectives.

- Take a Closer Look activities that develop students' AI understanding by providing students with scaffolded, guided learning activities that make connections between AI concepts and subject area content.

- Culminating Performances that challenge students to synthesize their learning, complete a meaningful performance task, and reflect on the societal impact of what they've learned.

While we have provided links to 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. ISTE 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 younger than thirteen years of age.

Extensions

Extensions include strategies and resources for expanding or enhancing the project to support extended student learning.

Glossary and Appendices

Glossary

The glossary includes definitions for terms found in the projects that may be unfamiliar or need explanation for students.

Appendix A: Unpacking Artificial Intelligence

Appendix A provides basic explanations and resources for understanding and teaching fundamental AI concepts.

Appendix B: Alignment to ISTE Standards and AI4K12 Big Ideas

This section provides a high-level overview of how the projects in all four guides in the *Hands-On AI Projects for the Classroom* series align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

PROJECT 1

What AI Does Well and Does Not Do as Well

When interacting with AI, elementary students often learn more about what AI cannot do well than what it can do well.

Project Overview

This project offers students opportunities to explore tasks AI is able to do well, such as image/speech recognition, and tasks done better by humans, such as discerning emotions or making ethical decisions.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

4–5 hours

TARGET GRADES

K–5

VOCABULARY

artificial intelligence
extraction

feature
image recognition

OBJECTIVES

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

- Identify types of tasks AI does well and explain how they know this.
- Identify types of tasks AI does not do well and explain how they know this.
- Understand that an AI is a computer program.

STANDARDS

ISTE Standards for Students

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.

3. **Knowledge Constructor**
   d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

ISTE Computational Thinking Competencies

3. **Collaborating Around Computing**
   a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.

4. **Creativity & Design**
   c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

AI4K12 Five Big Ideas in AI

1. **Perception**
   Computers perceive the world using sensors.

2. **Representation and Reasoning**
   Agents maintain representations of the world and use them for reasoning.

3. **Learning**
   Computers can learn from data.

4. **Natural Interaction**
   Intelligent agents require many kinds of knowledge to interact naturally with humans.

5. **Societal Impact**
   AI can impact society in both positive and negative ways.

Content Area Standard(s)

This project has been designed for implementation in any content area. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other modern advances in that field.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- 10 images—5 dogs and a mix of 5 other animals (e.g., cows, ducks, elephants, etc.), for each group of 3–4 students.
- Activity: **Aaron Wong AI Tic-Tac-Toe**
- Activity: **Bird Sounds**
- Activity: **Akinator** and **Mystery Animal**
- Tool: **Write with Transformer**

SUPPORTING RESOURCES FOR EDUCATORS

- Activity: **Intelligent Piece of Paper**

ADVANCED PREPARATION

- Familiarize yourself with each of the online resources.
- If you are working with children in grades K–2, watch the video "**What's intelligent about artificial intelligence**." Make note of the following two points: 1. One day, AI developers hope to create machines that can perform any task a human can. This is called general AI. 2. For right now, AI are limited to performing just one or a few limited tasks. This is called narrow AI. You will be mentioning these points to your students during the Activity 1 Discussion.
- Prepare 10 images for each group of 3–4 students. (5 images of dogs and a mix of images of 5 other animals, e.g., cows, ducks, elephants.) Number the images 1 to 10. Each group may be given the same sets of images. **Creative Commons Search** and **Pics4Learning** are sources of images.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students engage with the topic of what kinds of tasks AI can do well and what tasks it cannot do as well.

1. Ask students: What do you already know about AI around you? Do your parents use smartphones to navigate from one place to another? Do they have a voice-activated assistant in their home like Alexa or Google Assistant? Does someone in your family use Pandora or Spotify to select the music they listen to? Do they have a Netflix account that recommends movies to watch? How well do you think these computer programs and apps imitate human behavior?

2. Tell students that each of these is an example of **AI**. AI is the science and engineering of creating computer programs that can imitate human intelligence. AI cannot become human, but it can perform tasks in a human-like way.

3. If you are working with children in grades 3–5, show the video "**What's intelligent about artificial intelligence**." Discuss the video with students. Ensure that the following ideas are included in the discussion:

   - One day, AI developers hope to create machines that can perform any task a human can. This is called general AI.

   - For right now, AI is limited to performing just one or a few limited tasks. This is called narrow AI.

4. Brainstorm a list of AI technologies familiar to students. Include the name of the AI (e.g., Waze app or self-driving car) and the human behavior the AI mimics (e.g., navigating from Point A to Point B or driving a car). Tell students that in this project they will have opportunities to take part in offline and online activities that will help them learn more about some tasks AI does well, others that AI does not do well, and how AI learns to complete tasks.

TAKE A CLOSER LOOK

Activity 2: Two Tasks AI Does Well and Two Tasks AI Does Not Do As Well

In this online activity, students will share a laptop or tablet with a partner to explore four online examples of AI in action. If you are working with students in grades K–2, you may want to do some—or all—of these activities as a whole class.

1. Ask who plays Tic-Tac-Toe, who they like to play with, and who normally wins. Tell students that Aaron Wong has programmed an AI to play **Tic-Tac-Toe** using five rules for the AI to follow. Give students an opportunity to each play several games against the AI and request that they track how many times the AI wins, how many times they win, and how many times the game ends in a tie. Ask if playing Tic-Tac-Toe is a task the AI did well. Explain to students that this is an example of an AI trained to do one specific task. Point out that usually an AI can do one specific task very well. (See Extension Activity 1 for a related unplugged task.)

2. Ask students how birds communicate with one another. If they don't know the answer, explain that birds use calls to sound alarms or contact one another when looking for food, among other reasons. Tell them that it's possible to learn a lot about birds by listening to these calls and knowing what different bird calls sound like. To help people study birds, a group of programmers collected thousands of bird call recordings and put them into one large set called **Bird Sounds**. Then they created an AI that taught itself how to classify all the bird calls, find photos of the different birds, and label each of them. Now anyone can use Bird Sounds to find calls for specific birds, or just to explore. Give students several minutes to delve into the collection. Ask students if the AI did its task well. Was the collection easy to navigate? Were they able to browse the collection to access information about different birds? Were they able to find specific birds? Can they think of any ways to make the collection easier to use? Explain that this example and the Tic-Tac-Toe game are similar because they each do one thing. However, they are different because the Tic-Tac-Toe AI was trained using five rules, but with Bird Sounds, the AI taught itself how to identify, classify, and label the sounds. Say that the Bird Sounds AI is good at classifying and organizing sounds.

3. Tell students they are now going to play two animal guessing games that are AIs. The first is called **Akinator**. The class will think of an animal, and Akinator will try to guess what it is. The second is called **Mystery Animal**. In this activity students are challenged to guess an animal in 20 questions.

   - Begin with Akinator. Identify an animal for the AI to guess. Play the game as a whole class. How many questions did Akinator ask before guessing the animal? Was the guess correct? Were the questions clearly stated and easy to answer? Did you notice any patterns in the way questions were asked? Could these questions be helpful to you in the next game, where you need to ask questions?

   - Now give student pairs a few minutes to play the Mystery Animal game. Ask the following: What happened when you asked a question? Do you know how the AI "heard" you? Did the AI understand you right away when you spoke to it, or did you need to change the way you spoke to be understood by the AI? How many questions did you need to ask to correctly identify the animal? How is this game similar to Akinator, and how is it different? Do these two games work equally well, or does one work better than the other? Explain your answer. Help students understand that usually a text-based AI works better than a voice-recognition AI.

4. Finally, lead a class demonstration of **Write with Transformer**, a web app that is a demonstration site. It features two examples of AI text generators built using a text generation system called GPT-2 (checkpoints) and three models of different AI text generation systems. When you choose one of the five checkpoint or model options, you then type in a phrase or sentence, and the AI will generate three suggestions for the next phrase or sentence. You can briefly demonstrate just one option so students see how it works, or you can demonstrate multiple options to allow students to compare how each responds to the same initial prompt.

   - For example, click "Start Writing" for the first checkpoint. Click and drag to highlight the existing text, and type "I love to watch birds fly." Click "Trigger Autocomplete." This generates three responses. Read them aloud, ask students to choose the response that makes the most sense, and click on it. If none of the responses make sense, press the Tab key on your keyboard to generate three new responses. Repeat this process to generate additional responses, choosing those that make the most sense, if possible. The point is to give students the opportunity to see that much of what is produced is nonsensical.

- Ask students what could be done to make the text that's generated make sense. Help them conclude that a human being could edit the responses to make sense. Do this as a class. Ask the students if the Write with Transformer AI writes good stories. Ask them if they have any idea why this AI does not do this job well.

- You may repeat the above steps with the remaining checkpoint and/or with one or more of the models. Use the same initial sentence. Ask students to compare results of the different checkpoints and models. Are some better at generating responses that make sense with the initial prompt than others?

5. Ask students which of the four tasks were done well by the AI and which tasks were not. Tell students they are going to try two unplugged activities that will help them understand how an AI learns a task and why its capability might be limited.

Activity 3: Unplugged Activity–AI and Image Recognition

In this unplugged activity students learn how an AI uses images and physical characteristics to organize images of animals by type. If you are working with students in grades K–2, you may need to do the unplugged activities as a whole class.

1. Students work in small groups of 3–4 to complete this activity. Give each group 10 images, 5 dogs and a mix of 5 other animals (e.g., cows, ducks, elephants, etc.), and give each team one piece of writing paper. Tell students that they will be learning how an AI can be taught **image recognition** and how to organize images by type.

2. Ask one student on each team to turn the paper to landscape position and number it across the top from 1 to 10. Down the left side of each paper ask the student to list these five questions: Fur? Four legs? Paws? Tail? Mouth?

3. Explain that an AI can compare two images to see if they are identical, but that it is more complicated for an AI to recognize when two images might be of the same kind of thing when they are not identical. One way to teach an AI to recognize two images that are similar, but not identical, is to identify features of the image that can be used to tell one image from another. This is called **feature extraction**. An AI may not be able to "see" that two images are similar when they are not identical, but it can compare features. Give teams a few minutes to answer the questions for each image they have. Their answers should be "Yes" or "No."

4. Now tell students they will train the AI to recognize dogs. Say that to be a dog, the answer to each question must be "Yes." Have each team classify its images by dog or not dog, then check to see if the classification is correct. If students report that the classification is right, ask them which features eliminated images that were not dogs. If the classification is not accurate, ask them which image(s) ended up in the wrong group. During this discussion, ensure that students understand that the AI does not understand what it has been asked to do. It has simply followed the rule it was given—to place every image where the answer to all five questions is "Yes" into one group. It is especially helpful to have an AI do a task like this when dealing with a large amount of data, like the Bird Sounds collection explored in Activity 3.

CULMINATING PERFORMANCES

> **NOTE:** K–2 should work as a whole class; grades 3–5 as small groups.

Activity 4: Teach Something You've Learned

1. Ask students to think about all the different activities they have done in this project. Which did they like best and why? What did they learn about AI by doing that activity? Which activity was most difficult for them and why? What did they learn about AI by completing that activity? If they could choose one activity to teach to someone else, which one would it be and why?

2. Students in grades K–2 should work together to plan a presentation to share with another class. Students in grades 3–5 should work together to create learning stations where they can give their presentations during an event like an open house. The presentation or learning station should include:

   • An overview of what the students have been learning related to what AI does and does not do well.

   • A demonstration of the online or unplugged activity they decided to share.

   • An explanation of why the students chose that particular activity to demonstrate and what it taught them about what AI does or does not do well.

Activity 5: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of using AI.

   • What did you learn about things AI can do well and not so well?

   • Is AI the right solution for every problem? Why or why not?

Extensions

Here are two ways to expand students' exploration of what AI does and doesn't do well:

1. How the Tic-Tac-Toe game works: Students who played Tic-Tac-Toe against the AI may be interested in knowing why the AI almost always wins. Winning—or at least tying—every game of Tic-Tac-Toe is guaranteed when the player who goes first places the X in a corner and then faithfully follows four simple rules. They are:

   • Place the second X in the opposite corner. If an O was placed there, add the X to either of the other corners.

   • If there are two Xs and a space in a line, add the third X in that space. If there are two Os and a space in a line, add the third X in that space. If neither of those are true, add the third X to a free corner.

   • If there are two Xs and a space in a line, add the third X in that space. If there are two Os and a space in a line, add the fourth X in that space. If neither of those are true, add the third X to a free corner.

   • Add the final X to the free space.

Allow students to try playing using these rules. What happens when the first player follows the rules? What happens when the rules are not followed? Explain that the AI that plays Tic-Tac-Toe works because it uses an expert system that follows a set of rules once they have been learned.

2. The AI Tic-Tac-Toe game rules work well as long as the AI gets to go first, but what happens when it goes second? Pair students up to play several rounds of Tic-Tac-Toe. Student A gets to go first and can use any strategy they want. Student B goes second, but still must follow the rules listed in the first extension activity. What happens? Which person wins the most games? Why? The difference between a human and the AI that plays Tic-Tac-Toe is that a human is adaptable. Given new circumstances, a human will change the strategies used to solve a problem—winning at Tic-Tac-Toe in this case. This AI has been trained to solve a problem in just one way. The solution only works for the problem it was designed for—in this case, being the first player in a game of Tic-Tac-Toe. To be as intelligent as humans, an AI must be able to adapt.

PROJECT 2
Training Data and Machine Learning

A **machine learning algorithm** is a process or set of rules used by a computer to find and apply patterns in data. For this approach to succeed, tremendous amounts of accurate, relevant data are required. This **training data** must usually be supplied by people, but is sometimes acquired by the machine itself.

> "
> This AI project is for regular classroom teachers, not just technology specialists. I think that is an essential point since teachers at any grade level might find the topic exciting but intimidating. The project is hands-on and utilizes manipulatives, which is crucial for concrete learners in the elementary grades.
>
> — Patricia Aigner, Technology Director & Fifth Grade Technology Teacher, Rutland City Public Schools

Overview

In this activity, students are exposed to basic best practices for data collection for machine learning, including quality and quantity, by participating in introductory, unplugged activities designed to demonstrate how data are sorted and organized using rules.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

2.5–3 hours

TARGET GRADES

K–5

VOCABULARY

algorithm
bias
data
database
dataset

digits
feature
machine learning algorithm
training data

OBJECTIVES

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

- Gather and organize a dataset.

- Check a dataset for bias.

- Create rules for organizing the data.

STANDARDS

ISTE Standards for Students

3. Knowledge Constructor

    b. Students evaluate the accuracy, perspective, credibility, and relevance of information, media, data, or other resources.

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.

ISTE Computational Thinking Competencies

1. Computational Thinking Learner

    b. Learn to recognize where and how computation can be used to enrich data or content to solve discipline-specific problems and be able to connect these opportunities to foundational CT practices and CS concepts.

3. Collaborating Around Computing

    a. Model and learn with students how to formulate computational solutions to problems and how to give and receive actionable feedback.

4. Creativity & Design

    a. Design CT activities where data can be obtained, analyzed and represented to support problem-solving and learning in other content areas.

AI4K12 Five Big Ideas in AI

2. Representation and Reasoning

Agents maintain representations of the world and use them for reasoning.

3. Learning

Computers can learn from data.

5. Societal Impact

AI applications can impact society in both positive and negative ways.

Common Core State Standards for Mathematical Practice

CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP3: Construct viable arguments and critique the reasoning of others.

Preparation

MATERIALS

- Teacher computer and projector with internet connection for accessing tools and resources online.

- To complete this activity, you need a total of 85 vocabulary picture cards: 75 cards that fall within one general category (e.g., transportation, furniture, animals, food) and 10 vocabulary picture cards of items that do not belong in that general category. Suggestions for obtaining these cards are listed below in Advanced Preparation. The numbers of cards used in Activities 2, 3, and 4 vary as indicated below:

    Activity 2. General category—45 cards; not in the general category—5 cards.

    Activity 3. All cards used in Activity 2, plus an additional 20 cards in the general category.

    Activity 4. All cards used in Activities 2 and 3, plus an additional 10 cards in the general category and 5 additional cards not in the general category.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "Statistics in the Elementary Grades: Exploring Distributions of Data"

ADVANCED PREPARATION

Gather the cards required to complete Activities 2 through 4. Many elementary classrooms already have these. They may also be purchased online or at school supply stores, or you can make them yourself using images available on royalty-free sites such as Pics4Learning, Pixabay.com, and Smithsonian Open Access.

Instructions

GETTING STARTED

Activity 1: Algorithms and Data—an Introduction

In this activity, students are introduced to basic concepts related to algorithms and data.

> **NOTE:** This activity is appropriate for grades 3–5 and is optional for students in grades K–2.

1. Students may have heard terms like algorithm or data, but they may not actually understand what they mean. Begin this activity by helping students understand the following terms (You may need to reword the definitions provided here, depending on your students' skill levels):

   - **Algorithm.** A process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.
   - **Data.** The information computers store and send. Data takes many forms including video, pictures, text, and numbers.
   - **Database.** This is where data are stored. Data are often shown in a table, with rows and columns.
   - **Digits.** Numbers 0 to 9.

2. Watch the first 5:05 minutes of the video "**Episode 4: Data and Algorithms**." You may want to stop the video as points related to the vocabulary are made and discuss the information with your students. Stop the video at 5:05 minutes.

3. Ask students the following questions about the **dataset** in the sorting activity shown right before the video was stopped:

   - What did each item in the dataset have in common? (Pieces of candy in the shape of circles.)
   - How were the pieces of candy sorted? (From smallest to largest.)
   - Explain that datasets are organized by **features** or patterns. The dataset in the video represented pieces of candy in the shape of circles. Would a candy cane belong to that dataset? Why or why not? What about an M&M? Why or why not? What about a cake donut? Why or why not?
   - The data in the set of candy in the shape of circles was sorted by size: smallest circle to largest circle. That was the algorithm used to solve the problem of how to sort the data. If there were another piece of candy in the shape of a circle that was even larger than the pieces shown in the video, where would it belong in the series?

4. Explain to students that in this project they will explore how an AI is trained to organize data to complete a simple task by figuring out ways to organize the data, making sure there is a wide range of (unbiased) data within the set, and creating rules for organizing the dataset.

TAKE A CLOSER LOOK

Activity 2: What's a Dataset, and Getting Organized

In this unplugged activity, students will be given an overview of datasets: what they are and how they might be organized by labels.

1. Demonstrate Google's AI Experiment **Quick, Draw!**. You may want to show students the video on the Quick, Draw! site beginning at 0:52, or just play the game, whichever is best for your students. Tell students that training an AI to complete a task like recognizing an object that's drawn by someone requires a lot of data. In this unplugged activity, they will get a sense of how a dataset is used to teach an AI to recognize and classify things.

2. Place the first 50 vocabulary picture cards (45 in the general category and five not in the category) on a large table or on the floor so the class can see them. Ask students to look at the images and think about what overall category most of the pictures seem to represent. For example, cards showing things like bicycles, cars, boats, and trucks could represent the dataset *kinds of transportation*. Have students decide on the overall category and explain their thinking. If students notice the 5 cards that do not fit the general category, set them to one side, but leave them next to the other cards, because they are still part of the dataset for now.

3. Explain to students that 50 cards can be hard to work with all together, but would be easier to use if grouped into smaller categories. Have students imagine how hard it would be to work with a dataset of hundreds or thousands of images—like an AI does—without some way to organize them. Ask them to look at the cards again and think of ways the cards could be classified into smaller groups by assigning a label to each card. In this example, you might suggest they could use labels like things that travel on *land*, on the *sea*, or *in the air*. Classify the cards using these labels. Ask students: Is it easier to get a good idea of what kinds of cards are in the dataset when the cards are organized this way, instead of in one large group? If students ask about the 5 cards that do not belong in any of the smaller groups, say they will be taken care of in Activity 3. Now that students have identified labels for the cards in the dataset, explain that in the next activity, they are going to check the dataset to be sure that there are several examples of each type of transportation, and to be sure that every card in the dataset belongs there.

4. Hold a class discussion. Ask students to review the steps they took to name the entire dataset and then to identify labels. Challenge them to name other labels they might have used. In this example, they might have used *things that have wheels* and *things that do not have wheels*. Or, they might have labeled the cards *kinds of public transportation* and *kinds of private transportation*. There are many possibilities!

5. If you plan to go right on to Activity 3, leave the cards as currently classified and proceed to step 2 of the next activity.

Activity 3: Checking the Data

In this part of the unplugged activity, students are given an overview of why it's important to check the data in a set before using it to teach an AI.

1. This activity uses the same 50 vocabulary picture cards from Activity 2, as well as 20 additional cards that belong in the general category (set these aside initially). If you completed Activity 2 previously and have since picked up the picture cards, have students classify them again, using the labels they identified in Activity 2.

2. Ask students to look at the entire dataset, which they have grouped by labels. Ask them to look at one of these groups. In the example we've been working with, that could be *things that travel on land*. Ask students to brainstorm all the kinds of transportation that travels on land, such as bicycles, motorcycles, cars, trucks, busses, trains, tricycles, etc. Are there types of transportation they've named that are not included in the pictures already in that group? If so, ask them if it is important to include one or more examples of that type of land transportation in the dataset, and to explain their reasons. Say that whenever datasets are created, it's possible that important information might be left out. When this happens, the data are considered **biased**. That means that the dataset is not a good example of a category, because it is missing important information. To improve the dataset, the missing data need to be added. If students decide that the missing data are needed to fairly represent types of land transportation, ask them to look at the additional 20 cards they have not yet seen to find examples that can be added to the group. If the missing pictures are not available in the extra cards, search for them online, or draw them and add them to the group. This is the process of checking the dataset to be sure that it is diverse. Repeat these steps for the other labeled groups (*kinds of transportation that travel on water and in the air*, for this example). Add additional pictures as needed.

3. The next step is to remove cards that don't belong in the dataset. Note that this is another way data can be biased: by including information that does not belong in the dataset. Direct students' attention to the 5 pictures that do not represent kinds of transportation. Say that it's important for the information in a dataset to be accurate, because the data are going to be used to train an AI to recognize different kinds of transportation. Mention that an AI cannot think for itself, so it will not automatically recognize incorrect data. Help students come to the conclusion that these cards should be removed from the dataset.

4. If you plan to go right on to Activity 4, leave the cards as currently classified and proceed to step 2 of the next activity.

Activity 4: Creating Rules to Organize Data

In this part of the unplugged activity, students create rules for classifying any new cards added to the dataset.

1. This activity uses the same 70 vocabulary picture cards that were included in the dataset at the end of Activity 3. If you completed Activity 3 previously and have since picked up the picture cards, have students classify them again, using the labels they identified in Activity 2.

2. Tell students that it is possible to teach an AI how to determine if new data should be added to the dataset and to organize that new data. To do this, the programmer needs to develop rules about why a piece of data belongs to a particular category. Ask students how they knew which cards belonged to each of the labels they created in Activity 2. Help them conclude that they looked at each card and used knowledge they already had about the content to identify the features and patterns that differentiate pieces of data from one another.

3. Ask students to choose one of the labels created during Activity 2 and brainstorm a list of the features and patterns that can be used to identify cards that belong in that label. Using the example we've been working with, the label could be *land transportation*. What were some of the features students used to identify forms of transportation that belonged in that label? Students may suggest things like:

   • Has wheels

   • Is steered

   • Is piloted by someone/something

4. Test this rules list using existing data to be sure that the rules work. For example, "has wheels" is a sample rule. Look at the other labels. Are there forms of transportation there that have wheels? You probably have pictures of airplanes. Airplanes do have wheels, but they are used only for taking off and landing. Most forms of land transportation use wheels as their primary method of travel. How could the list of rules be modified to account for both situations? Try adding a rule: cannot fly. Would that eliminate forms of air transportation that may have wheels, but travel primarily in the air?

5. Are there cards that were included in *land travel* but do not fit in that label now because they do not have wheels, are not steered, or aren't piloted by someone/something? If a picture of a sleigh or sled is in the dataset, having no wheels would eliminate it from the label, but would that be correct? Perhaps "has wheels" is not an accurate rule for land vehicles after all. Could the rule be amended to include vehicles that are wheeled, tracked, railed, or skied? That would include sleighs and sleds in the land vehicle group, where they belong. The new rules might be vehicles that:

   • Are wheeled, tracked, railed, or skied

   • Cannot fly

   • Are steered

   • Are piloted by someone/something

6. Do all the cards currently in the group still belong there using these rules?

7. Now ask students to look at the additional 15 vocabulary picture cards (see the Materials list) you've gathered for this activity. Which of these new cards belong to this label, based on the rules? Why? Add those cards to the *land transportation* label.

CULMINATING PERFORMANCES

Activity 5: Organize the Remaining Data

In this final part of the unplugged activity, students will finish organizing the dataset by creating and testing rules for the remaining labels in the dataset.

1. **Grades K–2:** As a whole class, repeat the process described in Activity 4 to develop rules for the additional labels that students identified in Activity 2. Have students create and test rules for each label, then look at the 15 new cards to see which belong to the remaining labels, and which do not belong in the dataset (there should be 5 that do not belong to any label and therefore do not belong in the dataset).

2. **Grades 3–5:** Allow students to form groups of 3–4. Allow each group to repeat the process described in Activity 4 to develop rules for the additional labels that students identified in Activity 2. Have students create and test rules for each label, then look at the 15 new cards to see which belong to the remaining labels, and which do not belong in the dataset (there should be 5 that do not belong to any label and therefore do not belong in the dataset).

   Then, discuss the following as a class:

   - What did you learn about datasets and how they can be organized?

   - Describe some of the ways you thought of to create labels for the dataset you worked with.

   - What was most challenging about creating rules for adding items to labels?

Activity 6: Reflect

In this activity, students will discuss the following questions to reflect on their learning and consider the societal impact of creating and using datasets to train AI.

- How would an AI like Quick, Draw! be changed over time if people intentionally drew pictures incorrectly?

- How would an AI trained with the card data in our activities be affected if the rules were wrong?

- Why is correctly training AIs important? How could incorrectly trained AIs change our lives?

Extensions

Here are four ways to expand students' exploration of training data and AI:

1. Students in grades K–2 can practice the skills they've used during these activities by working in a learning center where they form datasets using manipulatives like pattern blocks, Cuisenaire rods, playing cards, colored counters, math link cubes, etc., to create datasets, identify labels within the dataset, check the quality of the dataset, and then develop rules for adding new items to the labels.

2. Students may have used Google Image Search to find photos to use in schoolwork. Ask if they have ever wondered how Image Search is able to identify images using keywords. Explain that the Image Search dataset is a much larger version of the image dataset they worked with during this project. Give them time to explore Microsoft's **COCO: Common Objects in Context** collection of images, which is organized by an AI. This dataset contains 91 common object categories (labels) and includes 328,000 images (dataset). Students may search for images that fit into one or more of the object categories.

3. Students in grades 3–5 can be challenged to work in teams to create their own datasets, which they will label, check for accuracy, and organize using rules they develop. Students may present their work to the whole class.

4. Classification algorithms are just one way an AI organizes data. Another way is through sorting algorithms. Students in grades 3–5 can explore various sorting strategies by viewing brief videos and then replicating the strategies shown using math manipulatives like: pattern blocks, Cuisenaire rods, colored counters, math link cubes, or LEGO. Following are links to the videos:

   - "**LEGO Bubble Sort**"
   - "**What's the fastest way to alphabetize your bookshelf?**"
   - "**Simple exchange sort**"

PROJECT 3
Senses vs. Sensors

Project Overview

In this project, students will identify the senses that animals, including people, use every day. They will explore the ways animals use their senses, and learn that robotic devices have sensors that mimic animal senses, enabling robots to interact with the environment.

SUBJECT

Science and Health

TARGET GRADES

K–5

ESTIMATED DURATION

4 hours

VOCABULARY

artificial intelligence	natural language processing
artificially intelligent robot	robot
autonomous	sense
image recognition	sensor

OBJECTIVES

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

- Explain how animals, including humans, use their senses to interact with their environment.

- Describe some ways AI robot sensors mimic animal senses.

STANDARDS

ISTE Standards for Students

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. **Innovative Designer**
   a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

ISTE Computational Thinking Competencies

4. Creativity & Design

    b. Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.

5. Integrating Computational Thinking

    b. Empower students to select personally meaningful computational projects.

AI4K12 Five Big Ideas in AI

1. Perception
Computers perceive the world using sensors.

5. Societal Impact
AI can impact society in both positive and negative ways.

Next Generation Science Standards

NGSS: K-LS1-1: Use observations to describe patterns of what plants and animals (including humans) need to survive.

NGSS: 4-LS1-2: Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Preparation

MATERIALS

- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Writing/Drawing materials: Paper, chart paper, magnet boards, and/or sticky notes, and drawing supplies.
- *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots* by Jennifer Swanson,[2] or another book that explains the sensors used by robots in simple language.
- Building blocks for stacking into a tower.
- Tool: Google's **Semi-Conductor**
- Tool: **Speechnotes**
- Tool: **Magic Sketchpad**

---

2 Swanson, J. (2016). *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots*.

SUPPORTING RESOURCES FOR EDUCATORS

- Directions for **Harold the Robot** unplugged activity.
- Article: "**How Many Senses Does a Human Being Have?**"
- Article: "**Making 'Sense' of Robot Sensors**"
- Article: "**Types of Robot Sensors**"
- Article: "**What's the Difference between Robotics and Artificial Intelligence?**"

ADVANCED PREPARATION

- Find examples of robotic sensors to share with students, either in a book like *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots* by Jennifer Swanson, or online.
- Become familiar with common types of robotic sensors for perceiving light, proximity, sound, temperature, and acceleration.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will engage with the topic of AI robots perceiving the world using sensors.

1. Ask students: How do people and animals interact with the world around them? What do you need to do to cross a street safely, enjoy a song, or decide if you like a certain food? Guide students to conclude that people and animals use their **senses** to help them navigate their environment by making decisions about the actions they take. Help students list the five basic senses people use (sight, hearing, taste, touch, smell). Ask the following questions: What do you know about your senses? How do you use your senses to make decisions about actions you take? Does what you learn apply in future situations that are similar?

2. Ask students to brainstorm ideas about why **robots** might need to interact with their environment. Share a book like *National Geographic Kids Everything Robotics: All the Photos, Facts, and Fun to Make You Race for Robots* by Jennifer Swanson to show examples of robots that have sensors. Ask students the following questions: Have you seen or heard about robots that can vacuum a floor, wash windows, or clean the cat's litterbox? How do these robots do these tasks? Once the robot has completed the task correctly, do you think it can apply what it has learned in similar situations? Explain that some robots are able to use their sensors to collect information and make **autonomous** decisions about how to complete a task even in a changing environment. These are called **artificially intelligent robots**, or AI robots.

3. Explain to students that the activities in this project will help them learn more about senses and sensors.

TAKE A CLOSER LOOK

Activity 2: Experimenting With Sensors

In this activity, students will experiment with three types of sensors that AI robots can use to perceive the world.

Explain to students that some—but not all—robots have **sensors** that enable them to interact with their environment. Remind them that robots that are able to use sensors to collect information and make autonomous decisions about how to complete a task are called AI robots.

1. A camera is one type of sensor that an AI robot can use to see. Give students a chance to experiment with an AI-powered **image recognition** application like Google's Semi-Conductor, which uses a webcam to see a person's movements, then analyzes and maps out the position and movement of the person with a neural network, and finally responds by having an orchestra play accordingly. Discuss the map of the movement on the screen, and ask students what the **AI** is seeing.

2. A microphone is a type of sensor that an AI robot can use to hear. Have students experiment with an AI-powered sound or voice application, such as Speechnotes, which listens to the student speak, uses **natural language processing** for speech recognition, and displays what the user said in text on the screen. Discuss the output on the screen and ask students how accurate the AI was at hearing and understanding the user.

3. A trackpad or touchscreen are sensors that an AI robot can use to perceive touch. Prompt students to experiment with an AI-powered touch-sensitive application like Magic Sketchpad, which perceives touch through a trackpad or touchscreen, maps the touch using lines on the screen, and uses a neural network to predict the rest of the user's doodle. Have students try to draw what the AI is expecting as well as things it does not expect. Discuss the accuracy of the mapping as well as the AI's guess about what would happen next in the doodle.

Activity 3: Introduction to Robots and Sensors

This activity is a variation of the classic Harold the Robot unplugged activity.

1. Students give directions for completing a task to an adult who interacts with the environment based on the directions being given—in this case, building a block tower. When the directions are completed, ask students to identify how many and which of the five basic senses the robot needed to use to follow the directions.

2. An AI robot is able to complete tasks autonomously without being given step-by-step directions. If an AI robot could complete this activity on its own instead of being given step-by-step directions, what would it need to be able to do without help? This activity is intended to expose students to the idea that it is possible for an AI robot with sensors to learn how to complete a task without being given specific directions every time.

3. In a class discussion, brainstorm ideas for an AI robot that could be trained to complete a different task. What might the task be, and what sensors would the robot need to complete the task? Record students' ideas for the next activity.

CULMINATING PERFORMANCES

Activity 4: Design an AI Robot

In this unplugged activity, students will design an AI robot that has the sensors it would need to perform a specific task. Students in grades K–2 will complete this as a whole class project. Students in grades 3–5 may complete this project in small groups.

1. Remind students that an AI robot uses sensors to perceive its environment and then uses the information to autonomously complete a task.

2. Review the list students generated when they brainstormed ideas for tasks they would like a robot to be able to complete. Select one from the list to use as a model. For example, perhaps students said they would like a robot that could wash dishes. An AI robot could be a logical solution. What would the design for this robot need to include? Walk the class through your example using the following 4 steps:

   • Name the AI robot and state its purpose: Dishbot—This AI robot saves time at home and in other places where food is served by loading and operating dishwashers.

   • Where would you find this AI robot? In private and commercial kitchens.

   • How does the AI robot move? Cylinders and motors control its moving parts (e.g., robotic arms and hands); wheels allow it to travel.

   • Which sensors would this AI robot need? Touch sensors let it know when it touches/is holding something; a camera enables it to "see" objects; and a sensor tells the robot its location in the kitchen in relation to the dishes and dishwasher.

3. The next step in this project is age dependent.

   Grades K–2. Once the class has walked through the above four planning steps, ask them to work in pairs or trios to draw an AI robot based on the class description. Nonwriters may dictate descriptions of their robots to a class helper to be recorded. Writers may create a pair/trio description of their robot to explain how their robot interacts with its environment to complete the task identified by the class. Student pairs/trios present their completed work to the class, creating an AI robot gallery for display.

   Grades 3–5. Students work in small groups to identify a task they want an artificially intelligent robot to complete. Each small group develops a presentation for the class that includes:

- A four-step description of their AI robot, as above.

- A drawing or a written example of the AI robot in action.

- A written description of what the AI robot is and how it will complete the task identified.

Activity 5: Reflect

In this activity, students should discuss the following question to reflect on their learning and consider the societal impact of using AI robots.

- How could the AI robot you designed for this project affect your life or the lives of your friends and family? Is it a good idea to have AI robots do things instead of people? Why and why not?

Extensions

Following are two ways to expand students' exploration of robots, AI, and sensors:

1. As we work to achieve interactions with technology that are so natural they become nearly unnoticeable, it's important that we ensure that young children are able to recognize that in addition to similarities between humans and robots (with or without AI), there are differences.

   - One strategy for clarifying this separation is to refrain from anthropomorphizing these machines. Supporting resources: "**Does your kid know: Robots have no feelings**," "**PopBots: An early childhood AI curriculum**," "**The Danger of Anthropomorphizing AI**"

   - Hold a class discussion. Have students brainstorm a list of AI robots they are familiar with. For example, they may include iRobot, Roomba, Roxxter, RX-V100, or similar AI robots. Ask students what pronouns they use to refer to these machines and why. Have a discussion about why designers might want to make AI robots seem to be human-like. Include a discussion about the fact that these devices are not "magical."

2. Introduce students in grades 3–5 to two additional animal senses: position in space and balance. For more information, see **7senses.org**

   - Ask students: How do robots locate their position? Resource: "**How a robot finds its location based on what it 'sees'**" How do they keep their balance? Resource: "**Two-legged robot mimics human balance while running and jumping**"

3. Facilitate this unplugged activity: Ask students if they know how some animals can tell where they are when they are under water or at night. Explain that these animals are likely using something called *echolocation*. The animal makes a noise and then listens for the echoes, which help the animal locate nearby objects. Show the video "**What Is Echolocation?**" to help students understand how echolocation works and why it's important. Tell students they are going to mimic echolocation themselves using the following steps:

   - Give each student a piece of writing paper and ask them to number it 1 through 9.

- Next to each number they will write one of the following words in any order: front, back, side. Students should not show their paper to anyone else.

- Have students pair up. Ask pairs to spread out around the classroom.

- One student in the pair should close their eyes.

- The student whose eyes are open should stand near their partner and snap their fingers or clap in front of, behind, or beside the blindfolded partner, following what they wrote on their paper.

- The partner with closed eyes will guess the location of each snap/clap and the other student will record if the guess was correct or incorrect. Repeat for a total of 9 snaps/claps.

- Partners should switch roles and repeat the exercise.

- Students should total how many times their partner guessed correctly and incorrectly.

- Lead a class discussion about the experience. How does this exercise relate to learning about additional senses, robots, and AI?

PROJECT 4
Navigation and AI

Getting from one place to another using AI-supported navigation systems has become a way of life. While early automobile GPS systems seemed to be miraculous, by today's standards, those systems were expensive and quite limited in their abilities to adapt to changing road and traffic conditions. Today's navigation systems are apps on smartphones or tablets. They fuse GPS with other sensors and data to make on-the-fly updates to directions when road and traffic conditions change.

Project Overview

In this activity students will participate in unplugged activities to explore how AI-supported navigation works. As an extension, older students may use Minecraft to build a block-based maze and teach an agent how to navigate the maze on its own.

SUBJECT
English language arts, math, geography

ESTIMATED DURATION
5–6 hours

TARGET GRADES
K–5

VOCABULARY
artificial intelligence
symbolic representation

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

- Explain that maps are representations of the world.

- Familiarize themselves with a school map and use that map to plan routes from one location on campus to another.

- Describe their understanding of training an AI in navigation.

STANDARDS

ISTE Standards for Students

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. Innovative Designer

    a. Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

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.

ISTE Computational Thinking Competencies

4. Creativity & Design

    b. Design authentic learning activities that ask students to leverage a design process to solve problems with awareness of technical and human constraints and defend their design choices.

    c. Guide students on the importance of diverse perspectives and human-centered design in developing computational artifacts with broad accessibility and usability.

5. Integrating Computational Thinking

    c. Use a variety of instructional approaches to help students frame problems in ways that can be represented as computational steps or algorithms to be performed by a computer.

AI4K12 Five Big Ideas in AI

2. Representation and Reasoning

Agents maintain representations of the world and use them for reasoning.

5. Societal Impact

AI can impact society in both positive and negative ways.

Common Core State Standards

    CCSS.ELA-LITERACY.W.K.7 – 5.7: Production and Distribution of Writing

    CCSS.ELA-RL.K.3 – 5.3: Key Ideas and Details

Common Core State Standards for Mathematical Practice

    CCSS.MATH-K – 4.OA.C.5: Generate and Analyze Patterns

Next Generation Science Standards

    Concepts related to pattern recognition and data analysis are interwoven throughout these standards.

National Geography Standards

National Geography Standard 1

At all grade levels, students need practice and experiences in how to collect and display information (data) on maps, graphs, and diagrams. They must understand what a map is and what it can—and cannot—do. They need to be able to read and interpret maps and other geographic representations. And finally, students must know how to make maps, from hand-drawn sketch maps to more complex representations using a range of appropriate technologies.

Preparation

MATERIALS

- A printed road map.
- A list of directions to any location.
- A phone, tablet, or laptop with internet connection, and a method for projecting what's on the device's screen.
- A large piece of butcher paper (for classroom floor plan).
- Pencils and markers.
- Double-sided tape.
- Construction paper cutouts that represent unfixed items to place on the classroom floor plan (e.g., desks, tables, bookcases, easels).
- 5–6 items to hide in the classroom.
- Construction paper cutouts that represent the hidden items.
- School maps (one copy per student, labeled if used with grades K–2, blank if used with grades 3–5).
- Crayons or colored pencils (each student needs one red, one blue, and one green).
- Printed copies of the three difficulty levels of mazes (easy, medium, hard), one of each level per student.
- Activity: **Code.org Course 2, Lesson 3. Maze: Sequence**
- Tool: **Google Maps**, **Maps**, **Waze**, or another AI-powered maps app.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Deepmind teaches AI to follow navigational directions like humans**"
- Article: "**Claude Shannon**"
- Resource: **Krazydad mazes** and **All Kids Network Free Printable Mazes**
- Article: "**Teaching AI to navigate like our brains**"
- Article: "**Using artificial intelligence to enrich digital maps**"

ADVANCED PREPARATION

Collect all materials and organize them by activity.

An AI-powered maps app is often pre-installed on smartphones and tablets. Confirm access and review functionality if needed. Alternatively, bookmark the Google Maps website on a laptop. Ensure you can project the screen on whatever device you are using.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will engage with the topic of AI-supported navigation and how it works.

1. Ask students: How do the members of your family who drive know how to get from one place to another in the car? Does it make a difference when the person driving already knows how to go somewhere, and when the person doesn't know where the destination is? Guide students to conclude that when the driver wants to go to a familiar place, they know how to navigate there unassisted. However, when heading to a new location, the driver will need help in the form of a map, a set of directions, or a navigation app like Google Maps, Maps, or Waze. Ask students which kinds of help their family members use when going to an unfamiliar location.

2. Demonstrate how these three types of tools help humans navigate: a printed road map, written directions, and a maps app.

   - First, show students the road map. Ask if they know what it is. Explain that people used to rely on printed road maps whenever they drove to unfamiliar places.

   - Then show students the written directions and explain that this was another navigation method used in the past. Describe how people used written directions when driving.

   - Finally, demonstrate the AI-powered maps app you selected, preferably on a tablet or smartphone. Show students how to add a destination, how to choose a starting point, and how the suggested route is displayed. Explain to students that this type of navigation app uses **AI**—the science and engineering of creating computer programs that can imitate human intelligence—to analyze different ways to get from one place to another and pick the shortest or fastest route.

TAKE A CLOSER LOOK

Activity 2: Creating and Navigating Classroom Floor Plans

In this unplugged activity, students will have an opportunity to explore spatial skills and navigation concepts by creating a map (a floor plan) of a familiar space—the classroom—and then using that map to navigate the space. Students will transfer their learning from this experience to understanding how AI represents the world. (The activity is designed for students to create one whole-class floor plan, but students in grades 3–5 may want to create individual floor plans instead.)

1. Explain to students that in order for an AI to make independent decisions, it must first have a model—or **symbolic representation**—of the world. A map is one kind of model. If the AI is going to make a decision about the best directions from one place to another, it will need a map that includes roads, buildings, and other landmarks.

2. Tell students that they are going to create an example of a representation of the world (model) by making a detailed floor plan (map) of the classroom on a large piece of butcher paper.

3. Depending on students' ages, you may need to explain that floor plans can show both the fixed structures of the room (e.g., walls, doors, closets, and windows) and unfixed items placed in the room (e.g., desks, tables, easels, and bookcases).

   - Demonstrate how to draw the fixed structures of the floor plan, and show students how to use the construction paper cutouts to represent the unfixed items on the floor plan. Help students make a pencil sketch of the fixed structures of the classroom on the butcher paper. Allow them to refer to the cutouts for the unfixed items that will be placed on the floor plan to ensure that the floor plan is large enough to accommodate the unfixed items, without being too large. Once students are satisfied with the pencil sketch, have them use markers to make that part of the floor plan more visible. Then ask students to place the construction paper cutouts on the floor plan, taking care to replicate the actual placement of unfixed items in the classroom. When students agree that the placement is correct, use double-sided tape to affix the cut-outs to the floor plan.

   OPTIONAL: For older students, you may want to extend the activity to apply students' understanding of scale and estimation. Explain that sometimes a person drawing a floor plan will measure the room and the objects in it so that the floor plan accurately depicts fixed and unfixed features. The floor plan is said to be drawn "to scale" if it and the actual room are the exact same shape but different sizes. Students could measure the classroom and objects to draw their floor plan to scale. Let students know that while their classroom floor plan will have the same general shape as the actual room, they likely will not measure everything to draw it exactly to scale.

4. Now, play a game so students will better understand symbolic representation using the floor plan.

- While the students are out of the room (for lunch or recess), hide 5–6 items you've selected (see the Materials list) around the classroom. Tape the construction paper cutouts of these items to the floor plan in the places where they've been hidden.

- Gather students around the floor plan. Ask them to identify what's been added to it. Divide the class into teams of 3–4 students and challenge them to locate the hidden items using the floor plan as a map. (If older students have created individual floor plans, give them a list of the items that have been hidden in the room and ask them to mark each object on their floor plan when they locate it.)

5. Wrap up this activity with a discussion reminding students that floor plans are a type of map, that maps are a symbolic way to represent the real world, and that AI uses maps and other models to represent the world around them.

Activity 3: More Than One Way to Get Somewhere

In this unplugged activity, students will be reminded that maps are representations of the world that can be used for reasoning. They will also be exposed to the idea that it's possible to learn from data provided on the map. They will familiarize themselves with a school map and plan routes from one location on campus to another, based on criteria provided by the teacher. Plan a whole-class activity for students in grades K–2 or a small group/individual activity for students in grades 3–5.

1. If working with grades K–2, give each child a copy of a labeled school map. If working with grades 3–5, give each child a copy of a blank school map. Ask students to tell you what they see, and what they think the map represents. If necessary, help them identify it as a school map. With K–2 students, review features of the map, and help them identify important locations on campus such as the playground, the library/media center, the cafeteria, the office, and specific classrooms. With grade 3–5 students, review the features of the map, and ask them to label important locations including those listed above.

2. Have students bring their maps outside the classroom. Explain that although students are familiar with campus already, they can still use the map to figure out different routes to various locations. Ensure that students are aware of how to hold the map to orient themselves, and then tell them the class is going to walk the campus using the map. Ask students to look at the map to decide how to walk from your classroom to the cafeteria. Call on a volunteer to describe one route to the cafeteria, showing on the map how they would walk there. Call on another volunteer to describe a different route to the cafeteria, showing that route on the map. Ask if there are additional routes the class could take to get to the cafeteria. Have a volunteer show you a third route, and then have that student guide the class to the cafeteria using the map. You may repeat this activity once or twice more, asking students to identify various routes to several locations on campus.

3. Return to the classroom. Ask students if they always use the same route to go from one place on campus to another, and to explain why. Help students see that different routes might be chosen based on factors like time (which route is quickest), distance (which route is shortest), or ease of use (the physical condition of the walkway, the number of students taking the same route, avoiding stairs when walking with crutches). Have students brainstorm additional reasons for choosing a different route to go from one place to another. List their ideas.

4. Choose 3 ideas (e.g., flattest route, fastest route, prettiest route) and assign each route a number: 1, 2, or 3. Tell students they are going to identify 3 different routes between the classroom and another spot on campus (teacher's choice). Explain that the red crayon represents route 1, the blue crayon represents route 2, and the green crayon represents route 3. Students will need to go outdoors to plan and record their routes (this may be a whole-class exercise for grades K–2 and a small-group or individual exercise in grades 3–5).

5. Return to the classroom. Ask students to explain the process they used to plan each route. What criteria did they use to identify the routes?

6. Remind students of Activity 1, which included a demonstration of 3 ways people navigate from one place to another (print maps, written directions, and navigation apps) and a discussion of which of these tools their family members use. Point out that students used paper maps in Activities 2 and 3. Ask them to compare and contrast ways these activities might have been different had they needed to rely on written directions or a navigation app to complete each task. Responses may include statements such as writing step-by-step directions could be more difficult and time-consuming than drawing a route on a paper map, or entering a destination into a navigation app. Remind students of the initial discussion in step 5 of this activity. Say they have identified strategies they used to identify their walking routes, and those would also work for writing directions, but what about navigation apps? How do the AI agents that make these apps learn to navigate from one place to another? Tell students they will learn more about how AI navigates in the next two activities.

Activity 4: Teach an Angry Bird to Navigate a Maze

This activity challenges students to explore the thought process behind teaching an AI to navigate a simple maze.

Although this activity does not incorporate AI, it helps elementary students understand the thought process behind teaching an AI to navigate a simple maze. View the activity "Code.org Course 2, Lesson 3. Maze: Sequence." Allow students to work individually or in pairs to complete this activity.

1. Model for students how to access the website for the activity. Before asking them to go to the site, show the class the tutorial video that appears on the webpage when it opens initially. This explains the task and how to use Blockly to program a path through the maze.

2. Now have students navigate to the site and click the X in the upper-right corner of the tutorial video to bypass it. The directions will appear on the page. Read them, and click "OK" to begin. This activity offers 11 levels, ranging from easy to hard. Allow students to complete as many levels as they can.

3. Conclude this activity by having a debriefing discussion with students. Discuss their experiences in using Blockly to program the bird to navigate the maze to reach the pig. How does this relate to AI-supported navigation systems? Help students conclude that—although on a much more sophisticated level—the AI navigation systems work on the same underlying principles that the students used in this activity. Just as students had to learn how the map works and use reason to get through the maze, an AI-supported navigation system must be trained with the map and use reasoning to provide directions for moving from one location to another.

CULMINATING PERFORMANCES
Activity 5: Rule-Based Navigation of Mazes

This activity challenges students to apply the skills they have learned related to training an AI to navigate a simple maze. Given one training rule, students will attempt to complete mazes ranging from very easy to difficult using just that rule.

1. Tell students that in 1950, a man named Claude Shannon created an electronic mouse that was able to teach itself how to navigate physical mazes. While not as sophisticated as training an AI to navigate a maze, this is believed to be one of the world's first examples of machine learning. Today, training an AI to navigate a maze based on the use of one or more rules is a common activity. One approach is for the AI to wander the maze randomly until it finds its way through. Another approach is to train the AI using one or more rules such as the left-hand rule, which says to *follow the left-hand wall until you reach the exit.*

2. Print three paper mazes ranging from very easy to difficult (one copy of each per student). Printable mazes of varying levels of difficulty are available online; two sources are **Krazydad mazes** and **All Kids Network Free Printable Mazes**. Give each student three mazes ranging from simple to difficult and challenge them to solve all three using the left-hand rule.

3. Are students able to complete all the mazes, regardless of difficulty, by following that one simple rule? Ask students to share their experience, and to decide if just one rule is enough. Tell students that yes, if they follow that rule they will almost always be able to get through the maze eventually. It also works to follow the right-hand wall.

4. End the activity with step 3 for K–2 students. With students in grades 3–5, say that random wandering or the left-hand rule can be used to solve mazes, but that these strategies are not always the most efficient way to approach this problem—that there are other maze-solving strategies they can explore. For example, could they find a faster way to solve the mazes they were given, or perhaps find the shortest route to solve a maze? Using fresh copies of the same mazes, ask students to try solving the mazes using a different strategy, and then write down the rule(s) they used for each maze.

Activity 6: Reflect

In this activity, students should discuss the following question to reflect on their learning and consider the societal impact of using AI-supported navigation systems.

- How do AI-supported navigation systems affect your life or the lives of your friends and family? Is it a good idea to rely on these systems to navigate from one place to another? Why or why not?

Extensions

Here are three ways to expand students' exploration of AI and Navigation:

1. Students in grades K–2 can practice their skills at plotting the shortest route from the school gate to the school door by completing the online activity **Late Again**, hosted on the NRICH Project website.

2. Students in grades 3–5 can practice their skills at plotting the various routes Alice the snail can take to traverse a brick wall to visit Brian the snail, with **Snails' Trails**, hosted on the NRICH Project website.

3. Students in grades 4–5 can create a **Minecraft maze** and then program an AI to **navigate that maze** on its own.

> " I'm excited about this project because students, especially younger students, need more interaction with maps and navigation. I would use this in my 5th grade class because it incorporates many skills and standards. Each activity builds on the last and the extension activities offer great ideas if students' interest is piqued.
> — Kaitlin Snow Kohn, 5th Grade Teacher
> Whittier Elementary School

Glossary

algorithm: a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.

artificial intelligence (AI): the science and engineering of creating computer programs that can imitate human intelligence.

artificially intelligent robot (AI robot): a robot that is able to use sensors to collect information and make autonomous decisions about how to complete a task even in a changing environment.

autonomous: having the capacity to act independently or without external control.

bias: preference for or against an idea or thing.

data: information.

database: storage for data, often shown in a table with rows and columns.

dataset: collection of data.

digits: numbers 0 to 9.

extraction: the action of identifying or separating out.

feature: unique measurable property.

image recognition: the ability of a computer program to analyze the pixels in an image and identify objects, people, or other subjects.

machine learning algorithm: a process or set of rules used by a computer to find and apply patterns in data.

natural language processing (NLP): the AI technology used to understand and interact with human language.

robot: a machine that is able to perform complex tasks automatically.

sense: a faculty, such as sight, hearing, or touch, used by people or animals to perceive information.

sensor: a device that allows a machine to perceive the natural world.

symbolic representation: a data representation or model that humans can understand.

training data: examples used to teach a machine learning model.

APPENDIX A
Unpacking Artificial Intelligence

This section provides basic explanations of fundamental AI concepts referenced in the *Hands-On AI Projects for the Classroom* series of guides, along with resources for supporting instruction.

What Is AI?

According to John McCarthy, who first coined the term, artificial intelligence is "the science and engineering of making intelligent machines, especially intelligent computer programs" (McCarthy, 2007). A technology powered by AI is capable of such things as using sensors to meaningfully perceive the world around it, of analyzing and organizing the data it perceives, and of autonomously using those data to make predictions and decisions.

AI technologies are sometimes classified as narrow and general AI. Narrow AI makes decisions about a specialized task, sometimes even based on a specific dataset of preprogrammed actions. The DeepBlue chess program that beat a human world champion in 1996, Apple's Siri, and self-driving cars are all examples of narrow AI. In contrast, general AI could hypothetically learn and adapt to perform any task and solve any problem that a human being can. General AI does not currently exist, but there are many examples of it in fiction, such as "WallE" and Baymax from "Big Hero 6."

Learn More

Video: "**What is Artificial Intelligence (or Machine Learning)?**"

Video: "**What's intelligent about artificial intelligence**"

Article: "**What Is Artificial Intelligence?**" by John McCarthy

Curriculum: "**AI4ALL's Open Learning Curriculum**." This free curriculum provides activities to teach students what AI is, what types of AI exist, and how to identify AI in the world around them.

How Do I Know If a Robot or Other Technology Has Artificial Intelligence?

Some robots and computer programs have AI, while others do not. A robot or software solution that has AI capabilities can do things such as recognize specific objects or faces, navigate around objects or complex maps on its own, classify or distinguish between objects, interact naturally with humans, understand or speak in a human language, recognize or express emotions, or improvise when encountering something unexpected. In these ways, the autonomous decisions made by AI are more advanced than simple automation of a task (performed a prescribed sequence of steps), which even non-AI robots and software are frequently used for. As the cost of technology decreases and the capabilities of AI technologies increase, we will likely see increased AI use across most devices and software.

Learn More

Article: "**What's the Difference Between Robotics and Artificial Intelligence**"

Article: "**How Robots Work: Robots and Artificial Intelligence**"

What Is Machine Learning?

Machine learning, a subset of AI, is the study of algorithms and models that machines use to perform a task without explicit instructions. Machine learning algorithms improve with experience. Advanced machine learning algorithms use neural networks to build a mathematical model based on patterns in sample "training" data. Machine learning algorithms are best used for tasks that cannot be completed with discrete steps, such as natural language processing or facial recognition.

Learn More

Video: "**Intro to Machine Learning (ML Zero to Hero—Part 1)**"

Video: "**How Does Machine Learning Work? Simply Explained**"

How Do Neural Networks Work?

Artificial neural networks are currently modeled after the human brain. While a brain uses neurons and synapses to process data, neural networks use layers of nodes with directed connections. Some of these connections are more important than others, so they have more weight in determining the outcome. Just like people, machines with neural networks learn through experience. As a machine processes a set of data, it recognizes patterns, assigns more weight to the most important information, learns to process inputs in order to develop the most accurate outputs, and creates a model from which to make future predictions or decisions. There are many types of neural networks, each with different design, strengths, and purposes.

Learn More

Video: "**Neural Networks and Deep Learning #3**"

Playlist: "**Neural Networks**"

Article: "**What Is Deep Learning?**"

What Is Natural Language Processing?

Natural language processing is the AI technology used to understand and interact with humans' natural language. Natural language processing powers technologies such as voice experiences and assistants, text predictors, grammar checks, text analyzers (such as spam filters), and language translators.

Learn More

Video: "**Natural Language Processing #7**"

Article: "**A Simple Introduction to Natural Language Processing**"

Video: "**How Do Chatbots Work? Simply Explained**"

Article and video: "**What Are Chatbots?**"

What Types of Ethical Considerations Surround AI?

All AI technologies are developed by humans. Whether they have been preprogrammed with a set of rules, or use training data to learn, they will have bias based on human input and decision-making. It is important that students understand that AI decisions are not objective, as well as to understand which stakeholders might benefit from certain biases in the technologies. Moreover, many AI technologies collect, store, and apply personally identifiable information about users. Students should be aware of privacy concerns related to these technologies.

Learn More

Curriculum: "An Ethics of Artificial Intelligence Curriculum for Middle School Students"

Video: "Algorithmic Bias and Fairness #18"

Article: "Ethical Concerns of AI"

Article: "Top 9 ethical issues in Artificial Intelligence"
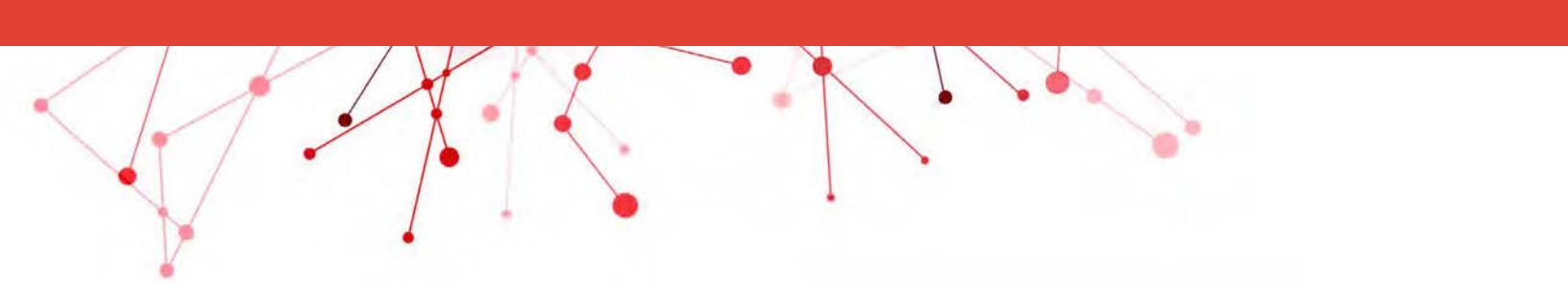
Video: "The ethical dilemma of self-driving cars—Patrick Lin"

Alignment to ISTE Standards and AI4K12 Five Big Ideas in AI

The following tables provide a big-picture view of how the projects in each guide align with the ISTE Standards for Students, ISTE Computational Thinking Competencies, and AI4K12 Five Big Ideas in AI.

Guide	Elementary				Secondary				Electives				Computer Science			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ISTE Standards for Students																
Empowered Learner	x	x					x			x	x	x	x		x	x
Digital Citizen					x			x			x			x		
Knowledge Constructor	x		x	x		x	x	x			x		x			
Innovative Designer		x	x				x		x	x					x	x
Computational Thinker			x	x	x		x		x		x		x	x	x	x
Creative Communicator					x	x		x			x			x		
Global Collaborator							x					x	x			

Guide	Elementary				Secondary				Electives				Computer Science			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ISTE Computational Thinking Competencies																
Computational Thinking (Learner)				x	x	x	x		x	x	x	x	x		x	x
Equity Leader (Leader)					x	x	x	x							x	x
Collaborating Around Computing (Collaborator)	x			x			x					x	x			
Creativity and Design (Designer)	x	x	x	x				x	x	x	x			x	x	
Integrating Computational Thinking (Facilitator)		x	x				x		x	x				x		

Guide	Elementary				Secondary				Electives				Computer Science			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
AI4K12 Five Big Ideas in AI																
Perception	x	x			x					x		x			x	
Representation & Reasoning	x		x	x			x		x			x	x	x	x	
Learning	x			x		x	x				x	x	x	x	x	x
Natural Interaction	x				x	x				x		x		x	x	
Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Development Team

Authors

Nancye Blair Black

Susan Brooks-Young

Content Contributors

Jared Amalong, Sacramento County Office of Education/AI4K12 Initiative, AI Subject Matter Knowledge

Joseph South, International Society for Technology in Education (ISTE)

Other Contributors

Patricia Aigner, Rutland City Public Schools

Angie Kalthoff, St. Cloud Area School District 742

Deborah Kerby, Tobyhanna Elementary Center

Yolanda Ramos, International Society for Technology in Education (ISTE)

Kaitlin Snow, Whittier Elementary School

Casandra Woodall, International Society for Technology in Education (ISTE)