Introduction

The Ohio Department of Education’s Office of Learning and Instructional Strategies is in the process of revising Ohio’s Model Curriculum for Computer Science.

The State Board of Education adopted Ohio’s Learning Standards and Model Curriculum for Computer Science in December 2018. Implemented in the 2019-2020 (FY2020) school year, the purpose of Ohio’s Learning Standards and Model Curriculum for Computer Science is to provide guidance to schools and districts. Ohio educators, many of whom engage daily with Ohio students, led the process to create Ohio’s Learning Standards and Model Curriculum for Computer Science.

The review and revision process presents an opportunity for families, computer science professionals, community members and other educators, to provide suggestions for improving the model curriculum through a public comment survey, open March 2 through March 18.

In the Fall of 2021, the public was invited to provide comments on the current standards and model curriculum. Advisory group members, who have an educational background or professional experience in computer science, met several times to discuss the public comment and make suggestions for revisions. The advisory group then provided direction and guidance to the working groups of Ohio educators, who worked to write the revisions.

The following is a draft of the revised model curriculum available for viewing and public comment. This document contains the revisions to the model curriculum for the Artificial Intelligence strand. This model curriculum addresses new proposed standards and therefore new content.

In your review, please focus on the content of the statements. All materials will be going through additional technical edits, but because of the timeline outlined in HB110, the Department wanted to make these drafts available for public comment at this time.

To see the model curriculum adopted by the Ohio State Board of Education in 2018 please visit the Model Curriculum for Computer Science.
Overview of the Computer Science Standards Framework

Ohio’s Computer Science Standards are organized by strands, topics and content statements.

Kindergarten through Grade 8—Content statements are organized by grade level. Below is an example of a content statement for kindergarten and its corresponding content statement code. This content statement addresses the topic of Devices within the Computing Systems strand.
Grade 3

<table>
<thead>
<tr>
<th>Strand</th>
<th>Artificial Intelligence</th>
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<tbody>
<tr>
<td>Topic</td>
<td>Machine Learning</td>
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</table>

**AI.ML.3.a** Label 3 different machine learning approaches to identify them to see different approaches.

**Expectations for Learning**

**LEARNING PROGRESSION**
In grade 2, students used machine learning, classifiers and discussed how the machine knew what they were drawing. In grade 3, students label three different machine learning approaches. In grade 4, students will explain three different types of machine learning.

**IMPORTANT CONCEPTS**
- Approaches to machine learning include supervised learning, unsupervised learning and reinforcement learning

**KEY SKILLS/PROCEDURES**
- Label types of machine learning to show various approaches to how machines learn

**Content Elaborations**

**CLARIFICATIONS**
Machine learning is the study of computer algorithms that improve automatically through experience. Applications range from data mining programs that discover general rules in large data sets, to information filtering systems that automatically learn users' interests.

**CONTENT FOCUS**
There are different types of machine learning.

**COMPUTER SCIENCE PRACTICES**
*Practice 3. Recognizing and Defining Computational Problems*
<table>
<thead>
<tr>
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**AI.ML.3.b** Give examples of bias to understand what it is and how it affects machine learning.

### Expectations for Learning

**LEARNING PROGRESSION**

This concept is introduced in grade 3. In grade 4, students will explain how machine learning can create bias.

**IMPORTANT CONCEPTS**

- What is a bias and how it can influence machine learning

**KEY SKILLS/PROCEDURES**

- Identify what a bias is to understand the concept and how it might affect machine learning

### Content Elaborations

**CLARIFICATIONS**

Bias can be found in all technology. It is based on the data sets used.

**CONTENT FOCUS**

Identifying bias in technology data sets.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
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<tr>
<td>AI.ML.3.c</td>
<td>Identify tasks that use AI to perform human tasks to understand how humans rely on AI.</td>
</tr>
</tbody>
</table>

### Expectations for Learning

#### LEARNING PROGRESSION

In grade 2, students listed attributions computers use for purposes of recognition. In grade 3, students identify tasks that use Artificial Intelligence (AI), the science and engineering of making intelligent machines and computer programs, to perform human tasks. In grade 4, students will describe tasks where AI can outperform humans on tasks.

#### IMPORTANT CONCEPTS
- AI can take over human tasks

#### KEY SKILLS/PROCEDURES
- Show that tasks that used to be done by humans can now be performed using AI to demonstrate how AI affects humans

### Content Elaborations

#### CLARIFICATIONS

AI can perform tasks that humans once did. As AI grows, it can take over more human tasks; for example, self-driving cars and using a search engine versus looking in books.

#### CONTENT FOCUS

AI is a growing field that performs some human tasks.

#### COMPUTER SCIENCE PRACTICES

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
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**AI.NI.3.a** Locate AI systems that are designed to help everyone have equal access.

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 2, students identified AI applications. In grade 3, students locate AI systems that are designed for accessibility. In grade 4, students will use AI systems that are meant to be more inclusive and how it affects the way humans use the systems.

**IMPORTANT CONCEPTS**

- AI systems can create equal access

**KEY SKILLS/PROCEDURES**

- List ways in which AI makes it more inclusive to demonstrate that AI can make people more "equal"

**Content Elaborations**

**CLARIFICATIONS**

AI systems include adaptive tools like text to speech, speech to text and translation programs.

**CONTENT FOCUS**

AI can assist in helping everyone to be included.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
## Artificial Intelligence

### Perception

**AI.P.3.a** Use different sensors, analog and digital and tell the difference between them, such as analog sensors - accelerometers, light sensors, sound sensors, pressure sensors and analog temperature sensors. The digital sensor consists of majorly three components: sensor, cable and transmitter. In digital sensors, the signal measured is directly converted into digital signal output inside the digital sensor itself.

### Expectations for Learning

#### LEARNING PROGRESSION

In grade 2, students will be able to tell about sensors and their relation to their function. In grade 3, students use different sensors to evaluate the differences between them. In grade 4, they will understand the difference between analog and digital and how they can be used.

#### IMPORTANT CONCEPTS

- How sensors are different

#### KEY SKILLS/PROCEDURES

- Recognize the difference between analog and digital sensors
- Explain how different sensors gather data

### Content Elaborations

#### CLARIFICATIONS

Recognize the difference between analog and digital clocks and thermometers.

#### CONTENT FOCUS

There are two basic ways sensors gather data; analog and digital.

### COMPUTER SCIENCE PRACTICES

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
## Artificial Intelligence

### Perception

**AI.P.3.b** Describe what computer perception is and how it affects computers to see how it compares to human perception.

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### Expectations for Learning

**LEARNING PROGRESSION**

In grade 2 students used intelligent agents to assist in research. In grade 3, students describe what computer perception is. In grade 4, students will give examples of how computer perception is affected by the environment.

**IMPORTANT CONCEPTS**

- Compare human and computer perception to show the differences

**KEY SKILLS/PROCEDURES**

- Compare how humans use senses to gather data about the world around them and computers use sensors to gather and interpret data

### Content Elaborations

**CLARIFICATIONS**

Comparison of input (how cold or hot) is determined by a human versus how a computer can tell if something is hot or cold.

**CONTENT FOCUS**

Comparison list of human sensor to computer sensor.

### COMPUTER SCIENCE PRACTICES

*Practice 3. Recognizing and Defining Computational Problems*

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**AI.RR.3.a** With guidance create a classification system using a tree structure to understand how computers think.

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 2, students created simple decision trees. In grade 3, students create a classification system using a tree structure. In grade 4, students will create a tree structure to understand binary solutions.

**IMPORTANT CONCEPTS**

- Explore the tree structure to examine the process for making decisions

**KEY SKILLS/PROCEDURES**

- Use a flowchart to show the decision-making process

**Content Elaborations**

**CLARIFICATIONS**

Decision trees in artificial intelligence are used to arrive at conclusions based on the data available from decisions made in the past.

**CONTENT FOCUS**

Decision trees help make decisions through machine learning.

**COMPUTER SCIENCE PRACTICES**

*Practice 4. Developing and Using Abstractions*

1. Extract common features from a set of interrelated processes or complex phenomena.
2. Evaluate existing technological functionalities and incorporate them into new designs.
3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
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**Strand: Artificial Intelligence**

**Topic: Representation & Reasoning**

**AI.RR.3.b** Use AI to answer questions and describe how the answer is reasonable.

### Expectations for Learning

**LEARNING PROGRESSION**

This concept was introduced in grade 3. In grade 4, students will describe how AI uses knowledge to make a reasonable answer.

**IMPORTANT CONCEPTS**

- AI tries to give a reasonable answer based on the input

**KEY SKILLS/PROCEDURES**

- Create a sentence using words with multiple meanings to see how the AI defines the words
  - Example: The word “pitcher” could mean a baseball pitcher or a container that holds water

### Content Elaborations

**CLARIFICATIONS**

Students learn concepts, such as how the computer knows the difference between words with similar sounds or spellings.

**CONTENT FOCUS**

AI is complex and has to make lots of decisions to differentiate between multiple meanings.

**COMPUTER SCIENCE PRACTICES**

*Practice 4. Developing and Using Abstractions*

1. Extract common features from a set of interrelated processes or complex phenomena.
2. Evaluate existing technological functionalities and incorporate them into new designs.
3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
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### Artificial Intelligence

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<td>Societal Impacts</td>
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<tr>
<td>AI.SI.3.a</td>
<td>Define what is a bias to understand how it can influence humans.</td>
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#### Expectations for Learning

**LEARNING PROGRESSION**

In grade 2 students discussed if AI was good or bad. In grade 3, students define bias and begin to understand how it can influence humans. In grade 4 students will give examples of bias and how it affects decision making.

**IMPORTANT CONCEPTS**

- Define bias as it pertains to AI

**KEY SKILLS/PROCEDURES**

- Illustrate the definition of bias and its connection to AI
- Explain how AI bias influences humans

#### Content Elaborations

**CLARIFICATIONS**

Bias is human nature and can have varied consequences.

**CONTENT FOCUS**

Bias is a human trait and can relate to AI.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Grade 4

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**AI.ML.4.a** Explain 3 different machine learning approaches to choose which may be best for a given situation.

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**LEARNING PROGRESSION**

In grade 3, students were introduced to three different types of machine learning and labeled them. In grade 4, students explain three different machine learning approaches. In grade 5, students will compare the three types of machine learning.

**IMPORTANT CONCEPTS**

- Explain three different machine learning approaches (supervised learning, unsupervised learning, reinforcement learning)

**KEY SKILLS/PROCEDURES**

- List problems AI could encounter
- Decipher which machine learning would work best to discover AI limitations

**Content Elaborations**

**CLARIFICATIONS**

Machine Learning is the study of computer algorithms that improve automatically through experience. Applications range from data-mining programs that discover general rules in large data sets, to information filtering systems that automatically learn users' interests.

**CONTENT FOCUS**

There are different types of machine learning.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
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3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Expectations for Learning

#### LEARNING PROGRESSION

In grade 3, students learned about the concept of bias in machine learning. In grade 4, students explain how machine learning can create a bias. In grade 5, students will describe how an algorithm can affect machine learning and how humans can introduce bias into algorithms for machine learning.

#### IMPORTANT CONCEPTS

- Explain how machine learning can create a bias

#### KEY SKILLS/PROCEDURES

- Give examples of how computers using machine learning can create bias

### Content Elaborations

#### CLARIFICATIONS

Data sets are formed from input from sensors.

#### CONTENT FOCUS

Input in machine learning can be biased based on the identified data set.

#### COMPUTER SCIENCE PRACTICES

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
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**AI.ML.4.c** Describe tasks where AI outperforms human tasks and when it does not, to describe how humans rely on AI.

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 3, students identified tasks that use AI to perform human tasks. In grade 4, students describe tasks where AI outperforms human tasks. In grade 5, students will describe tasks where AI outperforms humans and where it does not. Then propose ways AI could perform human tasks.

**IMPORTANT CONCEPTS**

- Students discover AI and its growth and change as it improves and outperforms humans

**KEY SKILLS/PROCEDURES**

- List ways humans depend on AI for everyday tasks
- Compare and contrast tasks humans and AI each do better

**Content Elaborations**

**CLARIFICATIONS**

AI can perform tasks that humans once did. As AI grows, it can take over more human tasks like self-driving cars.

**CONTENT FOCUS**

AI is a growing field that can replicate some human tasks. AI takes a long time to develop and is not perfect.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
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## Artificial Intelligence
### Natural Interactions

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</table>

**AI.NI.4.a** Use AI systems that are designed to be inclusive and describe how they affect the humans that use them.

### Expectations for Learning

**LEARNING PROGRESSION**

In grade 3 students located AI systems to help everyone have equal access. In grade 4, students use AI systems that are designed to be inclusive and describe how they affect humans. In grade 5, students will describe ways that AI can be used for inclusivity.

**IMPORTANT CONCEPTS**
- List ways AI can be used for inclusivity and how it can affect humans

**KEY SKILLS/PROCEDURES**
- List ways humans are barred from accessing technology; physical needs, community needs, etc.
- List ways technology can help humans to explain how AI can be used for inclusivity

### Content Elaborations

**CLARIFICATIONS**

Accessible design is a design process in which the needs of people with disabilities are specifically considered. Accessibility sometimes refers to the characteristic that products, services, and facilities can be independently used by people with a variety of disabilities.

**CONTENT FOCUS**

Humans can be barred from technology for a variety of reasons. AI can help level the playing field.

**COMPUTER SCIENCE PRACTICES**

*Practice 4. Developing and Using Abstractions*

1. Extract common features from a set of interrelated processes or complex phenomena.
2. Evaluate existing technological functionalities and incorporate them into new designs.
3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
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<td>Perception</td>
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**AI.P.4.b** Give examples of computer perception to understand how it is affected by the environment.

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**LEARNING PROGRESSION**

In grade 3, students moved from intelligent agents as a form of perception to how computers perceive the world compared to humans. In grade 4, students give examples of computer perception. In grade 5, students will demonstrate the limitations of how computers interact with humans.

**IMPORTANT CONCEPTS**

- Give examples of computer perception to demonstrate how computer input can create biased output.

**KEY SKILLS/PROCEDURES**

- Gather data on a topic from the class
- Compare gathered data to a larger group to demonstrate how it can be affected by the environment

**Content Elaborations**

**CLARIFICATIONS**

Computers only know what we tell them through data input.

**CONTENT FOCUS**

Data can show a bias.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
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**AI.RR.4.a** Create a classification system using a tree structure to understand binary solutions.

### Expectations for Learning

**LEARNING PROGRESSION**

In grade 3, students created a classification system to see how computers think. In grade 4, students create a classification system using a tree structure. In grade 5, they will create a tree structure to demonstrate binary solutions.

**IMPORTANT CONCEPTS**

- Create a flowchart using binary solutions to make a decision

**KEY SKILLS/PROCEDURES**

- Use a flowchart to show the decision-making process

### Content Elaborations

**CLARIFICATIONS**

Decision trees help AI make decisions through machine learning.

**CONTENT FOCUS**

Decision trees in artificial intelligence are used to arrive at conclusions based on the data available from decisions made in the past.

**COMPUTER SCIENCE PRACTICES**

*Practice 5. Creating Computational Artifacts*

1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, taking into account key features, time and resource constraints and user expectations.
2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.
3. Modify an existing artifact to improve or customize it.
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**AI.RR.4.b** Describe how AI represents knowledge to make a reasonable answer.

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 3, students were introduced to the idea of reasonable answers with AI. In grade 4, students describe how AI represents knowledge to make a reasonable answer. In grade 5, students will describe how AI knowledge supports reasonable answers.

**IMPORTANT CONCEPTS**

- AI tries to give a reasonable answer based on the input

**KEY SKILLS/PROCEDURES**

- Create scenarios that challenge the AI to provide an unreasonable answer

**Content Elaborations**

**CLARIFICATIONS**

Students determine what qualities make an answer reasonable. Students differentiate between different data sets to find a reasonable answer.

**CONTENT FOCUS**

AI is complex and has to make lots of decisions differentiate between multiple meanings.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
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## Artificial Intelligence

### Societal Impacts

**AI.SI.4.a** Give examples of bias to demonstrate how it can affect decision making.

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<tr>
<td><strong>LEARNING PROGRESSION</strong></td>
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<tr>
<td>In grade 3, students identified bias and how it can influence humans. In grade 5, students will explore how data can be influenced by bias and how it affects AI.</td>
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<table>
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<tr>
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<td>• Bias can affect decision-making</td>
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<tr>
<th><strong>KEY SKILLS/PROCEDURES</strong></th>
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<tr>
<td>• Give examples of bias to demonstrate how affects humans and machines based on algorithms used</td>
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### Content Elaborations

<table>
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<tr>
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<tbody>
<tr>
<td>Bias is a human trait and it has consequences.</td>
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<tr>
<th><strong>CONTENT FOCUS</strong></th>
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<tr>
<td>Bias is a way humans make quick decisions and they have consequences.</td>
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**AI.ML.5.a** Compare 3 different machine learning approaches to solve a problem.

### Expectations for Learning

**LEARNING PROGRESSION**

In grade 4, students explained three types of machine learning. In grade 5, students compare three different machine learning approaches to solve a problem. In grade 6, students will contrast the unique characteristics of human learning with the ways machine learning systems operate to identify the limitations of machine learning.

**IMPORTANT CONCEPTS**

- Compare how the machine learning approaches would look for a given problem

**KEY SKILLS/PROCEDURES**

- Give problems AI encounter and which machine learning might work best to see limitations of AI

### Content Elaborations

**CLARIFICATIONS**

Machine Learning is the study of computer algorithms that improve automatically through experience. Applications range from data-mining programs that discover general rules in large data sets, to information filtering systems that automatically learn users’ interests.

**CONTENT FOCUS**

Different types of machine learning can produce different outcomes.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Expectations for Learning

**LEARNING PROGRESSION**

In grade 4, students explained how machine learning can create a bias. In grade 5, students describe how algorithms and machine learning can exhibit biases. In grade 6, students will contrast the unique characteristics of human learning with the ways machine learning systems operate to identify the limitations of machine learning.

**IMPORTANT CONCEPTS**

- Algorithms created by humans create biases in machine learning

**KEY SKILLS/PROCEDURES**

- Give examples of bias (sample bias, exclusion, bias, recall bias, observer bias, racial bias, association bias, etc.) found in machine learning to see how computers can create a bias

### Content Elaborations

**CLARIFICATIONS**

Algorithmic bias describes systematic and repeatable errors in a computer system that create unfair outcomes, such as privileging one arbitrary group of users over others.

**CONTENT FOCUS**

Humans create algorithms that machines use to learn. These algorithms can be unintentionally biased.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Artificial Intelligence

#### Machine Learning

**AI.ML.5.c** Describe tasks where AI outperforms human tasks and when it does not and propose possible ways to have AI perform more human tasks.

### Expectations for Learning

**LEARNING PROGRESSION**

In grade 4, students described tasks where AI outperforms humans’ tasks and when it does not. In grade 5, students describe tasks where AI does and does not outperform human tasks. In grade 6, students will individually and collaboratively compare language processing algorithms to solve a problem based on given criteria.

**IMPORTANT CONCEPTS**

- List tasks AI perform that are better or worse than the performance of a human

**KEY SKILLS/PROCEDURES**

- Research a specific type of AI and follow its history; for example, self-driving cars
- List the pros and cons of that AI to show how it can outperform human tasks

### Content Elaborations

**CLARIFICATIONS**

AI can perform tasks that humans once did. As AI grows, it can take over more human tasks like driving cars.

**CONTENT FOCUS**

AI takes time to develop and as it improves it can take over more human tasks like driving.

**COMPUTER SCIENCE PRACTICES**

**Practice 3. Recognizing and Defining Computational Problems**

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
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<td>Natural Interactions</td>
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<tr>
<td><strong>AI.NI.5.a</strong></td>
<td>Describe ways that AI systems can be designed for inclusivity to support inclusivity in AI.</td>
</tr>
</tbody>
</table>

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 4, students used AI systems designed to be inclusive and learned how it affects the humans that use it. In grade 5, students describe ways that AI systems can be designed for inclusivity. In grade 6, students will illustrate the structure of a neural network to describe how its parts form a set of functions that compute an output.

**IMPORTANT CONCEPTS**

- Research design processes
- Explain why AI is designed for inclusivity

**KEY SKILLS/PROCEDURES**

- Use the design process to create an inclusive software or hardware prototype to model how humans research to create inclusive design

**Content Elaborations**

**CLARIFICATIONS**

AI has to be designed with the end-user in mind, including those with special needs.

**CONTENT FOCUS**

AI can assist in helping everyone to be included.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Expectations for Learning

**LEARNING PROGRESSION**

In grade 4, students described the differences between analog and digital sensors. In grade 5, students describe how sensor inputs are converted as analog or digital signals. In grade 6, students will give examples of computer perception that can extract meaning and how humans combine information from multiple modalities to understand how computers use sensors.

**IMPORTANT CONCEPTS**

- Describe the uses of different sensors (analog and digital)

**KEY SKILLS/PROCEDURES**

- Identity that computers take the input from sensors in different ways to describe how that input can be used

### Content Elaborations

**CLARIFICATIONS**

Recognize various uses of analog and digital sensors.

**CONTENT FOCUS**

The focus is on the two basic ways sensors gather data and the uses of different sensors.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
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**AI.P.5.b** Demonstrate a limitation of computer perception to understand how computers interact with humans.

**Expectations for Learning**

**LEARNING PROGRESSION**

In grade 4, students gave examples of how computer perception is affected by the environment. In grade 5, students demonstrate a limitation of computer perception to understand how computers interact with humans. In grade 6, students will give examples of computer perception that can extract meaning and how humans combine information from multiple modalities.

**IMPORTANT CONCEPTS**

- List the limitations of current computer perception

**KEY SKILLS/PROCEDURES**

- Demonstrate the limitations of computer perception through use of data to show that limited data can affect how humans and computers interact

**Content Elaborations**

**CLARIFICATIONS**

Computers only know what we tell them through data input.

**CONTENT FOCUS**

Data can show a bias.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
### Expectations for Learning

#### LEARNING PROGRESSION

In grade 4, students created a classification system to understand binary solutions. In grade 5, students create a classification system using a tree structure to demonstrate binary solutions. In grade 6, students will illustrate how a computer can solve a maze, route on a map or reason about concepts in a knowledge graph by drawing a search tree.

#### IMPORTANT CONCEPTS
- Creating decision trees with binary choices

#### KEY SKILLS/PROCEDURES
- Use a flowchart to show the decision making process

### Content Elaborations

#### CLARIFICATIONS

Decision trees help AI make decisions through machine learning. For more information, see quantum computing.

#### CONTENT FOCUS

Decision trees in artificial intelligence are used to arrive at conclusions based on the data available from decisions made in the past.

#### COMPUTER SCIENCE PRACTICES

*Practice 5. Creating Computational Artifacts*

1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, taking into account key features, time and resource constraints, and user expectations.
2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.
3. Modify an existing artifact to improve or customize it.
## Expectations for Learning

### LEARNING PROGRESSION

In grade 4, students were describing how AI knowledge is used to make a reasonable answer. In grade 5, students describe how AI representations support reasoning to answer questions. In grade 6, students will illustrate how a computer can solve a maze, route on a map or reason about concepts in a knowledge graph by drawing a search tree.

### IMPORTANT CONCEPTS

- AI tries to give a reasonable answer based on the input

### KEY SKILLS/PROCEDURES

- Create a data set that would have AI bring back a reasonable answer

### Content Elaborations

### CLARIFICATIONS

Train an AI to give a reasonable answer.

### CONTENT FOCUS

AI is complex and has to make lots of decisions differentiate between multiple meanings.

### COMPUTER SCIENCE PRACTICES

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
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**LEARNING PROGRESSION**

In grade 4, students gave examples of bias and how it affects decision-making. In grade 5, students will explore how data is influenced by bias. In grade 6, students will identify and explain how humans have agency in curating training datasets to identify bias in machine learning.

**IMPORTANT CONCEPTS**

- Data input for AI and how it creates bias

**KEY SKILLS/PROCEDURES**

- Explore the various types of bias based on data sets
- Give examples of bias (sample bias, exclusion, bias, recall bias, observer bias, racial bias or association bias) found in machine learning

**Content Elaborations**

**CLARIFICATIONS**

The type of bias can affect the outcome of AI. For example, advertising based on Big Data, streaming services and social media.

**CONTENT FOCUS**

Bias in data input can have negative consequences.

**COMPUTER SCIENCE PRACTICES**

*Practice 3. Recognizing and Defining Computational Problems*

1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
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