Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

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.

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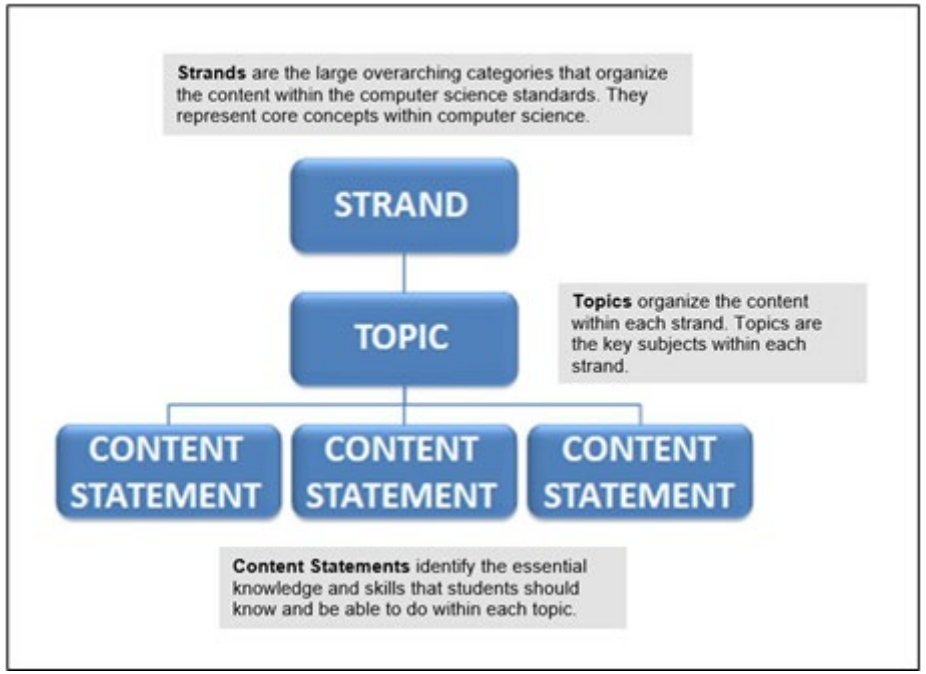
Overview of the Computer Science Standards Framework

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

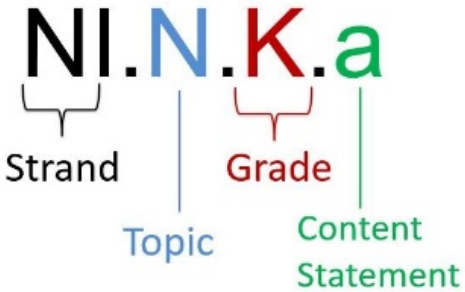


Kindergarten through Grade 8-Content statements are organized *by grade level*. Below is an example of a content statement for kindergarten and its corresponding content statement code. This content statement addresses the topic of *Devices* within the *Computing Systems* strand.

COMPUTING SYSTEMS

Devices

CS.D.K.a With guidance, identify and label commonly used devices and their components, explaining their connection to different tasks, to perform a variety of tasks.



Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Grade 6

Strand	Artificial Intelligence
Topic	**Machine Learning**
AI.NI.6.a Individually and collaboratively compare language processing algorithms to solve a problem, based on a given criteria (e.g., time, resource, accessibility).	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students described ways that Artificial Intelligence (AI) systems), or the science and engineering of making intelligent machines and computer programs, can be designed for inclusivity to support inclusivity in AI. In Grade 7, students will model how unsupervised learning finds patterns in unlabeled data to identify how machine learning takes place. **IMPORTANT CONCEPTS** • Explain how people learn how to do something • Discuss how people learning is a process unique and different than how a machine may learn • Explain how machines learn information • Explain and discuss whether humans can learn things that machines cannot and why **KEY SKILLS/PROCEDURES** • Students will be able to analyze their own learning processes (metacognition) and compare and contrast how a machine learns information. • Students will be able to identify the limitations of machine learning and explain why those limitations exist. **Content Elaborations** **CLARIFICATIONS** Metacognition is the awareness and understanding of one's thought processes. **CONTENT FOCUS** Human learning is complex and impacted by a variety of factors including social, environmental and emotional factors. Machine learning does not happen the same way human learning occurs; therefore, there are limitations to what a machine can learn as it does not share the same experiences as humans.

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Strand	Artificial Intelligence
Topic	**Machine Learning**
	COMPUTER SCIENCE PRACTICES *Practice 3.* Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Artificial Intelligence
Topic	**Machine Learning**
AI.NI.6.b Identify and describe how computers mimic human behavior to better serve humans.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students modeled how unsupervised learning finds patterns in unlabeled data to identify how machine learning takes place. In high school, students will explain at least one way that bias can enter machine learning system and explain how that bias impacts people. **IMPORTANT CONCEPTS** • Explain the process of training in machine learning • Discuss using a reason model in machine learning • Compare the differences between the process of training in machine learning • When would you use training and when would you use a reasoning model using a reason model in machine learning **KEY SKILLS/PROCEDURES** • Students will be able to define training in terms of machine learning • Students will be able to define what a reasoning model is • Students will be able to explain the difference is between training and using a reasoning model **Content Elaborations** **CLARIFICATIONS** Training: the process of providing a machine learning algorithm with training data to learn from and create a machine learning model; reasoning model: also known as machine reasoning, generate conclusions from available knowledge by using logical techniques like deduction and induction.

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Strand	Artificial Intelligence
Topic	**Machine Learning**
	CONTENT FOCUS Training is the process of creating a machine learning model by using a machine learning algorithm on a dataset that will give the desired result. Reasoning models use logic like deduction and induction to determine an action to a set of data based on what knowledge the machine has available. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Artificial Intelligence
Topic	**Natural Interactions**
AI.NI.6.a Individually and collaboratively compare language processing algorithms to solve a problem, based on a given criteria including time, resource, accessibility.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students described ways that AI systems can be designed for inclusivity to support inclusivity in AI. In Grade 7, students will curate a dataset to train a language processing algorithm to create a program that incorporates voice commands. **IMPORTANT CONCEPTS** • Define and discuss language processing algorithm • Discuss different kinds of language processing algorithms and their uses • Explain how a given language processing algorithm solves a problem with a set of given criteria **KEY SKILLS/PROCEDURES** • Students will be able to identify and describe language processing algorithms and their applications • Students will be able to determine a language processing algorithm for a given set of criteria and support their argument for its use

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Strand	Artificial Intelligence
Topic	**Natural Interactions**
	Content Elaborations **CLARIFICATIONS** Language processing algorithm: computers analyze, understand and derive meaning from human language in a smart and useful way; Examples of language processing algorithms: • Lemmatization and Stemming • Keyword Extraction • Topic Modeling • Knowledge graphs • Named Entity Recognition • Words Cloud • Machine Translation • Dialogue and Conversations • Sentiment Analysis • Text Summarization • Aspect Mining • Topic Modeling • Bag of Words • Tokenization • Stop words removal **CONTENT FOCUS** Language processing algorithms have different applications depending on the given problem or dataset. Machine learning programs used language processing algorithms to understand human language. **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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Strand	Artificial Intelligence
Topic	**Natural Interactions**
AI.NI.6.b Identify and describe how computers mimic human behavior to better serve humans.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students described ways that AI systems can be designed for inclusivity to support inclusivity in AI. In Grade 7, students will identify the components of a chatbot and explain how each component contributes to the chatbot's human-like responses. **IMPORTANT CONCEPTS** • Discuss ways computers mimic human behavior • Discuss why computers mimic human behavior • Research and discuss things computers are not yet able to mimic in human behavior • Assess things computers will not be able to do that humans can **KEY SKILLS/PROCEDURES** • Students will be able to identify how computers mimic human behavior and describe why they are programmed to do so • Students will be able to describe the ways computers mimic human behavior and what the purpose is of those particular actions • Students will be able to explain why it is beneficial for computers to mimic human behavior **Content Elaborations** **CLARIFICATIONS** Artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind. **CONTENT FOCUS** Artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind with the goal to have programs that can solve problems faster and better than a human mind is capable of doing.

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Strand	Artificial Intelligence
Topic	**Natural Interactions**
	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.

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.6.a Give examples of different types of computer perception that can extract meaning from sensory signals to understand how computers collect information from sensors.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students learned about how sensors inputs are converted as analog or digital signals to describe their uses. In Grade 7, students will learn how intelligent agents combine information from multiple sensors **IMPORTANT CONCEPTS** • Compare the ways computers perceive the world around them • Categorize and describe sensors that work with computers • Explainthethe types of data that is collected from sensors and used by computers **KEY SKILLS/PROCEDURES** • Students will be able to identify a sensor • Students will be able to describe the data a sensor collects • Students will be able to identify how computers perceive the world **Content Elaborations** **CLARIFICATIONS** Computer perception is a system for computers to understand the world. Signals come from sensors such as thermometers, accelerometers and cameras.

Strand	Artificial Intelligence
Topic	**Perception**
	CONTENT FOCUS How computers perceive the world through 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.6.b Give examples of how humans combine information from multiple modalities to understand how computers use sensors to collect data.	**Expectations for Learning** **LEARNING PROGRESSION** In earlier grades, students learned about the various types of sensors and their applications. In Grade 7, students will learn how intelligent agents combine information from multiple sensors. **IMPORTANT CONCEPTS** • Discuss and explain how computers and humans capture information • Explain how data from multiple sources combine to create a more complete dataset **KEY SKILLS/PROCEDURES** • Students will be able to describe how the human body uses its senses together in comparison to a computer using sensors **Content Elaborations** **CLARIFICATIONS** Modalities are one of the main avenues of sensation.

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Strand	Artificial Intelligence
Topic	**Perception**
	CONTENT FOCUS How are computers and humans alike in how they perceive the world? **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.

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.6.c Give examples of different types of computer perception that can extract meaning from sensory signals to show the connection between sensors and computer perception.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students learned about how sensors inputs are converted as analog or digital signals to describe their uses. In Grade 7, students will learn how edge detectors can be composed to form more complex feature detectors. **IMPORTANT CONCEPTS** • Explain how computers perceive the world around them • Explain how computers use sensors • Describe the types of data that are collected from sensors and used by computers **KEY SKILLS/PROCEDURES** • Students will be able to identify different types of computer perception • Students will be able to identify how computer perception can extract meaning from sensory signals • Students will be able to show the connection between sensors and computer perception

	Content Elaborations **CLARIFICATIONS** Computer perception is the ability of a computer to perceive data in a way similar to humans. **CONTENT FOCUS** How do sensors work with computers to perceive the world? **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.6.d Classify a given image (e.g., "traffic scene", "nature scene", "social gathering", etc.) and then describe the kinds of knowledge a computer would need in order to understand scenes of this type to utilize the image in an algorithm.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students learned about how sensors inputs are converted as analog or digital signals to describe their uses. In Grade 7, students will learn how to illustrate the concept of feature extraction from images by simulating an edge detector. **IMPORTANT CONCEPTS** • Explain the kind of information does a computer need to classify an image • Describe what kinds of information may not be in the image that would be important for utilizing it in an algorithm • Distinguish how to ensure a computer has enough information to classify an image **KEY SKILLS/PROCEDURES** • Students will be able to explain what image classification is in terms of artificial intelligence and computers • Students will be able to describe the information a computer needs to classify an image • Students will be able to explain how computers use image classification in an algorithm

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Strand	Artificial Intelligence
Topic	**Perception**
	Content Elaborations **CLARIFICATIONS** Image classification is the process of categorizing and labeling groups of pixels or vectors within an image based on specific rules. An algorithm is a process or set of rules to be followed in calculations or other problem-solving operations. **CONTENT FOCUS** Identify the information a computer needs to classify an image for use in an algorithm. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Artificial Intelligence
Topic	**Representation & Reasoning**
AI.RR.6.a Illustrate how a computer can solve a maze, find a route on a map or reason about concepts in a knowledge graph by drawing a search tree.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students described how AI representations support reasoning to answer questions. In 7th grade, students will compare several algorithms that could be used to solve a specific type of reasoning problem. **IMPORTANT CONCEPTS** • Explain how a search tree guides a person through the process of doing an activity • Describe how a computer might use a search tree to solve a problem or complete a task **KEY SKILLS/PROCEDURES** • Students will be able to create a search tree that will create a series of directions or instructions to navigate a maze, map or concept to see the connection between search trees and algorithms • Students will be able to explain how their search tree functions to follow the series of directions and complete the process

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Strand	Artificial Intelligence
Topic	**Representation & Reasoning**
	Content Elaborations **CLARIFICATIONS** A tree is a non-linear data structure organized hierarchically through a collection of nodes. **CONTENT FOCUS** Describe the process a search tree works in a computer program to locate information and complete a task. **COMPUTER SCIENCE PRACTICES** *Practice 5.* Creating Computational Artifacts 2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.

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Strand	Artificial Intelligence
Topic	**Societal Impacts**
AI.SI.6.a Identify and explain how humans have agency in curating training datasets to identify bias in machine learning.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students explored how data is influenced by bias and how it affects decision-making to defend arguments in AI. In Grade 7, students will identify and explain the effect training data has on the accuracy of an artificial intelligence system to uncover bias in training data. **IMPORTANT CONCEPTS** • Explain what it means to have agency in creating something • Explain the purpose and process of curating a dataset • Define bias and how it might show up in machine learning • List how to avoid bias in machine learning **KEY SKILLS/PROCEDURES** • Students will be able to identify ways datasets can contain bias in machine learning by analyzing a dataset for bias • Students will be able to explain how humans have agency in curating training datasets to ensure bias is not present in machine learning programs • Students will be able to explain how bias impacts machine learning **Content Elaborations** **CLARIFICATIONS** Bias in machine learning is a phenomenon that skews the result of an algorithm in favor or against an idea. **CONTENT FOCUS** Humans have biases and those biases may be present in datasets since they are created and curated by humans. This can cause a machine learning program to exhibit bias in its responses. Bias can include sample bias, exclusion bias, measurement bias, recall bias, observer bias, racial bias and association bias. There are strategies for avoiding bias in datasets, such as knowing your users, having a diverse development team, pulling data from multiple sources and testing for bias.

Strand	Artificial Intelligence
Topic	Societal Impacts
	COMPUTER SCIENCE PRACTICES *Practice 3.* Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Artificial Intelligence
Topic	Societal Impacts
AI.SI.6.b Identify and explain how algorithmic bias impacts artificial intelligence systems to prevent bias in future datasets.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 5, students explored how data is influenced by bias and how it affects decision-making to defend arguments in AI. In Grade 7, students will identify and explain the problems of classification in the supervised artificial intelligence context to create data sets that are inclusive and accurate. **IMPORTANT CONCEPTS** • Explain how algorithmic bias can impact artificial intelligence systems • Explain the process of identifying bias in algorithms to help prevent bias in future datasets **KEY SKILLS/PROCEDURES** • Students will be able to identify and explain algorithmic bias • Students will be able to identify and explain how algorithmic bias impacts AI systems • Students will be able to explain how to prevent bias in future datasets by identifying bias in algorithms **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. This occurs when an algorithm produces results that are systemically prejudiced due to erroneous assumptions in the machine learning process.

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Strand	Artificial Intelligence
Topic	**Societal Impacts**
	CONTENT FOCUS Strategies for overcoming algorithmic bias include narrowing datasets to be more specific to the problem. Structure data to represent different opinions. Know where data is coming from and understand it. Consider the end-user as you are developing a program. Seek feedback from a diverse pool of people and use the feedback to improve the algorithm. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.

Grade 7

Strand	Artificial Intelligence
Topic	**Machine Learning**
AI.NI.7.a Curate a dataset to train a language processing algorithm to create a program that incorporates voice commands.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students contrasted the unique characteristics of human learning with the ways machine learning systems operate to identify the limitations of machine learning. In Grade 8, students will train a classification or prediction model using machine learning on a tabular dataset to evaluate the quality of the dataset. **IMPORTANT CONCEPTS** • Explain how unsupervised learning find a pattern in unlabeled data • Describe how machine learning uses unsupervised learning of unlabeled data **KEY SKILLS/PROCEDURES** • Students will be able to explain what unsupervised learning is and how it works in machine learning. • Students will be able to explain the difference between labeled and unlabeled data • Students will be able to create a model of how machine learning takes place through unsupervised learning • Students will be able to identify how the unlabeled data is identified by the unsupervised learning program **Content Elaborations** **CLARIFICATIONS** unsupervised learning - kind of machine learning where a model must look for patterns in a dataset with no labels and with minimal human supervision; labeled data: data is marked up, or annotated, to show the target, that a machine learning model should predict; unlabeled data: data that have not been tagged with labels identifying characteristics, properties or classifications. **CONTENT FOCUS** Depending on the model of learning that is utilized to train a machine, the model will do different things with the data it is given, especially if the data is unlabeled. Unsupervised learning models identify patterns in unlabeled data sets, creating new information based on the patterns it finds in the dataset.

Strand	Artificial Intelligence
Topic	**Machine Learning**
	COMPUTER SCIENCE PRACTICES *Practice 3.* Recognizing and Defining Computational Problems 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intelligence
Topic	**Natural Interactions**
AI.NI.7.a Curate a dataset to train a language processing algorithm to create a program that incorporates voice commands.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students individually and collaboratively compared language processing algorithms to solve a problem based on a given criteria. In Grade 8, students will create a program, individually and collaboratively, that implements a language processing algorithm to create a functioning chatbot. **IMPORTANT CONCEPTS** • Describe a situation in which voice commands would be used • Determine what voice commands a program should be able to understand and the reasons for the chosen commands • Explain the process of making language processing algorithms more accurate • Explain where datasets for language processing algorithms come from **KEY SKILLS/PROCEDURES** • Students will be able to identify applications of voice commands to determine what algorithm will work best for a given set of data • Students will be able to develop a dataset to train a language processing program • Students will be able to train a language processing algorithm to recognize a dataset of voice commands to complete a task or problem **Content Elaborations** **CLARIFICATIONS** Voice command is a conversational AI tool that uses voice commands to receive and interpret directives.

Strand	Artificial Intelligence
Topic	**Natural Interactions**
	CONTENT FOCUS For a language processing algorithm to function accurately, it needs to be trained on a set of data that will give the desired outcome to the user. Datasets need to be as thorough as possible to ensure accuracy, so more data will yield better results for the language processing algorithm in practice. **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.

Strand	Artificial Intelligence
Topic	**Natural Interactions**
AI.NI.7.b Identify the components of a chatbot and explain how each component contributes to the chatbot's human-like responses.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students identified and described how computers mimic human behavior to better serve humans. In Grade 8, students will critically analyze and discuss features that make an entity "intelligent" including discussing differences between human, animal, and machine intelligence to identify how machine intelligence varies from natural intelligence. **IMPORTANT CONCEPTS** • List the components of a chatbot • Explain the function of each component of a chatbot • Explain how chatbot components function together to create a human-like response **KEY SKILLS/PROCEDURES** • Students will be able to identify and describe the components of a chatbot and how they function independently and collaboratively to mimic human behavior

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Strand	Artificial Intelligence
Topic	**Natural Interactions**
	Content Elaborations **CLARIFICATIONS** Chatbot components (not exhaustive): question and answer system; environment (natural language processing); front-end systems (the part the users see and use); traffic servers (determines where information should go, ex. response goes to front-end system); custom integrations (how it works with other programs like calendars, placing orders, taking payments, etc.) **CONTENT FOCUS** Chatbots have a core set of components that are required for them to function and respond in a human-like manner. Some chatbots have additional components that make their responses more human-like and add layers of problem-solving to the response. **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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Strand	Artificial Intelligence
Topic	**Perception**
AI.P.7.a Give examples of how intelligent agents combine information from multiple sensors to react to an input.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students learned about the different types of computer perception and how it can extract meaning from sensory signals and how humans combine information from multiple modalities. In Grade 8, students will explain how sounds and images are represented digitally on a computer. **IMPORTANT CONCEPTS** • Describe the types of information an intelligent agent gathers from its sensors • Explain the process of putting sensory data together to help the intelligent agent • Describe the types of input an intelligent agent would react to **KEY SKILLS/PROCEDURES** • Students will be able to identify different types of sensory data and how it combines • Students will be able to identify how intelligent agents use sensory data • Students will be able to explain how an input starts a reaction with an intelligent agent **Content Elaborations** **CLARIFICATIONS** Intelligent agents are anything that perceives its environment and can take action on an input. It may react to sensory input and learn from it over time to improve reactions. **CONTENT FOCUS** Students study how combining sensory data helps an intelligent agent react to an input. **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.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.7.b Describe how edge detectors can be composed to form more complex feature detectors, e.g., for letters or shapes.	**Expectations for Learning** **LEARNING PROGRESSION** In lower grades, students will illustrate how the outlines of partially occluded objects in an image differ from the real shapes of objects. In grade 7, students will describe how edge detectors can be composed to form more complex feature detectors. In high school, students will demonstrate how perceptual reasoning at a higher level of abstraction draws upon earlier, lower levels of abstraction. **IMPORTANT CONCEPTS** • Describe how edge detectors can be used to form letters • Describe how edge detectors can be used to form shapes • Explore more complex feature detectors **KEY SKILLS/PROCEDURES** • Students will be able to identify edge detectors and their uses • Students will be able to identify the functions of edge detectors **Content Elaborations** **CLARIFICATIONS** The progression from signal to meaning takes place in stages, with increasingly complex features extracted at each stage. **CONTENT FOCUS** Students can try detecting an "A" by looking for a combination of three oriented edges. Edges are detected by looking at pixels. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.

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Strand	Artificial Intelligence
Topic	**Perception**
AI.P.7.c Illustrate the concept of feature extraction from images by simulating an edge detector.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students learned how to classify an image and describe the kind of knowledge a computer would need to understand scenes. In Grade 8, students will illustrate how sequences of words can be recognized as phrases by looking at how the words fit together. **IMPORTANT CONCEPTS** • Explain situations that vision would be required to solve a problem • Describe the function of an edge detector and explain how it works • Explain how an edge detection can help with feature extraction from an image **KEY SKILLS/PROCEDURES** • Students will be able to simulate an edge detector through online or offline activities utilizing pixels and grids • Students will be able to explain how an edge detector aids in feature extraction from images and create a visualization of the process **Content Elaborations** **CLARIFICATIONS** Feature extraction is a transformation of input data into a set of features. Edge detection is the process of determining which pixels are the edge pixels **CONTENT FOCUS** Students explore how a program determines where the edges of a feature in an image are located and how it is used to extract features. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Representation & Reasoning**
AI.RR.7.a Compare several algorithms that could be used to solve a specific type of reasoning problem	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students illustrated how a computer can solve a maze, find a route on a map, or reason about concepts in a knowledge graph by drawing a search tree. In Grade 8, students modeled the process of solving a graph search problem using breadth-first search to draw a search tree. **IMPORTANT CONCEPTS** • Describe and explain algorithms students encounter daily and the problems the algorithm solving **KEY SKILLS/PROCEDURES** • Students will be able to identify types of algorithms by name and describe what each one does and give and example of how it used • Students will be able to select one or more algorithms to solve a specific type of reason problem and explain why the chosen algorithms would solve that problem **Content Elaborations** **CLARIFICATIONS** Types of algorithms (not exhaustive): • Brute Force Algorithm • Recursive Algorithm • Dynamic Programming Algorithm • Divide and Conquer Algorithm • Greedy Algorithm • Backtracking Algorithm • Randomized Algorithm **CONTENT FOCUS** Algorithms are used to solve problems and specific ones work better than others as solutions.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Representation & Reasoning**
	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.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Societal Impacts**
AI.SI.7.a Identify and explain the effect training data has on the accuracy of an artificial intelligence system to uncover bias in training data.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students identified and explained how humans have agency in curating training datasets to identify bias in machine learning. In Grade 8, students will identify and explain how the composition of training data affects the outcome of supervised artificial intelligence system to identify bias in future datasets. **IMPORTANT CONCEPTS** • Describe the effects of training data on the accuracy of an AI system • Discuss how the effects of training data might be used to determine if an AI system is biased/accurate **KEY SKILLS/PROCEDURES** • Students will be able to identify and explain the effect of training data on an AI system • Students will be able to explain how the effect of training data on an AI system can help uncover bias in the training data • Students will be able to come up with strategies to create a more accurate and bias-free dataset **Content Elaborations** **CLARIFICATIONS** Bias (in machine learning) is the phenomenon that skews the result of an algorithm in favor or against an idea. **CONTENT FOCUS** Humans have biases and those biases may be present in datasets since they are created and curated by humans. This can cause a machine learning program to exhibit bias in its responses. Bias can include sample bias, exclusion bias, measurement bias, recall bias, observer bias, racial bias, association bias. There are strategies for avoiding bias in datasets, such as knowing your users, having a diverse development team, pulling data from multiple sources, and testing for 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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Strand	Artificial Intelligence
Topic	**Societal Impacts**
AI.SI.7.b Identify and explain the problems of classification in the supervised artificial intelligence context to create data sets that are inclusive and accurate.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 6, students identified and explained how algorithmic bias impacts artificial intelligence systems to prevent bias in future datasets. In Grade 8, students will identify bias potential in the design of artificial intelligence systems and describe how to utilize inclusive AI design to prevent algorithmic bias. **IMPORTANT CONCEPTS** • Explain how classification in a dataset can create problems in supervised AI systems • Explain how datasets can be developed that are inclusive and accurate by improving classification **KEY SKILLS/PROCEDURES** • Students will be able to explain how classification works in a dataset and how it is used in a supervised AI system • Students will be able to develop strategies for creating inclusive and accurate datasets using classification **Content Elaborations** **CLARIFICATIONS** Classification means to identify shared characteristics of certain classes in a dataset. **CONTENT FOCUS** Classification of datasets can create algorithmic bias if the data is not complete, balanced, selected, or labeled appropriately. Ensuring that classes represent as many possible data points as possible is one means of creating a more inclusive and accurate dataset to mitigate algorithmic bias in AI. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.

Grade 8

Strand	Artificial Intelligence
Topic	**Machine Learning**
AI.NI.8.a Create a program, individually and collaboratively, that implements a language processing algorithm to create a functional chatbot.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students modeled how unsupervised learning finds patterns in unlabeled data to identify how machine learning takes place. In high school, students will explain at least one way that bias can enter the machine learning system and explain how that bias impacts people. **IMPORTANT CONCEPTS** • Explain the difference between a classification and a prediction model • Compare how the same tabular dataset creates different results when run through a classification model vs. a prediction model • Interpret the quality of the dataset once the model has been run and explain what qualities should be present • Describe strategies for improving datasets **KEY SKILLS/PROCEDURES** • Students will be able to explain the difference between a classification and prediction model and the reasons for using one versus the other in machine learning • Students will be able to identify the quality of their dataset based on the outcome of running their chosen model • Students will be able to train a classification model or prediction model using a tabular dataset **Content Elaborations** **CLARIFICATIONS** A classification model is a process of finding a good model that describes the data classes or concepts. The purpose of classification is to predict the class of objects whose class label is unknown. A prediction model identifies or predicts the missing or unavailable data for a new observation based on the previous data and future assumptions. In prediction, the output is a continuous value. A tabular dataset is a collection of rows and columns.

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Strand	Artificial Intelligence
Topic	**Machine Learning**
	CONTENT FOCUS Machine learning models have specific applications based on what the desired outcome is of a given dataset. Classification models sort a data set into groups of similar data (ex. grouping students by interest in specific sports) vs. Prediction models create a prediction based on previous data to take a new dataset and predict where it will go or do (ex. predicting a student's lunch order based on their previous orders.) **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.

Strand	Artificial Intelligence
Topic	**Natural Interactions**
AI.NI.8.b Critically analyze and discuss features that make an entity "intelligent", including discussing differences between human, animal, and machine intelligence to identify how machine intelligence varies from natural intelligence.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students identified the components of a chatbot and explain how each component contributes to the chatbot's human-like responses. In high school, students will describe how artificial intelligence drives many software and physical systems. **IMPORTANT CONCEPTS** • Compare human, animal, and machine intelligence • Explain what it means for something to be intelligent • List the ways to determine intelligence • Discuss ways to improve the intelligence of machine learning/AI **KEY SKILLS/PROCEDURES** • Students will be able to analyze natural vs. machine intelligence and explain the differences and commonalities of the two • Students will be able to identify and describe elements of intelligence in humans, animals and machines to better understand how machines learn

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Strand	Artificial Intelligence
Topic	Natural Interactions
	Content Elaborations **CLARIFICATIONS** Natural intelligence is the ability of a living being to think, gain from various expressions, comprehend complex ideas, solve numerical issues, adapt to new situations, use knowledge to manipulate one's environment and speak with fellow living beings. **CONTENT FOCUS** Machine intelligence is limited to the information given to it. It cannot learn and grow from mistakes or the past. It takes longer to adjust to new information than natural intelligence. Machines are faster than human brains and machines are not able to mimic social and emotional behaviors on their own. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.

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Strand	Artificial Intelligence
Topic	**Perception**
AI.P.8.a Explain how sounds and images are represented digitally in a computer to explain how sensor data is stored in a computer.	**Expectations for Learning** **LEARNING PROGRESSION** In grade 7, students explain how images are represented digitally by computer. In grade 8, students explain how sounds and images are represented digitally in a computer. In high school, students explain how radar, lidar, GPS and accelerometer data are represented. **IMPORTANT CONCEPTS** • Computers perceive the world using sensors • Perception is the extraction of meaning from sensory information using knowledge • Sounds and images can be represented digitally **KEY SKILLS/PROCEDURES** • Explain how sounds are represented digitally in a computer • Explain how images are represented digitally in a computer • Understand how sensor data is stored in a computer **Content Elaborations** **CLARIFICATIONS** Sounds are digitally encoded by sampling the waveform at discrete points (typically several thousand samples per second), yielding a series of numbers. **CONTENT FOCUS** The transformation from signal to meaning takes place in stages, with increasingly abstract features and higher-level knowledge applied at each stage. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.8.b Describe how a vision system might exhibit cultural bias if it lacked knowledge of objects not found in the culture of the people who created it to create inclusive and equitable data sets.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students learned how edge detects can be composed to form more complex feature detectors. In high school, students will learn what AI can do that humans and more traditional programs cannot. **IMPORTANT CONCEPTS** • Define cultural bias • Discuss cultural bias as it applies to vision systems • Distinguish ways to overcome cultural bias in vision systems • Analyze how to make a vision set more inclusive and equitable **KEY SKILLS/PROCEDURES** • Students will be able to analyze vision systems to understand how the dataset for the system might exhibit cultural bias • Students will be able to explain ideas for creating more equitable and inclusive vision programs and why they are important **Content Elaborations** **CLARIFICATIONS** Cultural bias is the interpretation of situations, actions, or data based on the standards of one's own culture. A vision system allows a computing device to inspect, evaluate, and identify still or moving images. Domain knowledge must take multiple cultures into account if an AI application is to serve diverse groups. **CONTENT FOCUS** How does cultural bias impact the accuracy of vision systems? A self-driving car that only knows about American traffic signs will not be able to recognize traffic signs in Europe or Asia. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Perception**
AI.P.8.c Illustrate how sequences of words can be recognized as phrases, even if some of the words are unclear, by looking at how the words fit together to create a text recognition program.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students learned how to illustrate the concept of feature extraction from images by simulating an edge detector. In high school, students will learn what AI can do that humans and traditional programs cannot. **IMPORTANT CONCEPTS** • Recognize how the meaning of a word can change when it is used in a sentence • Explain how the meaning of a word can be determined by its context • Draw conclusions about how text recognition programs misinterpret an input because of the words it is given **KEY SKILLS/PROCEDURES** • Students will be able to identify how words fit together into phrases and the impact of the phrase on the meaning of the words within it • Students will be able to create a series of phrases to work accurately within a text recognition program **Content Elaborations** **CLARIFICATIONS** Text recognition programs are also known as optical character recognition (OCR) and are used to detect text in images and scanned documents. **CONTENT FOCUS** Student should be aware of how the meaning of a word changes when used in a phrase and how that will impact text recognition. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

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Strand	Artificial Intelligence
Topic	**Representation & Reasoning**
AI.RR.8.a Model the process of solving a graph search problem using breadth-first search to draw a search tree	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students compared several algorithms that could be used to solve a specific type of reasoning problem. In high school, students will assess the impact of data on algorithmic outcomes. **IMPORTANT CONCEPTS** • Explain what a breadth-first search is and summarize when it is used • Relate how a breadth-first search is visualized in a search tree **KEY SKILLS/PROCEDURES** • Students will be able to explain set theory and graph theory specifically how information can be organized into a set, node, and an edge (ex. Set: internet, node: computers, edge: routers) • Students will be able to create a search tree that can be searched using breadth-search first **Content Elaborations** **CLARIFICATIONS** A graph (in computer science) is a non-linear data structure, that consists of nodes and edges, visualizes relationships between objects; breadth-first search. An algorithm or method of graph traversal that considers a given node as the parent and connected nodes as children. A breadth-first search visits the sibling vertices before the child vertices. **CONTENT FOCUS** Graph theory shows the relationship between objects and set theory consists of sets of well-defined objects. Breadth search first allows a search of each node of a graph by moving through "children" of a node to "siblings" before moving on to the next "child" and repeating until the whole graph is searched. **COMPUTER SCIENCE PRACTICES** *Practice 4.* Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

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Strand	Artificial Intelligence
Topic	**Societal Impacts**
AI.SI.8.a Identify and explain how the composition of training data affects the outcome of a supervised artificial intelligence system to identify bias in data sets.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students identified and explained the effect training data has on the accuracy of an artificial intelligence system to uncover bias in training data. In high schools, students will identify, research and analyze current events in the field of artificial intelligence, considering new technology developments, social and ethical impact and future implications. **IMPORTANT CONCEPTS** • Analyze how the composition of training data affects the outcome of a supervised AI system • Determine how bias can be identified in a training data set **KEY SKILLS/PROCEDURES** • Students will be able to identify how the composition of training data affects the outcome of a supervised AI system and explain how this can be used to identify bias in data sets **Content Elaborations** **CLARIFICATIONS** Bias (in machine learning) is a phenomenon that skews the result of an algorithm in favor or against an idea. A supervised artificial intelligence system is a computer algorithm trained on input data that has been labeled for a particular output. **CONTENT FOCUS** Supervised AI are trained on a set of data that will give a desired result when run. Datasets with bias will cause the AI system to be biased, as the training data impacts how it responds to datasets given to it in the future. There are strategies for overcoming bias in datasets. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Computer Science Model Curriculum: Artificial Intelligence, Grade 6-8 DRAFT

Strand	Artificial Intelligence
Topic	**Societal Impacts**
AI.SI.8.b Identify bias potential in the design of artificial intelligence systems and describe how to utilize inclusive AI design to prevent algorithmic bias.	**Expectations for Learning** **LEARNING PROGRESSION** In Grade 7, students identified and explained the problems of classification in the supervised artificial intelligence context to create data sets that are inclusive and accurate. In high school, students will analyze the impact new artificial intelligence developments have or will have on its intended users and society at large. **IMPORTANT CONCEPTS** • Explain the process of identifying bias in the design of an AI system • What strategies will you use to prevent bias from occurring in an AI system • Explain how to use inclusive AI design to prevent algorithmic bias. • Define an inclusive AI design **KEY SKILLS/PROCEDURES** • Students will be able to define and explain inclusive AI design • Students will be able to identify bias in the design of an AI system **Content Elaborations** **CLARIFICATIONS** Inclusive design is a methodology that understands the full range of human diversity as a resource for a better design. **CONTENT FOCUS** Strategies for inclusive AI design include user studies, algorithm development, and system validation. **COMPUTER SCIENCE PRACTICES** *Practice 3.* Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.