Hands-On AI Projects for the Classroom

A Guide for Electives Teachers

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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.

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AI in the Classroom: Strategies and Activities to Enrich Student Learning by Nancye Blair Black

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

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Contents

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. Anticipating the explosion of interest in AI in education, we 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 + ASCD Chief Innovation 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. We also believe students need to learn to use AI tools effectively and ethically in their academic lives and beyond. Because of this, 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. After seeing the hype about AI in the news and social media, you might 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. Some AI tools can even use what they have learned to generate new examples of data, text, art, and code based on the patterns that were detected. 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?

Over the last decade, the majority of articles about the use of AI in K–12 education 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. Recently, attention has shifted to generative AI tools like ChatGPT, prompting both potential time-saving planning applications for teachers and concerns about what will happen when students use these types of tools to generate art, essays, or code.

However, these conversations 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 visual and performing arts, physical education, foreign languages, and other electives or special courses that don't fall neatly into the four core academic areas of English/language arts, social sciences, mathematics, and science. Why devote a guide to these areas of study? Once the stuff of science fiction, AI now permeates nearly every facet of our lives, and while most of us are aware of tools like virtual assistants or navigators, we may not be cognizant of the ways that AI is impacting the arts, sports, journalism, and language acquisition. For example:

- News outlets use AI to generate headlines and articles, to tag and organize the thousands of photos they receive daily, and to create virtual newscasters.
- AI-powered language programs pledge that users will gain fluency in new languages in just twenty minutes of practice per day.
- Film producers use AI to create movie trailers, analyze scripts, and generate virtual actors.
- In sports, AI is used for tasks like the scouting of players, planning and monitoring athlete training programs, and tracking athletes' health and fitness.
- Artists create AI-generated art using tools that apply styles, filters, and other effects to existing images.

These examples point out the importance of all people understanding the degree to which AI is being used to influence our learning, reading, entertainment, physical activity, and more. 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 reminding students that AI is a tool created by humans.

Until recently, conventional wisdom has held that the areas of study targeted in this guide are unaffected by AI—that creativity demands human input. For now, this may be true to an extent, but it is entirely likely that in the not-too-

distant future, people who want careers in these fields will be required to incorporate AI into their work to some degree. In many instances, this will simply necessitate that the end-user (director, choreographer, coach, journalist, or educator, for example) understand how to use an AI tool to block a play, choreograph a dance, profile an athlete's strengths and weaknesses using data collected with wearable technology, access a curated collection of news images, or teach students how to use a tool that will help them learn a new language most efficiently. In other cases, an artist may need to create their own machine learning model that will classify images they wish to use. Each of these examples emphasize that, while the people who design these tools will likely be coming from math, science, and computer science disciplines, end-users like artists, performers, coaches, and educators must be participants in the conversation if these tools are to effectively meet their needs.

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 artwork—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 elective classrooms. 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 computer science or 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 deciding which project activities you will 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 AI and Art project can be completed by students of upper elementary, middle, and high school grade levels; however, students' understanding of the machine learning and neural networks that power the style transfer art applications should deepen as they get older. 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,

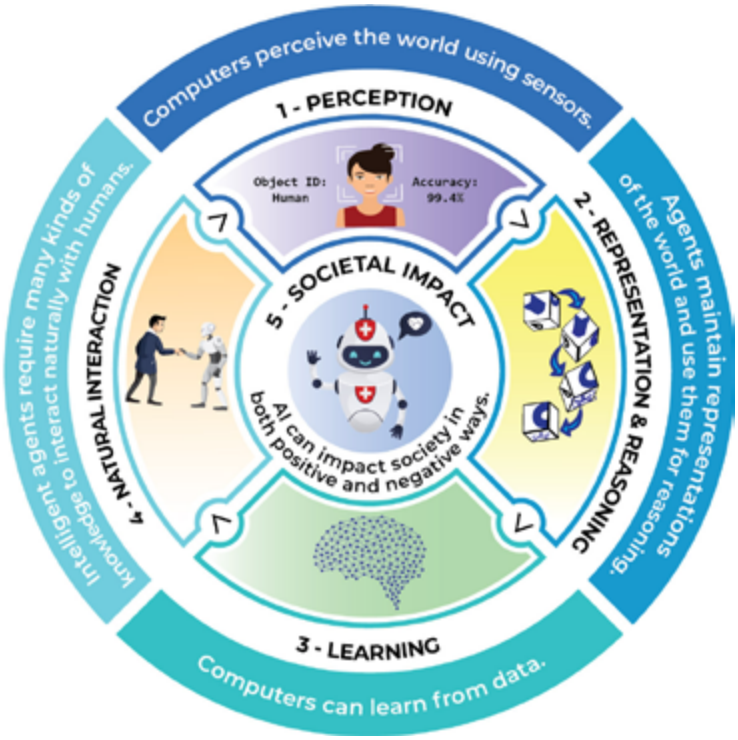

FIGURE 1. Five big ideas in AI. Credit: AI4K12 Initiative. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

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 first four 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. The fifth guide supports all educators in teaching K–12 students about ethical considerations and AI. 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, 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 five 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

Create an AI Expert Guessing Game

Whether in music, language learning, or sports, subject-matter experts have a deep understanding of their specific discipline. For example, they might know nuances of every composition in Mozart's catalog or all the statistics of the latest Olympic record breakers. Based on that knowledge, they are able to make critical distinctions, decisions, or recommendations to others in their field.

Project Overview

In this project, students will think about how experts classify information about a specific subject, then transfer that knowledge to think about how AI can classify large sets of data and use that information to make decisions to solve real-world problems. They will apply this knowledge to create a guessing game based on their coursework. This project would be great for synthesizing knowledge at the end of a course unit or for reviewing content-area knowledge at the end of the year.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

2–4 hours

TARGET GRADES

4–12

OBJECTIVES

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

- Use a decision tree to classify subject matter data.
- Understand how AI uses classification algorithms to make decisions and solve real-world problems.
- Create a guessing game that simulates an AI classification algorithm.

VOCABULARY

artificial intelligence
branch
classification algorithm
classifier
data
data science
decision tree
features
leaf node
node
symbolic representation
test data
training data

STANDARDS

ISTE Standards for Students

1.4. Innovative Designer

- **d.** Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

1.5. Computational Thinker

- **a.** Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.
- **b.** Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.
- **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

5.1. Computational Thinking

- **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.

5.4. Creativity & Design

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

5.5. 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.

Content Area Standard(s)

This project has been designed for implementation in a variety of elective classrooms, from art and music to physical education and journalism. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other advances in that field.

Preparation

MATERIALS

- Writing/drawing materials: Paper, chart paper, magnet boards, and/or sticky notes and drawing supplies.
- Activity: **Akinator**

SUPPORTING RESOURCES FOR EDUCATORS

Article: "**Understanding Decision Trees**"

Article: "**What Is Classification in AI?**"

Article: "**Machine Learning for Kids–Decision Trees**"

Instructions

GETTING STARTED

Activity 1: Classification Activity

In this activity, students will activate prior knowledge about classification strategies by working in small groups to organize a set of data.

1. Display or distribute a list of 20–30 objects or terms from your subject area. For example, in a music class, you might include the names of instruments, types of notes or rhythms, and/or musical genres. Alternatively, a physical education class might have a list of sports, players, and/or equipment.
2. In small groups, have students classify the items on the list into subgroups (and even sub-subgroups). Tell them they can sort the items and represent the data any way they would like. For example, students might organize football players by their team, by their position, or by characteristics of their performance; any of these strategies would be appropriate. Once all student groups have sorted the items, have each group explain to the class how they organized the data, what each category is, and what **features** the items in a given category have in common.

   > **NOTE:** Sticky notes, chart paper, and/or a magnet board for each group might help them better visualize their groupings.

3. Ask students:
    - How did your classification method compare to that of the other groups? Do you think some ways of organizing the items are better than others? Why?
    - How would experts in our subject matter organize these same items? Why? What evidence do we have of that?
    - AI can be used to classify items in large sets of data based on criteria. What might you do differently to teach a computer to accurately classify the items on the list?
4. Conclude the discussion by letting students know that, in this project, they are going to learn how AI analyzes and classifies information. Then, they will think about ways that AI could be applied to solve problems relevant to their own coursework. Finally, they will create a guessing game that will simulate an AI classification process.

TAKING A CLOSER LOOK

Activity 2: AI Classifiers

In this activity, students consider various types of data representation, then dig deeper to see how AI can use decision trees to classify data.

1. Explain to students that **data**—or information—can be represented in many ways. People can organize data into graphs, charts, patterns, logic models, Venn diagrams, thinking maps, or infographics. Consider showing examples related to your content area.
2. Introduce students to AI and classification algorithms. Key points should include:
    - A description of what **artificial intelligence** is, and that people across all fields are using AI to power decision-making about data sets. This process is part of a bigger field of data analysis called **data science**. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
    - **Classification algorithms** are one way that AI categorizes even large sets of data. Based on the result, computers can recommend or make decisions about what actions to take. Many times, AI is able to find patterns and trends that humans are unable to see, especially when processing very large data sets.
    - AI classifiers must be provided with **training data**, which are examples from each category it is classifying. For example, consider a classifier that distinguishes between four categories: equilateral triangles, scalene triangles, isosceles triangles, and not triangles. The classifier then analyzes the data to recognize the different **features**–or unique measurable properties–between the categories, such as the number of sides or the lengths of the sides. It uses what it learns about data to create an AI classification model, such as a decision tree or neural network. With the model in place, a classification algorithm can determine which category new items belong in. While no model is perfect, the more comprehensive the training data for each category, the better the classifier will work.
    - **Decision trees** are a type of **symbolic representation**—a representation humans can understand—that AI can use to represent and classify data. Decision trees are branching flowcharts in which each **node**

represents a question or test. The answer to each node's question determines which **branch** of the flowchart is followed. The branches might lead to more question nodes and eventually end with a **leaf node** that defines that branch's class label. For a visual example, you could show the weather examples from the article "**Machine Learning for Kids – Decision Trees**" or 0:42-2:17 of the video "**How Decision Tree Works? Beginners Guide**."

3. Following the instructions below, facilitate an interactive demonstration about how to construct a decision tree using the example of triangles above or another topic from your subject area content or of student interest.

   - Start at the Top Node: The decision tree starts with a question node. An easy way to get started is to use a question that has a yes or no answer. For example: Does the shape have 3 sides? If yes, it is a type of triangle. If not, it is not a triangle.
   - Follow the Branches: Each yes or no answer leads you down a different path or branch of the tree. For example, if the shape has three sides, the next question node might say "Does it have equal sides?" If yes, it's an equilateral triangle. If not, it is scalene or isosceles.
   - Reach the Leaves: At the end of each branch, after a series of questions, the AI arrives at a decision leaf that states the category. In this example, the AI is able to follow the branches to sort items into four categories: equilateral triangles, scalene triangles, isosceles triangles, and not triangles.

   After demonstrating one decision tree, help students to understand that the features used in nodes and the order of the questions in the nodes and branches affect the accuracy and efficiency of the AI's ability to decide which category the item belongs in. For example, in creating a decision tree about types of triangles, it would make sense to first ask if the shape has three sides. If yes, then it is a type of triangle and more question nodes can determine which type. If not, then that branch of the decision tree would lead to a leaf for "not triangles" and no other questions would be needed. Alternatively, if the first question asked is about whether all the sides are equal length, other shapes such as squares or equilateral pentagons would also go down that branch. An additional question node about the number of sides would need to be included in every branch. While this can still work, it is a less efficient decision tree algorithm. If the question about the number of sides is never asked, but instead the nodes simply ask whether all sides are equal lengths, two sides are equal lengths, or no sides are equal lengths, some items that are not triangles may end up in the wrong categories, while other items may not fit into any of the categories at all. Demonstrating each of these examples can help students see how the quality of the data and the model will impact the AI's ability to classify correctly.

4. Ask students to reflect on this experience: Would they be able to learn to classify types of triangles or other categories of items using a decision tree? Do they think this is a good way to teach an AI to classify items? Why or why not? Tell students that decision tree algorithms are best used by AI when data can be fairly easily divided into a finite number of categories based on their defining features.

Activity 3: Solving Classification Problems with AI

In this activity, students consider real-world problems that AI might be able to solve with classification algorithms.

1. Explain to students that classification algorithms, like decision trees, are used by AI to solve many real-world problems. Examples include:

- Helping spam filters distinguish between what is and isn't spam.
- Powering AI recommender systems to recommend a movie or TV show based on what you've previously watched and liked.
- Distinguishing features for facial recognition to open your phone or for visual recognition of a person in the road for a self-driving car.
- Diagnosing medical conditions by distinguishing between symptoms and combinations of symptoms.

2. Have students brainstorm in small groups to come up with classification problems related to your subject area that might be helped by AI. Students should both determine what type of data would need to be used as well as explain the problem classifying it would solve. Then, have students share their group's ideas with the whole class. Discuss which of those ideas might have the biggest positive or negative impact on that field. Student responses might include:
   - Physical education: Analyzing videos of golf swings to determine if they are using a traditional swing, one plane swing, or a stack and tilt swing.
   - Music: Classifying new music based on its characteristics, like genre or tempo, so that an app can make recommendations to users.
   - Visual arts: Classifying and tagging a large database of artwork based on the materials used to create each piece, so that they are easier to search.
   - Foreign languages: Analyzing recordings of languages in remote communities to determine if the language spoken is common to the region or a unique dialect.
   - Home economics: Classifying recipes by featured ingredients, calories, difficulty, or taste.

CULMINATING PERFORMANCES

Activity 4: Create an AI Expert Guessing Game

In this activity, students will develop their own decision trees to classify information from their coursework. Students will use their decision trees to simulate a Twenty Questions game with an AI agent.

1. Introduce students to the web and app guessing game **Akinator**, which uses AI to analyze answers to yes or no questions to identify a real or fictional character. As time allows, have students try the game as a whole class or as individuals to test its ability to narrow down people in different categories based on the user's answers.
2. Have students work as individuals or in small groups to create a decision tree to classify information in your content area into categories. Students can do this on paper or using a concept-mapping tool like **Coggle** or **LucidChart**. Let students know that they will later use this decision tree to simulate their own AI guessing game with their classmates. The decision tree should:
   - Be about a specific topic related to the content area you are studying, such as music genres, types of balls, or French verb conjugations.

- Have between four and ten categories, represented by the leaf nodes.
- Have a connected series of nodes that each ask a yes or no question. The top node should have the broadest question so that each side of the tree is balanced.

  > **NOTE:** More advanced students might want to create nodes with questions that have more than two possible answers, such as red, blue, or green.

- Have branches off each node that connect to either the next question or the final category leaf on that branch.

3. *Optional:* Have students prepare for the game portion of this activity by creating a game title and visually appealing version of their decision tree.
4. For the simulated AI expert guessing game, have students work in small groups. Each round, the group will pick one decision tree to work with. One student will secretly choose an item that would fall into only one category (leaf) on that tree. Then, another person will act as the AI, using only the questions and branches on the decision tree to try to guess the other player's item. Then, the group will move to the next round and test another tree.

Activity 5: Reflect

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

- How accurate were your decision trees? Were there questions that you included, but probably shouldn't have? Were there questions that you didn't include, but should have? (Possible takeaway: The accuracy of the data and the tree affects the accuracy of the AI's decisions.)
- Did you always agree with the yes or no answers that your classmates gave? Or would you have described, distinguished, or classified some of the categories differently? (Possible takeaway: The classification can be biased based on human input, lack of balance or representation in the data set, or other reasons.)
- What if you needed to add another category to your tree? How would that affect the rest of the tree? (Possible takeaway: As fields advance, AI technologies will need to continually learn to continue making accurate decisions.)
- Based on your experiences in this project, what is one real-world problem you would want AI to use classification to help solve?

Extensions

Here are two ways to expand students' exploration of classification algorithms:

1. For hands-on experience with an AI classification tool, have students experiment with **Google Lens**, which analyzes and classifies images from a mobile device camera. Students can see whether this specific neural network is able to correctly identify objects related to your content area and discuss more advanced AI

classification concepts like vector representations, confidence levels, or reasons why the result might be wrong.

2. If students enjoy working with a classifier app, they can create their own image classification app project with **App Inventor** or create various image classification or decision tree Scratch projects, like "Pokemon Images," "Sorting Hat," and "Car or Cup," with **Machine Learning for Kids**.

Since some of these extension activities collect and analyze students' images, please check the account requirements for each activity against your school/district student data privacy policy to ensure the activity complies with that policy. In addition, some activities' Terms of Service may require parental permission to be COPPA and FERPA compliant for students younger than thirteen years of age.

PROJECT 2
Design an AI Agent

People may envision interacting with AI agents in a natural, human-like fashion; however, at this point in time, AI agents still have a way to go before they can converse with humans fluently, consistently recognize facial expressions or emotions, or make inferences about human behavior based on interactions. Students need to understand both the complexity of these types of interactions and some of the challenges faced in developing technology that could enable more nuanced levels of interaction.

> I teach more than one elective—media as well as computer science courses. Although the nature of the courses are different, I feel I could use this project in any of the classes I teach. The resources are excellent and I like that the project is unplugged because it helps me address issues of equity and access among my students.
>
> — **Leah Aiwohi, Computer Science and Media Arts Teacher, Kauai High School**

Project Overview

The purpose of this unplugged project is to give students opportunities to consider what AI agents need to be able to do to effectively interact with humans within the context of fields such as the arts, foreign languages, or physical education. In this project, students explore how AI agents are currently being used in a discipline addressed in this guide. Then they work independently or in groups to identify a task or challenge related to the discipline and design an intelligent agent people could interact with in a natural fashion to complete that task or meet that challenge.

SUBJECT

Appropriate for all subject areas.

ESTIMATED DURATION

4–6 hours

TARGET GRADES

6–12

OBJECTIVES

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

- Explain how AI agents are being used in a specific field of study.
- Use a PEAS (Performance, Environment, Actuators, and Sensors) representation to describe the parts of an AI agent of their own creation.

VOCABULARY

AI agent
sensor

STANDARDS

ISTE Standards for Students

1.1 Empowered Learner

d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

1.4. Innovative Designer

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

ISTE Computational Thinking Competencies

5.1. Computational Thinking

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.

5.4. 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.

5.5. 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.

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 a variety of elective classrooms, from art and music to physical education and journalism. When possible, we recommend selecting relevant content area standards related to understanding the use of technology or other advances in that field.

Preparation

MATERIALS

- Writing/drawing materials (for designing the AI agent): Drawing paper, writing paper, pencils, pens. This work can also be done on a device, if desired, using a word processor or drawing program.
- Computer(s) or tablet(s) with internet connection for accessing tools and resources online.
- Chatbot: **Kuki** or **I Am Sophie**

ADVANCED PREPARATION

- Review and select resources that provide examples of ways AI is currently applied in your field of study (the arts, sports, journalism, language acquisition, etc.). Sample resources are suggested in the Instructions, but you may prefer to find your own related resources.
- Create appropriate definitions for the following terms: *agent, sensor, actuator, effector, intelligent agent,* and *PEAS Representation*. Possible definitions can be found in the article "**Agents in Artificial Intelligence**." You may also want to read the article, "**Understanding PEAS in Artificial Intelligence**" prior to creating definitions.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students engage in the topic of AI agents through class discussion.

Ask students: Have you ever used a smart device, at home or at school, such as a smartphone, smart TV, Roku, or Nest Hello video doorbell? If you could have a virtual assistant or robot perform any one task for you in this class, what would it be? Give students a chance to brainstorm. As they learn more about AI agents, they will have an opportunity to return to this question later in the project.

TAKE A CLOSER LOOK

Activity 2: AI Agents in Action

In this activity, students will examine how AI agents are currently being used in a specific field of study, such as the arts, sports, journalism, or language acquisition. If students do not have previous experience interacting with an AI agent, you may want to begin this activity by having them interact with one of these AI chatbots, **Kuki** or **I Am Sophie**.

> **NOTE:** There are age restrictions if you choose to use Kuki described as follows: "6.4. Use of ICONIQ by minors. If you are under 13 years of age, you are not authorized to use the Services, with or without registering. In addition, if you are under 18 years old, you may use the Services, with or without registering, only with the approval of your parent or guardian." There are no age restrictions when using I Am Sophie.

Use the following examples—or others you have curated—to explore with students how AI is currently being used in your field of study. More advanced students may be able to do this research on their own.

1. **AI agents**—in the form of software, virtual assistants, and robots—are currently being used in all fields to make tasks easier or more efficient. Sometimes they are also being used to analyze the work of experts and high performers, identifying defining characteristics and applying them in new ways. Here are some examples:

   - AI is being used to generate art in several areas, including visual arts, music, and poetry—and even to turn out scripts for movies. This art is made through the use of neural networks, which MIT News defines as "a means of doing machine learning, in which a computer learns to perform some task by analyzing training examples." Can AI generate images, music, scripts, poetry, and the like? Yes. Are these products truly art? Maybe, but maybe not. Is AI art better than what human beings create? That's definitely a matter of opinion at this time.

     Sample resources: "**If it wasn't created by a human artist, is it still art?**," "**Explained: Neural networks**," "**Neural Network in 5 Minutes**," "**Could a computer ever create better art than a human?**"

   - Sports are individual or team activities, often competitive, that require physical activity and some level of skill. You might think Artificial Intelligence would have little or no impact on sports, but that has not turned out to be the case. A 2023 article published on yahoo!finance, identifies multiple ways AI is impacting the world of sports including: athlete monitoring and tracking; real-time data analytics; and, equipment development. Students will likely be familiar with wearable technologies like FitBit or other smart sports watches. And companies are exploring the use of fitness apps to create individualized workouts and provide virtual coaching to athletes.

     Sample resources: "**Smart Ways Journalists Can Exploit Artificial Intelligence**," "**AI Journalism: Where Will the Rise of Automated News Writing and Fact-Checking Take the Industry?**"

   - AI is making headway in journalism as well. For example, there are newsrooms using AI to translate articles into multiple languages to increase reader access. Some journalists are using apps to transcribe audio interviews into text. And, there are well known news outlets using AI to create news stories in one or more of the areas of entertainment, sports, and finance and to fact-check articles.

     Sample resources: "**Automated Journalism—AI Applications at New York Times, Reuters, and Other Media Giants**," "**Artificial intelligence-enhanced journalism offers a glimpse of the future of the knowledge economy**"

   - Teaching or learning a foreign language? AI-supported translation apps facilitate on-the-spot communication in multiple languages, and language-learning apps can be used to build vocabulary and practice speaking a new language. While some fear that these apps may make foreign language teachers obsolete, others say

that the apps offer a great introduction to a new language, but human instructors are still a critical part of learning the mechanics of grammar and pronunciation, not to mention the nuances of language.

Sample resources: "**Ai Means a Rethink of Teaching Foreign Languages**," "**How Is the Role Of Teachers Changing as a Result of the Application of Artificial Intelligence?**"

2. Discussion: Have students explore several of the examples of AI technologies shared in the resources provided below that relate to your content area(s). Ask students: What do you think? Are there tasks where AI outperforms humans and tasks where it does not? Explain what you think and why.

   - **AIArtists.org**: Learn about some of the people who are creating AI art.
   - **The AI Art Gallery**: Collection of AI-generated art.
   - "**Exploring the Potential of AI Generated Music [5 Examples of Songs Created with AI]**": Explore the potential for AI generated music.
   - **Chrome Music Lab**: Experiments designed to make it possible for students and others to explore use of AI tools to create music.
   - "**You'll Never Dance Alone with This Artificial Intelligence Project**": Building co-creative AI dances. Two videos are included.
   - "**Living Archive by Wayne McGregor**": Using AI to choreograph dances. One video is included.
   - **Creative Tools to Generate AI Art**: Comprehensive list of AI tools used to create everything from images to text to music.
   - "**The Top AI Art Generators in 2024**": A list of AI Art Generators educators may want to explore.
   - "**Don't Speak the Language? How to Use Google Translate as Your Interpreter** ": Google offers two apps, Google Translate and Google Assistant, that can be used to translate text, translate images, transcribe speech, translate conversations, and more.
   - "**Why is AI a good thing for language teachers and learners?**": A discussion of some ways AI might enhance the teaching and learning of foreign languages.
   - "**8 Best Translation Apps**": Translation apps for iOS and Android.
   - "**Strength And Conditioning App – 5 Keys for High Schools**": A strength and conditioning app for high school students.
   - "**Thriving as a Sports Coach in the Age of Chatgpt and Ai Revolution**": Apps coaches can use to enhance their skills in working with athletes.
   - "**How AI Is Saving Orthopedic and Sports Medicine Practices An Hour Each Day**": How is AI being used in sports medicine?
   - "**AI in Journalism: The Pros and Cons of Automated News Writing**": What are some of the advantages and drawbacks of using AI in journalism?
   - **The top AI text generators in 2023**: Being mindful of district and/or site rules regarding use of AI text generators, explore this list of 28 different text generators currently available.

- **AI + Writing**: Check out these Google Experiments that use AI to write.

CULMINATING PERFORMANCES

Activity 3: Design an AI Agent

In this unplugged activity, students use AI vocabulary and concepts to design an AI agent that has the capabilities it would need to perform a task in a given content area. Depending on students' ages and skill levels, you may want to have them complete this activity as a whole class project, in small groups, or individually.

1. Begin by sharing and discussing the definitions for the following terms: *agent, sensor, actuator, effector, intelligent agent,* and *PEAS Representation.* There are many online resources available for defining these terms. JavaTpoint offers all six on one page in simple terms: "**Agents in Artificial Intelligence**."
2. Ask students to brainstorm a list of tasks or challenges they encounter in your class. Create a class list of these ideas. Select one from the list to use as a model. For example, perhaps you teach an art or shop class where, as a result of the kinds of projects being done, the floors need to be swept at the end of each activity. This cuts significantly into class work time. Students might suggest creating an intelligent agent that could solve that problem. A logical solution might be a robot that uses AI to clean the classroom floor at the end of the period so that students are able to use all class time for creative work. What would this robotic device consist of?
3. Using the PEAS Representation model, walk the class through your example by filling out a PEAS Representation, drawing a picture or giving an example of it in action, and writing a brief description of what this intelligent agent looks like and how it will solve the problem identified. See the example in the following table:

SweepBot	
The purpose of this intelligent agent is to preserve instructional time for class work by completing cleaning chores that have previously been done by students.	
Performance measure	Clean classroom floors, increased project work time for students, safe classroom environment
Environment	Art/shop classroom, large work tables, stools, equipment, dry and wet trash on the floor, other obstacles
Actuators	Pneumatic actuators (cylinders and motors), wheels, brushes, vacuum
Sensors	Cliff sensors, bump sensors, wall sensors, optical encoders, and dirt detection sensor

4. Once students have completed the example PEAS representation as a class, have students work independently or in small groups to identify a task or challenge related to their course and design an intelligent agent people could interact with in a natural fashion to complete that task or meet that challenge. Students should develop a presentation for the class that includes:

- A PEAS Representation of their AI agent
- A drawing or a written example of the AI agent in action
- A written description of what the intelligent agent is and how it will solve the problem identified

Activity 4: Reflect

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

- Lead the following discussion: Consider how the intelligent agent you designed for this project could impact your life or the lives of those around you. What are the pros/cons of using an intelligent agent to perform that task instead of having a person perform them?

Extensions

Here are two ways to expand students' exploration of AI agents, natural interaction, and user interfaces:

1. There are natural user interface designers who strive to develop intelligent agents that capitalize on human's abilities to interact with digital objects using capabilities like vision, speech, gestures, or handwriting. The rationale for this focus is to make the use of technology as transparent as possible.

   Sample resources: "**10 of the Most Innovative Chatbots on the Web**," "**Introduction to guidelines for human-AI interaction**"

   Class discussion: Brainstorm a list of technologies students regularly use. Then discuss ways they interact with these technologies. For example, they may include keyboards, mice, game controllers, touch screens, voice, handwriting, etc. How might environment impact the ability to interact with a device? What about physical disabilities or language challenges? Ask students which devices are easiest for them to use and why. Ask them which kinds of interaction they think most people prefer.

2. As we work to achieve transparent interactions with technology, it's important that we ensure that children and adults are able to recognize that there are differences between humans and intelligent agents—that humans are able to control intelligent agents. One strategy for achieving this separation is to refrain from anthropomorphizing these machines.

   Sample resources: "**Evolution is making us treat AI like a human, and we need to kick the habit**," "**How anthropomorphism hinders AI education**"

   Class discussion: Brainstorm a list of intelligent agents students currently interact with. For example, they may include Siri, Google Assistant, Alexa, and similar agents. Ask students what pronouns they use to refer to these agents and why. Have a discussion about why interface designers might want to make intelligent agents seem to be almost human. Include a discussion about the fact that these devices are not "magical."

PROJECT 3
AI and Art

Human artists are able to apply various artistic approaches to create artwork with a unique style of their own. When we think about the art of Vincent Van Gogh, Claude Monet, or Roy Lichtenstein, a distinct set of stylistic characteristics come to mind.

Project Overview

In this project, students will examine the unique characteristics of various artistic styles and then see how an artificial neural network can be used to learn and apply stylistic elements in artwork.

> I love the simplistic lesson plan with its clear objectives and steps for instruction. The advanced planning links are very helpful!
>
> — **Vickie Waite, Computer Science and Video Production Media Arts Teacher, Maclay Middle School**

SUBJECT

Visual arts

ESTIMATED DURATION

3–4 hours

TARGET GRADES

4–12

OBJECTIVES

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

- Explain the basics of how machine learning and neural networks work.
- Discern between distinguishing characteristics of various artists and artwork.
- Create original artwork that remixes multiple images and styles using a digital tool powered by an AI neural network.

VOCABULARY

artificial neural networks
extract
feature
generative AI
machine learning
model
nodes
prompt engineering
style transfer tools
text-to-image tool

STANDARDS

ISTE Standards for Students

1.1. Empowered Learner

- **d.** Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

1.2. Digital Citizen

- **c.** Students demonstrate an understanding of and respect for the rights and obligations of using and sharing intellectual property.

1.3. Knowledge Constructor

- **a.** Students plan and employ effective research strategies to locate information and other resources for their intellectual or creative pursuits.

1.5. Computational Thinker

- **b.** Students collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making.

1.6. Creative Communicator

- **b.** Students create original works or responsibly repurpose or remix digital resources into new creations.

ISTE Computational Thinking Competencies

5.1. Computational Thinking

- **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.

5.4. Creativity & Design

- **d.** Create CS and CT learning environments that value and encourage varied viewpoints, student agency, creativity, engagement, joy, and fun.

AI4K12 Five Big Ideas in AI

3. Learning

Computers can learn from data.

5. Societal Impact

AI can impact society in both positive and negative ways.

National Core Arts Standards

Anchor Standard 2

Organize and develop artistic ideas and work.

Anchor Standard 7

Perceive and analyze artistic work.

Preparation

MATERIALS

- Computers with internet connection for accessing tools and resources online (one per student or group). Alternatively, if using mobile devices, consider using an app alternative to **Teachable Machine**, such as the **TeachableMachine iOS app** or **GenAI Teachable Machine**.
- Teacher computer and projector.
- Tools: **Google Tags experiment**, **Google's Curator Table**, **Teachable Machine**

ADVANCED PREPARATION

- Select an AI style transfer tool (defined and used in Activity 5: Neural Art), such as **Deep Dream Generator's Deep Style**, **Fotor's GoArt**, **CapCut's AI Image Style Transer**, or the **Prisma** app for iOS or Android.
- Select an AI text-to-image tool (defined and used in Activity 5: Neural Art), such as **Craiyon**, **Dream by Wombo**, **Stable Diffusion**, or **Dalle-2**. Several AI image generators are also integrated into other media creation tools you or your students may have access to, such as **Canva**.

> **NOTE:** Since AI tools, like style transfer tools and text-to-image tools, are rapidly advancing, please be sure to review 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 or eighteen years of age.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students will activate prior knowledge about art as they consider how they describe and characterize artists' styles.

1. Ask students to imagine that a friend is going to a large art museum. While you don't know exactly what pieces will be included, you want to make sure your friend looks for art by your favorite artist. How might you describe the artist's style so that your friend recognizes their artwork without reading the name of every piece's artist? For example, does your favorite artist use primary colors or pastels? Do they work with paint or pencil or clay? Do they typically portray nature, people, animals, objects, or shapes?

   > **NOTE:** If you are working with elementary students who do not have much experience with famous artists or artwork, this same activity can be done with children's book illustrators, such as Eric Carle, Shel Silverstein, or Anna Dewdney.

2. Now, ask students to imagine that they wanted to teach a computer to recognize artwork by the same artist. Do they think they could use the same descriptions, or would they need to use a different method?
3. Conclude the discussion by letting students know that, in this project, they are going to learn how AI technologies are being used to identify, organize, tag, and even create art. By the end of the project, they will be able to meet each of the three project objectives.

TAKING A CLOSER LOOK

Activity 2: Explore with Students

In this activity, students will look at how AI is used to visually analyze, organize, and tag art.

1. Project the "**Every piece of art you've ever wanted to see—up close and searchable**" TED Talk video, prompting students to think about how AI is being used to analyze and organize the combined art collections of over one thousand museums and archives in **Google Arts & Culture Project**.
2. Direct students to explore how AI visually perceived, analyzed, and tagged the collection's artwork through the **Tags experiment**.

Activity 3: Identifying Artists' Styles

In this activity, students will analyze and characterize artists' styles.

1. Project the **Google Tags experiment** and search for an iconic art tag. As a whole class, challenge students to analyze the tagged artwork. For example, if you examined the tag "water lily," ask students:

- Given the characteristics of Claude Monet's art (such as nature images; paintings; short brush strokes; natural lighting; or strong, unmixed colors), can you identify which of these pieces are his just by looking at them?
- Knowing which of the water lily images are Monet's, would you add any other characteristics to the description to better identify which ones are his?
- Based on those same characteristics, would you be able to tell that the red and pink "Peony Garden" tagged with "water lily" is a Monet by the style of painting (even though the colors and content are different)? How might you need to change the list of characteristics to include Monet's works that do not include water lilies?

2. Have students—as individuals or in small groups—research two or more artists that you are studying in your course and **extract** the identifying **features** of their styles into a list. For example, if students are studying Dutch painters, they might characterize Vincent Van Gogh's style as having thick brush strokes (impasto), bold colors, portraits, and landscapes, while characterizing Piet Mondrian's style as having straight lines, right angles, primary colors, black, and white. Students can find collections of artists' works by using a resource like **Google's Curator Table** and can then organize these criteria using a digital or paper-based graphic organizer, such as a classification tree, Venn diagram, or brace thinking map. Enhance this activity by reinforcing specific stylistic characteristics and vocabulary from your curriculum.
3. *Optional:* Conclude with a partner game in which students trade graphic organizers, show each other a piece of art by one of the artists they researched, and have the other guess the artist based on listed characteristics.

Activity 4: Training an AI Art Recognition Model

In this activity, students will transfer their own experience of style extraction to see how AI can be taught to extract similar types of stylistic characteristics. Then, students will train a machine learning model to recognize artists' work.

1. Provide a basic description of AI and machine learning to students. Supporting resources can be found in **Appendix A: Unpacking Artificial Intelligence**.
2. Explain to students that we can train AI to identify the style of an artist much like we learned to identify them by analyzing an artist's works in the last activity. Key points should include:
   - **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 artificial neural networks to build a model that it can use to make decisions or predictions.
   - **Artificial neural networks** (ANN) 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 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.

- For example, to teach a machine to identify the artist of a work of art, we could provide a neural network with many examples of art by the artist and let it visually analyze those works to find a pattern of common characteristics among them. Then, when the model is tested with a new work of art, it would look for those characteristics to determine if it is by that artist. It could also use that model to apply those characteristics to another image to make it look like it is created in the style of that artist.

3. Have students train an art recognition model with Google's **Teachable Machine**. Students can create an image project, define classes for multiple artists or styles of art, upload several image samples for each class, train the machine learning model, and then test the model with new art images to see how accurately the model is able to recognize and classify the artwork by artist or style.

> **NOTE:** For elementary students, this step can be skipped or the model training could be done as a class. Older students could work as individuals or in small groups to train a model to recognize work by the artists they previously researched.

CULMINATING PERFORMANCES

Activity 5: Neural Art

In this activity, students will use generative AI tools to create two types of digital images. First, students will use a style transfer tool to apply the style of one artwork to the content of another. Then, students will use a text-to-image tool that will produce a new work of art based on text-based prompts.

> **NOTE:** Since generative AI tools, like style transfer tools and text-to-image tools, are rapidly advancing, please be sure to review 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 or eighteen years of age.

1. Explain to students that many advances are being made in an area of AI called **generative AI**. Generative AI is a type of AI computer program that learns from training data in order to create new data, including visual art, poems, and music. Tell them that in this activity, they will experiment with two types of generative AI tools that can be used in the co-creation of visual images: style transfer tools and text-to-image tools.
2. Introduce students to an AI-powered **style transfer tool**, such as **Deep Dream Generator's Deep Style**, **Fotor's GoArt**, **CapCut's AI Image Style Transer**, or the **Prisma** app for iOS or Android. These AI-powered style transfer tools use pre-trained neural networks that have been taught to do three things: identify essential content elements in one image, identify essential stylistic elements in a second image, and combine the two models to create a third merged image. When you provide the neural network with a content and style image, it analyzes them similarly to how the students did, identifies the most essential characteristics, and uses that data as the last step or layer in the neural network. It then synthesizes the most essential content and style characteristics to create a third merged image (see Figure 2).

FIGURE 2. Merged image created from content image and style image using DeepArt.

3. Provide students with a demonstration of the style transfer tool they will be using.
   - Show them a sample content image and a style image to be used.
   - Prompt students to make a prediction of how the merged output image will appear.
   - Run the program with the content and style images. Show students the merged image and have them compare and contrast the AI output to their predictions.
4. Have students use the style transfer tool to create their own neural art artifact that combines a content and style image to create a final merged "neural art" image. Students should use original art or photographs for their content images or may remix others' works in accordance with their copyright or license. Finished artifacts should include:
   - The content, style, and merged images.
   - A short written description of how the AI-powered tool processed the specific images they provided, including what content and style elements the neural network identified and merged.

   > **NOTE:** Depending on the features of the selected tool, some students may also want to upload their own style images, such as a work of art by the artist they were previously researching.

5. Introduce students to an AI-powered text-to-image tool, such as **Craiyon**, **Dream by Wombo**, **Stable Diffusion**, or **Dalle-2**. Explain to students, "These AI-powered text-to-image tools use artificial neural networks that have been trained on the relationships between images and the words that describe them. These tools can receive text or other language prompts in natural human languages, then generate a new image based on the types of images in its training data that are associated with those words.

   The practice of crafting descriptive prompts in order to get the best output from an AI tool is called **prompt engineering**. More specific and detailed prompts typically lead to image creation that is closer to what the prompt writer imagines. Generative image prompts might include objects, descriptive details, context, style or artist names, and/or art mediums."

6. Provide students with a demonstration of the text-to-image tool they will be using.
    - Show students several sample text prompt descriptions that feature different types of details their prompts might include. For example: a monkey; an abstract monkey eating a banana; a monkey on a bicycle in the style of Van Gogh; a watercolor painting of a happy monkey on a red unicycle racing down the street; or a hyper realistic image of a curious monkey looking at bananas growing on a tree, bright colors, cinematic lighting.
    - Ask students to make a prediction of how each output image will appear.
    - Run the program to create an image based on each prompt. Show students the generated image and have them compare and contrast the AI output to their predictions.
7. Have students use the text-to-image tool to create two of their own neural art artifacts based on original prompts that they compose. Students should iterate to improve their prompts until they get an image that they are satisfied with. Consider sharing a student-friendly resource like "**How to Write the Best Prompts for AI Art Generators**" to support students' prompt engineering efforts. Finished artifacts should include:
    - One text-to-image tool generated artifact from a prompt that includes the style of an artist they researched earlier in the project.
    - One text-to-image tool generated artifact from a prompt of their choosing.
    - A short written description of how the AI-powered tool processed the prompts they provided, including what content and style elements they believe the neural networks included based on their prompts. A description of the prompts they used and how they improved their prompts to improve the quality of their final image.
8. Finish this activity with a gallery walk where students can view and even provide feedback on each other's artwork.

Activity 6: Reflect

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

- How does art created with AI differ from art created solely by human artists?
- Do you think art made with AI counts as real art?
- If an artist uses AI technologies to create their work, who would you define as the artist—the human, the AI, the programmer that developed the AI, or the person that trained the AI, or someone else?
- Should AI images be copyrightable, and why? If so, who should be allowed to hold the copyright?
- How do you think AI technologies might change the way people make art now and in the future?

Extensions

Here are two ways to expand students' exploration of AI and art:

1. Some AI art tools use a special type of neural network structure called a generative adversarial network (GAN). Support students in learning more about how GANs work with these resources:
   - The **DAILy Workshop** curriculum from MIT includes a unit on GANs and generative AI applications. In these activities, students can play a GAN Game to see how the neural networks in the AI tool work. They can also experiment with other examples of AI art tools.
   - **AI4ALL's Open Learning Curriculum** provides a module called How GANs (Generative Adversarial Networks) Work. Through interactive lessons, this module supports students in exploring how GANs work, as well as different ways these AI tools can be used and ethical considerations around their use.
2. You and your students can also explore additional AI-powered art tools and what artists are doing with them at **AIArtists.org**.

PROJECT 4

AI-Powered vs. Human Translators

Thanks to the use of AI and machine learning, translation results are far more accurate than they used to be. Translation apps are still no substitute for learning to speak a foreign language, but they can be used to increase mastery of a foreign language and to enable users to function in situations where they need to communicate with someone who speaks another language.

Project Overview

In this hands-on project, students work independently or in pairs to translate text (words, phrases, paragraphs) into a target language and parse those translations to determine the accuracy of at least two AI-powered translators. Then they engage in a live conversation with a fluent speaker of another language other than English using the translator they have identified as being most reliable. The purpose of this project is to help students develop an understanding of how AI-powered translators function, make determinations and predictions about their accuracy, and use a translator to carry on a conversation with someone fluent in a language other than English. It is also a way to involve students in exploring how AI benefits translation and when it is a better choice not to use AI.

> I'm excited about this project because it can help show my students when it's appropriate to use a translator and when it is not. For instance, a translator is a good communication tool to use when you do not speak a specific language, but it is not a good tool for learning how to speak another language.
>
> — **Julianne Lowenstein, French Teacher, Wissahickon Middle School**

SUBJECT

World languages

ESTIMATED DURATION

3 hours

TARGET GRADES

8–12

OBJECTIVES

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

- Compare and contrast the accuracy of the output of human and AI-powered translators.
- Use an AI-powered translator to hold a real-time conversation with a speaker of another language.

VOCABULARY

AI
machine learning
natural language processing

STANDARDS

ISTE Standards for Students

1.1. Empowered Learner

d. Students understand the fundamental concepts of technology operations, demonstrate the ability to choose, use, and troubleshoot current technologies, and are able to transfer their knowledge to explore emerging technologies.

1.7. Global Collaborator

b. Students use collaborative technologies to work with others, including peers, experts, or community members, to examine issues and problems from multiple viewpoints.

ISTE Computational Thinking Competencies

5.1. Computational Thinking

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.

5.3. Collaborating Around Computing

c. Plan collaboratively with other educators to create learning activities that cross disciplines to strengthen student understanding of CT and CS concepts and transfer application of knowledge in new contexts.

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.

ACTFL: American Council for the Teaching of Foreign Languages Standards

ACTFL 1.2: Students understand and interpret written and spoken language on a variety of topics.

Interpersonal Communication–Standard 3.1: Students reinforce and further their knowledge of other disciplines through the foreign language.

Connections–Standard 4.1: Students demonstrate an understanding of the nature of language through comparisons of the language studied and their own.

Preparation

MATERIALS

- Writing materials: Paper, pens and pencils, dry erase boards, worksheet with vocabulary, sentences, and paragraphs to be translated.
- Computer(s) or mobile device(s) with internet connection for accessing tools and resources online.
- Two or more translator tools, such as **Google Translate**, **Microsoft Translator**, **Deep Learning Translator**, or **Skype Translator**. Another option is to use Siri on iPads or iPhones or **Google Assistant** on Android devices.
- Teacher computer and projector.

SUPPORTING RESOURCES FOR EDUCATORS

- Article: "**Google Research Team Builds Practical Machine Translation Systems for 1000+ Languages**"
- Article: "**Machine Translation vs. Human Translation: Will Artificial Intelligence Replace the World's Second Oldest Profession?**"
- Article: "**From Classroom to Real World: How Machine Translation is Changing the Landscape of Foreign Language Learning**"
- Article: "**Using AI for Personalized Language Learning: A Comprehensive Guide**"
- Webinar recording: **Translating Google Translate: Instructional Strategies for Machine Translation in the Language Classroom**
- Website: **Microsoft Translator for Education**

ADVANCED PREPARATION

- Select apps and websites to be used for translation. Make sure all are accessible on school network and devices.
- Prepare vocabulary words, phrases, sentences, and paragraphs for students to translate into the target language.

Instructions

GETTING STARTED

Activity 1: Discussion

In this activity, students consider the topic of AI-powered translators through class discussion.

- Ask students: Have you ever used an AI-powered translation tool like Google Translate or Microsoft Translator? What are your thoughts about them? Do they replace the need to learn how to speak a foreign language? Give students a chance to brainstorm. As they learn more about AI-supported translators, they will have an opportunity to return to this question later in the project.

TAKE A CLOSER LOOK

Activity 2: Introduction to AI-powered Translation Apps.

In this activity, students will explore AI and machine learning as they consider how these capabilities are currently being used to help people communicate in multiple languages.

1. Begin by defining **AI** and **machine learning**. Have students brainstorm a list of ways these technologies are used in daily life. Supporting resources can be found in **Appendix A: Unpacking Artificial Intelligence**.
2. Explain what **natural language processing** is, how it processes and analyzes large amounts of data—such as language—and translates it/negotiates its meaning. Include a discussion of potential pros and cons of the use of AI and machine learning for natural language processing. Supporting resources can be found in Appendix A: Unpacking Artificial Intelligence.
3. Introduce AI-powered translation apps. AI-powered translation apps facilitate on-the-spot communication in multiple languages not only by translating written and spoken words from one language to another, but also by accurately conveying the meaning of the words being translated. This means that it's easier to avoid mistranslations than in the past, but does not mean that AI translators negate the need to actually learn how to speak a foreign language. While the capabilities of today's AI translators are far greater than even a few years ago, they are still not perfect. However, these translators can be used to help students increase their vocabularies and learn syntax and grammar. They can support real-time conversations, assuming students have enough knowledge of the language to be able to evaluate the efficacy of multiple AI translators to determine which are most reliable. AI-powered translators can also be leveraged to personalize student learning by providing immediate feedback and enabling students to work independently.

4. Support your introduction with these or other resources:
   - "**AI in Language Learning: Today's Uses, Benefits, and Concerns**"
   - "**Ai Means a Rethink of Teaching Foreign Languages**"
   - "**How to learn a new language with AI**"
   - "**Essentials of Artificial Intelligence for Language Learning**"
5. Discuss: Given what students already know about learning to speak a foreign language, what strategies could they use to test the reliability of at least two AI translators? Brainstorm a list of suggestions—for example, parsing sentences that have been translated is a way to judge the quality of that translation.

Activity 3: Test-Drive a Couple of Translation Tools

In this activity, students try out at least two AI translation tools to determine which one they will use during live conversations with people who are fluent in the language students are studying. Depending on students' ages and skill levels, you may want to have them complete this activity as a whole class project, in pairs, or individually. Also, as written, this activity is a five-step process, but you may decide to skip the second step based on your students' familiarity with basic vocabulary words in the target language.

1. Begin by reviewing available tools for translating languages and communicating including dictionaries, human translators, and apps/web tools for translation, as well as headphones and other electronic translation devices that are available. Explain that for this project students will evaluate the accuracy of AI translators readily available for use on mobile devices, such as smartphones or tablets.
2. Provide students with a list of vocabulary words to translate from English to the target language using a dictionary or glossary. Depending on the length of the list, allow 5–10 minutes for students to work in pairs to complete the translation. Ask students to share their answers before using the AI translator. Then, ask them to use an app or web tool to translate the same vocabulary list. Have each partner use a different AI translator so they can compare their results and compare how well each of their offline translations align with the AI-supported results. How much time does using an AI-powered translator require? Are the answers generated by the app or web tool the same as those found in the dictionary or glossary?
3. Next, provide students with a list of sentences to translate from English to the target language using a dictionary or glossary. Depending on the number of sentences, allow 15–20 minutes for students to work in pairs or small groups. Ask students to share their responses before using their AI translators. Then, ask them to use the app or web tool to translate the same sentences. Which is more efficient? Parse the responses, reviewing the syntax of the translated sentences and the differences in word selection. Discuss words which may be confusing for a nonhuman translator, such as homophones and homographs, including bat, hang out, pen, invalid, resume. How do humans know the difference? How might AI know the difference? How does context impact meaning and word choice?
4. Repeat this process one more time, giving students one or two paragraphs to translate first on their own and then using their AI translators.

5. Discuss: How is this experience similar to translating words and sentences and how is it different? As the text to be translated becomes more complex, is there a shift in the quality of the translations? What are the benefits of using translators? What are the drawbacks? Which translator is easiest to use and most accurate?

CULMINATING PERFORMANCES

Activity 4: Real-Time AI-Powered Translation

This culminating performance prompts students to explore the use of an AI translator to facilitate conversations with people who speak the target language fluently. The purpose of this activity is to create an environment where students can experience the use of a translator to support conversations beyond their current level of proficiency in the target language. These conversations can take place in the classroom with community members or online with native speakers identified by the teacher.

1. Students need to plan a 5-minute conversation in which they will learn 3–5 things about the person they speak with.
2. Using the conversation feature of the AI translator they have identified as most accurate, students speak English and the person they interview speaks the target language.
3. At the close of the conversation, the student asks the person to rate the accuracy of the translation. Did the translations make sense? Did they struggle with understanding, or was the conversation easy to follow? Were mistakes made? Would they recommend this AI translator as an effective communication tool?
4. Students write an evaluation of the AI-powered translator used for the conversation. Include information about basic specs and the information provided by their conversation partner along with an overall rating of the translation tool.

Activity 5: Reflect

In this activity, students should discuss the following questions to reflect on their learning and consider the personal and societal impact of using AI-powered translators.

1. Consider the AI translator you used during the final conversation. Would you be able to use this tool in an environment where you needed to communicate with people who do not speak English? For example, could you use this app when traveling in a foreign country? How might this facilitate travel?
2. How might this tool enable you to collaborate with non-English speakers? For example, could you use this app to help a new non-English-speaking student feel welcome at your school?
3. What barriers might use of this app raise or lower? Why? How might the use of an AI translator impact your life or the lives of those around you? What are the pros and cons of using an AI translator to learn a foreign language and/or communicate with non-English speakers?

Extensions

Another test of the accuracy of an AI-generated translation is to take the text generated in the first translation and have the tool translate that text back into English. How close to the original English is this translation? Why are there differences? What can be learned from this exercise?

> As a language teacher, I realize that there are many opportunities available through online language translators that students may try to use rather than doing their own translation. I often discuss these tools in class to help students to better understand how these tools should or could be used. Being able to recognize the difference in using these tools to assist in learning, for example to translate a word and have options to choose from, versus using a translator to complete an entire translation, is important. It is important that our students understand how the technology works. For anyone implementing the project, I recommend providing commonly mistranslated phrases or words that humans would quickly be able to distinguish to test the accuracy of the tools and make sure to involve students in the discussions.
>
> — **Rachelle Dene Poth, STEAM and Foreign Language Teacher, Riverview Junior Senior High School**

Glossary

AI agent: an entity that uses sensors and actuators to autonomously act on its environment and achieve goals.

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

artificial neural network (ANN): a computer system modeled after the human brain that uses layers of nodes with weighted, directed connections to learn to perform tasks.

branch: the part of a decision tree that represents the possible options of a node's test.

classification algorithm: a method of categorizing data into classes based on common features.

classifier: an AI classification algorithm.

data: information.

data science: a field in which people work to extract knowledge and actionable insights from data.

decision tree: a branching flowchart with nodes, branches, and leaves that symbolically represents a series of tests and classification labels.

extract: identify or separate out.

feature: unique measurable property.

generative AI: a type of AI computer program that learns from training data in order to create new data, such as text, images, music, or videos.

leaf node: the part of a decision tree that defines that branch's class label.

machine learning (ML): a subset of AI involving the study of algorithms and models that machines use to perform a task without explicit instructions.

model (machine learning): a mathematical representation of a dataset developed by AI.

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

node (decision tree): the part of a decision tree that represents a question or test.

node (neural network): an artificial neuron that receives weighted input, performs a function, and produces output in a neural network.

prompt engineering: the practice of crafting descriptive prompts in order to get the best output from an AI tool

style transfer tool: an application that uses a pre-trained neural network to identify essential content elements in one image, identify essential stylistic elements in a second image, and combine the two models to create a third merged image.

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

test data: examples used to verify the accuracy of a machine learning model.

text-to-image tool: an application that uses an AI model in order to receive natural language input description (i.e. text or voice) from a user and generate an original image that matches the description.

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 AI?**"

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

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

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

Resource: "**How AI Works**"

Resource: "**Glossary of Artificial Intelligence Terms for Educators**"

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?**"

Resource: "**Overview of GAN Structure**"

Article: "**What is GPT?**"

What Is Natural Language Processing?

Natural language processing (NLP) is the AI technology used to understand and interact with humans' natural language. NLP 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**"

Article: "**A Complete Guide to Natural Language Processing**"

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

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

Article: "**Chatbot vs ChatGPT: Understanding the Differences & Features**"

Video: "**How Chatbots and Large Language Models Work**"

Article: "**Chatbot vs ChatGPT: Understanding the Differences & Features**"

Video: "**How Chatbots and Large Language Models Work**"

What Is Generative AI?

Generative AI is a type of machine learning that uses advanced algorithms, such as a generative adversarial network (GAN) or a generative pre-trained transformer (GPT), in order to create new data. Based on what they have learned from training data, generative AI tools can generate text, images, video, music, code, and other types of media.

Learn More

Video: "**Introduction to Generative AI**"

Video: "**How Dall-E 2 and Other AI Art Generators Create Images From Text | WSJ**"

Article: "**Generative Artificial Intelligence in education: What are the opportunities and challenges?**"

Article: "**What Kids Need To Know About Generative AI: Unleash Your Creativity!**"

What Types of Ethical Considerations Surround AI?

There are numerous ethical considerations that surround the development and implementation of AI technologies. For example, 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. In addition to various activities that consider AI's societal impacts throughout all of the guides, the *Hands-On AI Projects for the Classroom: A Guide on Ethics and AI* helps to more fully illuminate these and other ethical considerations that students should explore.

Learn More

Video: "**Teach AI | Prepare our students for the future**"

Video: "**Algorithmic Bias and Fairness #18**"

Resource: **UNESCO's "Ethics of Artificial Intelligence**"

Report: "**The Ethical Framework for AI in Education**"

Article: "**Artificial Intelligence and Ethics: Sixteen Challenges and Opportunities**"

Video: "**Do you know AI or AI knows you better? Thinking Ethics of AI**" (version with multilingual subtitles)

Video: "**The ethical dilemma of self-driving cars—Patrick Lin**"

Video: "**The danger of AI is weirder than you think | Janelle Shane**"

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

APPENDIX B

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				Ethics			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ISTE STANDARDS																				
1.1 Empowered Learner	x	x					x			x	x	x	x		x	x		x	x	
1.2 Digital Citizen					x			x			x			x			x	x	x	x
1.3 Knowledge Constructor	x		x	x		x	x	x			x		x				x	x	x	x
1.4 Innovative Designer		x	x				x		x	x					x	x			x	x
1.5 Computational Thinker			x	x	x		x		x		x		x	x	x	x	x			x
1.6 Creative Communicator					x	x		x			x			x					x	
1.7 Global Collaborator							x					x	x						x	
5.1 Computational Thinking				x	x	x	x		x	x	x	x	x		x	x	x	x	x	x
5.2 Equity Leader					x	x	x	x							x	x	x	x	x	x
5.3 Collaborating Around Computing	x			x			x					x	x							
5.4 Creativity & Design	x	x	x	x				x	x	x	x			x	x		x		x	x
5.5 Integrating Computational Thinking		x	x				x		x	x				x						x

Guide	Elementary				Secondary				Electives				Computer Science				Ethics			
Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
AI4K12 FIVE BIG IDEAS IN AI																				
1. Perception	x	x			x					x		x			x				x	
2. Representation and Reasoning	x		x	x			x		x			x	x	x	x				x	
3. Learning	x			x		x	x				x	x	x	x	x	x	x	x	x	x
4. Natural Interaction	x				x	x				x		x		x	x				x	
5. Societal Impact	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

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