Ohio's Standards and Model Curriculum Computer Science

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Introduction to Ohio's Model Curriculum for Computer Science

Substitute House Bill170 took effect in March 2018, requiring the State Board of Education of Ohio to adopt standards and a model curriculum for grade K-12 instruction in computer science. A team of Ohio educators came together to develop and write the computer science standards and model curriculum, and the State Board adopted these in December 2018.

Ohio House Bill 110, passed in July 2021, included several new provisions for K-12 computer science education. The law requires the Ohio Department of Education to update the Ohio Learning Standards and Model Curriculum for Computer Science within one year of the effective date of HB 110 (Ohio Revised Code 3301.079(A)(4). Following the established process, a team of Ohio educators came together to develop and write the revisions for the computer science standards and model curriculum, and the State Board adopted these in 2022.

Ohio's Standards in Computer Science are fully aligned to Ohio's fiveyear strategic plan for education, *Each Child, Our Future*. The strategic plan acknowledges a major education policy shift around technology. A student's ability to use technology strategically is now identified as foundational and just as important as mathematics and English language arts, from which all other learning is built.

GUIDING ASSUMPTIONS

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The team of Ohio educators that developed the standards and model curriculum had a clear goal – to encourage districts and educators to give all Ohio students opportunities to learn computer science. Beginning in the earliest grades and continuing through grade 12, Ohio's students will develop a foundation of computer science knowledge and gain experiences in computational thinking and problem solving to become creators and innovators of computing technology. Ohio's Computer Science Standards and Model Curriculum will give students experiences that help them discover and take part in a world continually influenced by technology and to understand the role of computing in that world.

OVERVIEW OF THE COMPUTER SCIENCE STANDARDS CONTENT

The standards will support a progression of learning in each core concept or strand to provide computer science experiences for all Ohio students. The K-8 standards integrate computer science into instruction across subject areas including mathematics, science, history, English language arts, fine arts, world language and career and technology courses. The high school computer science standards provide both foundational and advanced opportunities districts can use to design as separate courses or, when appropriate, integrate into other disciplines.

Ohio's Computer Science Standards and Model Curriculum are organized in the following strands:

- **Computing Systems** Addresses how devices, including hardware and software, interact to accomplish tasks and how students can troubleshoot computing systems when they do not work as intended.
- **Networks and the Internet** Addresses how devices and networks connect to share information and resources and how students can apply cybersecurity concepts to protect information.
- **Data and Analysis** Addresses how data can be collected and stored; analyzed and communicated; and used to make more accurate predictions.
- Algorithmic Thinking and Programming Addresses program development, including the use of algorithms, variables, control structures and modules.
- Artificial Intelligence (AI) Addresses machine learning, natural interaction, perception, representation and reasoning and societal impacts.
- Impacts of Computing Addresses computing's influence on our world by examining the relationship between computing and culture, computing's impact on social interaction, and legal and ethical implications of computing.

Computational Thinking is a problem-solving process that students use to engage with concepts in the computer science standards. This thinking involves formulating problems in a way that can be carried out by a computer. Using computational thinking to solve a problem includes breaking down the problem into manageable parts, recognizing patterns, excluding irrelevant details to abstract or identify general principles that generate these patterns and developing step-by-step sequences or algorithms to solve the problem and similar problems. Computational thinking can be applied with or without computers, for example, through unplugged" activities. While computational thinking is a focus in computer science, it also is used in content areas beyond computer science.

It is important that computer science not be confused with other aspects and uses of computer technology in schools, including:

- **Computer literacy** "refers to the general use of computers and programs, such as productivity software." Examples of computer literacy include performing an internet search and creating a digital presentation.
- Educational (computer) technology "applies computer literacy to school subjects. For example, students in an English class can use a web-based application to collaboratively create, edit and store an essay online."
- **Digital citizenship** "refers to the appropriate and responsible use of technology, such as choosing an appropriate password and keeping it secure."
- Information technology "often overlaps with computer science but is mainly focused on industrial applications of computer science, such as installing [and operating] software rather than creating it. Information technology professionals often have a background in computer science."

(K-12 Computer Science Framework, 2016, pp.13-14)

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.



Grades 9-12 - Content statements are organized by grade band into two levels – Foundational and Advanced. Foundational level standards are targeted at students who have limited or no experience in Computer Science. Standards at this level ask students to demonstrate competency of one or more subsets of the standards. Advanced standards are targeted at students demonstrating mastery at the foundational level. See an example of a content statement for high school and its corresponding content statement code below. This content statement addresses the topic of Networking within the Networks and the Internet strand, at the Foundational Level.

NETWORKS AND THE INTERNET

Networking

NI.N.9-12.F.a Evaluate and select networking devices to establish scalable communications.



Equity and Computer Science1

COMPUTER SCIENCE FOR ALL

To help realize the vision of computer science for all students, equity must be at the forefront of the state's efforts to implement the computer science standards. Equity is more than whether classes are available. It includes how those classes are taught, how students are recruited and how the classroom culture supports diverse learners and promotes retention. When equity exists, schools expect academic success for every student and make that success accessible to every student. The result of such equity is a classroom of diverse students based on factors such as race, gender, disability, socioeconomic status and English language proficiency. All students have high expectations and feel empowered to learn.

Computer science faces intense challenges related to access, opportunity and culture.

 The 2021 State of Computer Science report showed that only 51 percent of public high schools offer foundational computer science courses (Code.org et al, 2021). This data showed that students with the least access are Black, Latino and Native American, from lower income backgrounds and urban and rural areas.

Even when computer science courses are available, there are wide gaps in participation and the level of instruction.

- For the 2020 Advanced Placement (AP) Computer Science exam, only 31 percent of students were female, 6 percent were Black or African American, 16 percent were Hispanic or Latino and 0.5 percent were Native American (College Board, 2020).
- The potential impact of these gaps in participation is illustrated in the statistic that females who take high school AP Computer Science are 10 times more likely to major in computer science

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in college than students who do not take this course (Morgan & Klaric, 2007).

• Especially in schools with large numbers of African American and Latino students, computer classes too commonly offer only basic, rudimentary user skills rather than engaging students in the problem-solving and computational thinking practices that form the foundation of computer science (Margolis et al., 2012).

The lack of representation in computer science after K–12 reflects the lack of access and participation in grades K–12. In 2021, only 26.2 percent of workers employed in computer and mathematical occupations were female. Only 8.5 percent were Black or African American, and only 8.3 percent were Hispanic or Latino (Bureau of Labor Statistics, 2021).

EFFORTS TO INCREASE EQUITY

Even when schools have made computer science courses available to students, inequity can be perpetuated at the classroom level. Educators can work to ensure equity through changes in curriculum, instruction and classroom culture.

Educators can reach students with disabilities using learning accommodations, curricular modifications and established techniques for differentiated instruction. For example, the Quorum programming language accommodates students with visual impairments by enabling the programming language to be read by computer screen readers (Quorum, 2019). Recent research shows ways to use Universal Design for Learning (UDL) to develop and refine introductory computer science experiences for a wider range of learners (Hansen et al., 2016). Educators also can apply instructional strategies used in other content areas to support struggling learners and students with disabilities. For example, if verbal prompting helps in math instruction, it will likely help in computer science instruction (Snodgrass, Israel, & Reese, 2016).

Retrieved from <u>http://www.k12cs.org</u>.) This work is licensed under Creative Commons (<u>CC BY-NC-SA 4.0).</u>

¹ The "Equity and Computer Science" section has been modified from chapter two of the K-12 Computer Science Framework, "Equity in Computer Science Education." (K–12 Computer Science Framework. (2016).

- A variety of approaches make programming more accessible to young learners and beginners. Visual, block-based programming languages allow students to program without the obstacle of syntax errors (errors in typing commands) found in traditional text-based languages. Programming environments on tablets have made programming even more accessible to younger children by reducing the number of available commands and the amount of reading required to navigate the options (Strawhacker & Bers, 2014).
- To address a *lack of computer and internet access*, educators can help students learn many computer science topics, such as algorithmic thinking, searching, sorting and logic through "unplugged" activities. Ohio's initiative, InnovateOhio, strives to transform Ohio's communities and bring opportunity for growth in the rural and urban areas through a statewide broadband strategy to improve access to high-speed internet (InnovateOhio, 2022).
- To reach *females and underrepresented minorities*, teachers can use strategies to work against issues such as the threat of stereotyping or bias. For example, stereotype threats can be mitigated by altering the wording of test questions to be gender-neutral and using examples that are equally relevant to both males and females (Kumar, 2012). It also is important for students to have diverse role models in the field so they can imagine themselves as a computer scientist. Role models also help dispel stereotypes of how computer scientists look and act (Goode, 2008).

Below, are other practices that teachers can adopt and adapt to change classroom culture and broaden participation in computer science:

- Connect computer science to concepts that motivate children, like fairness and social justice (Denner et al., 2015).
- Practice culturally relevant pedagogy to tie computer science to students' experiences, culture and interests (Margolis et al., 2014). Designing projects and instruction to be socially relevant and meaningful for diverse students helps them "build personal relationships with CS concepts and applications -- an

Department of Education important process for discovering the relevance of CS for their own lives." (Margolis et. al, 2012, p. 76)

• Reflect on beliefs and actions to address stereotypes among students and teachers (Margolis et al., 2014).

EQUITY AND THE COMPUTER SCIENCE STANDARDS

The computer science standards reflect the writing team's considerations on equity. The standards describe concepts and skills all students can benefit from, regardless of whether they go on to postsecondary computer-science education or a career in computer science.

Equity is woven into the computer science concepts and skills across grade levels. This is especially apparent in the core concept or strand involving *Impacts of Computing*. Here, students examine the social implications of the digital world, including their impacts on equity and access to computing. Specific content statements address equity directly. For example, in grade 3, students identify diverse user needs and "how computing devices have built-in features to increase accessibility to all users." In grade 7, students "evaluate various technologies to identify issues of bias and accessibility." Students in grade 8 build on prior learning to work against existing inequities, they propose guidelines "to positively impact bias and accessibility in the design of future technologies."

As students design computational products, they engage in computer science practices that also directly involve consideration of equity, inclusion and diversity. Students foster inclusion as they develop products that "include the unique perspectives of others" and "address the needs of diverse end-users." Students encourage diversity through working in teams "with individuals possessing diverse perspectives." Involving students in such practices stresses the need to practice equity when doing computer science. Through such practices, students can see the benefit of, for example, considering the products they develop from the perspectives of a diverse group of end-users, such as those with visual impairments and English language learners.

Ohio's Model Curriculum & Instructional Supports for Computer Science

OVERVIEW OF THE MODEL CURRICULUM

The purpose of the model curriculum is to provide clarity on Ohio's Computer Science Standards and set the foundation for planning and developing instruction to implement these standards. The model curriculum reflects the expertise of Ohio educators. It is not a collection of lessons or a full curriculum. It does not suggest pace, sequence or the amount of time teachers should spend on topics.

The model curriculum contains two sections: **Expectations for Learning** and **Content Elaborations.**

Expectations for Learning

LEARNING PROGRESSION

Explains the position of the content statement within its respective learning progression, including previous and future learning

IMPORTANT CONCEPT

Identifies important concepts students should develop

KEY SKILL/PROCEDURES

Identifies key skills and procedures students should know and demonstrate

Information about learning progressions, important concepts and key skills and procedures clarifies the expectations for student learning and guides teachers in developing lessons and assessments, both formative and summative.

Content Elaborations

CLARIFICATIONS

Provides clarification of the content

CONTENTFOCUS

Identifies the aspects of the content that teachers should stress with their students

COMPUTER SCIENCE PRACTICES

Identifies connections to the **Computer Science Practices** that describe the behaviors and ways of thinking that computationally literate students use to engage in their technological world (K-12 Computer Science Framework)

OVERVIEW OF THE INSTRUCTIONAL SUPPORTS

Instructional supports will offer instructional strategies and resources that target specific content statements. The Department will add instructional supports as they are identified and developed, after careful vetting and review.

These supports will include descriptive examples of instructional strategies. Supports will also identify connections to other content statements in Computer Science, across content areas and to careers to help teachers plan instruction and incorporate computer science content into their curricula. Other supports woven throughout will include descriptions of common misconceptions and ways to structure computer science experiences that are equitable and accessible to all students.

Computer Science Model Curriculum: Career Connections

It is important for students to understand how the knowledge and skills they acquire in school apply to their ultimate career and life goals. Ohio's Model Curriculum for Computer Science provides examples of Career Connections. These Career Connections are a starting point for teachers to begin drawing connections to careers for students. The Instructional Supports mentioned earlier will continue this work and address Career Connections more fully.

When developing Career Connections, schools and districts may consider using the Career Connections Framework. The framework is a planning tool districts and schools can use to provide students with opportunities to develop a vision and realistic plans for their future. It aligns the many efforts around college and career readiness to support students in becoming productive and engaged citizens. While many of the career connections throughout this model curriculum are designed to help students become aware, explore and plan for specific careers, it is understood that students often will change career pathways of interest over time. Throughout Ohio's Learning Standards and Model Curriculum for Computer Science, many of the skills students are beginning to learn and refine can be associated with work environments. *Career Connections in this model curriculum are organized by the Computer Science Standards Strands, providing one example per grade band for each strand.* In this way, teachers can see how these connections relate to key computer science knowledge and skills in each strand and progress by grade band. The Career Connections lend themselves to interdisciplinary connections and students explore careers that go well beyond those involving information Computer Science. Again, these are suggested starting points for educators and can be modified or expanded. Career Connections are in a separate section within those model curriculum entries that contain them.

An example of a Career Connections entry in the Model Curriculum is shown on the next page.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.3.a Identify	computing	Expectations for Learning
world and express	have changed the	LEARNING PROGRESSION
technologies influe influenced by cultu	technologies influence and are influenced by cultural practice.	In grade 2, students compared and contrasted how technology use has changed and the impact it has had on their personal lives. In grade 3, students identify the impact technology has on everyday life in the local community. In grade 4, students will recognize the impact of technology on the global community.
		IMPORTANT CONCEPTS
		 People within a local community use technology in various ways Daily life is influenced by the technology in a community
		KEY SKILL/PROCEDURES
		 Identify specific types of technology used in the local community Describe ways that various technology resources impact daily life in a local community
		Content Elaborations
		CLARIFICATIONS
		New computing technology is created, and existing technologies are modified for many reasons, including to increase their benefits, decrease their risks, and meet societal needs. Students explore topics that relate to the history of technology and the changes in the world due to technology. Topics could be based on current news content, such as robotics, wireless internet, mobile computing devices, GPS systems, wearable computing, or ways social media has influenced social and political changes. (CSTA K-12 Computer Science Standards, 2017)
		CONTENT FOCUS
		The focus is on the impacts of technology on the local community.
		COMPUTER SCIENCE PRACTICES
		 Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspective of others and reflect on one's own perspectives when designing and developing computational products.
		Career Connections
	F	CAREER AWARENESS
		Using a resource such as Smithsonian Institute, students learn about computing technologies from the past. Students choose one type of technology to research to see how it has changed society and how people work. Students create an artifact such as a timeline or presentation to share their findings.

Career Connections Across K-12

CAREER AWARENESS - ELEMENTARY GRADES (K-5)

Students become familiar with careers through learning that connects classroom instruction to future work. Career awareness strategies show students various types of careers and stimulate interest in future work.

Computer Science Model Curriculum Example: Giving elementary students opportunities to learn about work environments and discover unique career opportunities associated with the Computer Science skills they are learning will aid in stimulating student interest in future work. Discussing careers that use digital tools can be an effective way to tie Computer Science to career awareness.

8\]hrough embedded activities. Career exploration strategies are opportunities for students to discover work environments and understand the various aspects of the workplace. Strategies include tools and instruments that help students understand and appreciate their strengths and interests. Students start plans for their future with career information and postsecondary education data. Plans include course selection and planning as well as career aspirations and goals. **Computer Science Model Curriculum Example**: Middle school is an important time for students to begin refining their interests and furthering their understanding of the workplace. These are prime grades to begin having students use their Computer Science knowledge and skills to explore career options in the Computer Science fields.

(ATP.PD.7.a) Students explore careers in coding like computer programming as well as those careers that support creative professions such as filmmaker, podcaster, digital imaging specialist, and other creative professions. Students present or create an artifact showing their learning.

CAREER PLANNING - HIGH SCHOOL (9-12)

Students continue career exploration while focusing on career planning. Activities provide advanced experiences that offer handson opportunities in the workplace. Career planning strategies focus on making clear links between career options and educational decisions. Students develop the skills to revisit previous exploration and planning strategies as they face career changes throughout life.

Computer Science Model Curriculum Example: High school students need to begin finalizing their post-high school plans. To gain further insight into what options exist for students, it is important to give students opportunities to interact with and work in the community.

(AI.ML.9-12.F.b) Students research Artificial Intelligence Career Pathways using the Dynamic Career Pathways tool in OhioMeansJobs K-12 and identify qualifications (education, certification, and experience) career progression (entry, intermediate, advanced and expert level progression).

BUILDING SKILLS ALIGNED TO THE OHIOMEANSJOBS-READINESS SEAL

Career Connections learning strategies are an effective way for students to establish an understanding of and demonstrate the professional skills that will be essential for success in their career and life goals. The professional skills outlined in the OhioMeansJobs-Readiness Seal can be found across the career connection learning strategies within the model curriculum. These associations will help students make connections to the expected skills and behaviors within the world of work and can be used to support high school students in meeting the seal requirements.

There are clear associations between Ohio's Learning Standards and Model Curriculum for Computer Science and the professional skills outlined in the OhioMeansJobs-Readiness Seal. For example, a distinct connection exists between the knowledge and skills in the standards and model curriculum and professional skills involving Computer Science where the student has "an in-depth understanding of emerging Computer Science and leverages Computer Science to solve problems, complete tasks and accomplish goals." Additional associations exist using the outlined Career Connections found throughout this model curriculum.

Grades K-2

KINDERGARTEN

Strand	Computing Sy	vstems
Торіс	Devices	
CS.D.K.a With guidance, identify and label commonly used device and their components, explaining their connection to different tasks to perform a variety of tasks		Expectations for Learning LEARNING PROGRESSION In kindergarten, with guidance, students name and use common devices and their components to perform a variety of tasks. In grade 1, students will begin operating the devices independently.
		 IMPORTANT CONCEPTS Every device has a unique identifier. Different devices perform different tasks.
		 KEY SKILL/PROCEDURES With guidance, name devices used by students and their components.
		Content Elaborations
		CLARIFICATIONS Students will name devices' main components (e.g., tablet, computer, monitor, mouse, printer) and explain the connection between device components and different tasks. They will recognize and name software.
		CONTENT FOCUS The focus is on identifying devices and using the correct terminology for hardware and software.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing Systems	
Торіс	Hardware/So	ftware
CS.HS.K.a With support, identify hardware and so for accomplishin	guidance and and use oftware necessary g a task.	Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students name and use hardware and software to perform functions. In grade 1, students will begin comparing hardware and software and their functions. IMPORTANT CONCEPTS Identify hardware and software and the functions they perform.
		 KEY SKILL/PROCEDURES With guidance and support, identify the differences between hardware and software, their functions and purpose. Use hardware and software to perform functions.
		Content Elaborations
		CLARIFICATIONS Students will classify and sort hardware and software. They will label software and hardware and their functions.
		CONTENT FOCUS The focus is on the identification of hardware and software and their function.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing Systems	
Торіс	Troubleshoo	ting
CS.T.K.a With g support, use pro strategies to trou a problem.	uidance and blem-solving ibleshoot	 Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students use a problem-solving process to identify problems and begin troubleshooting. In grade 1, they will continue using a problem-solving process. IMPORTANT CONCEPTS

Strand	Computing Systems	
Торіс	Troubleshooting	
		Career Connections CAREER AWARENESS Students may not be aware of the career options available to them. Using digital tools to learn about career options is a wonderful way to begin introducing the world of work to students. One way to do this would be to have students watch " <u>ABC Jobs Song for Kids</u> " and identify three to five careers unfamiliar to them where troubleshooting is a component. The teacher can then lead discussions on how troubleshooting is a component of all careers.

Strand	Networks and the Internet	
Торіс	Networking	
NI.N.K.a With g support, create information can electronically to understanding c is transmitted (e social media).	uidance and a list of ways be shared gain a deeper of how information e.g., email,	Expectations for Learning LEARNING PROGRESSION In kindergarten, students are introduced to the idea of what a network is and how people use it. In grade 1, students will begin to develop an understanding of concepts of networking and unique identifiers within a global community. They will also begin to develop an understanding of what devices people use to network and how each device people network with has a unique identifier. In addition, students will recognize that computing devices with unique identifiers can be connected to access and retrieve information.
		 IMPORTANT CONCEPTS Users of the internet communicate with a global community. A variety of information can be communicated electronically.
		 KEY SKILL/PROCEDURES Identify communications that can be transmitted electronically with guidance.
		Content Elaborations
		CLARIFICATIONS The internet is global. Students will identify the devices we use to communicate using the internet.
		CONTENT FOCUS The focus is on introducing students to networks and electronic communication.
		COMPUTER SCIENCE PRACTICES
		 Practice 1. Fostering an Inclusive Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks and the Internet	
Торіс	Cybersecuri	ity
NI.C.K.a With gu support, identify practices (e.g., p protect private in	idance and and use secure asswords) to formation.	Expectations for Learning LEARNING PROGRESSION In kindergarten through grade 2, students work on being able to explain why it is important to use technology in a responsible way to make decisions about its use. Students also work to demonstrate how to use technology appropriately and safely and how to protect login information.
		 IMPORTANT CONCEPTS Students, with guidance will make decisions when using technology.
		 KEY SKILL/PROCEDURES With guidance and support, students create and use passwords appropriately. With guidance and support, students log in and out of apps and devices.
		Content Elaborations
		CLARIFICATIONS Realize that kindergartners require assistance with their passwords initially. Focus on the importance of passwords staying in the classroom. This provides peer assistance with passwords but allows the teacher to focus on the importance of not sharing passwords.
		CONTENT FOCUS The focus is on using passwords and devices appropriately.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

	Strand	Networks and the Internet	
	Торіс	Internet of Th	ings
 NI.IOT.K.a Wi support, identi devices are to devices can co the internet. NI.IOT.K.b Wi support, recog devices conne data over the idemonstrate h is shared. 	NI.IOT.K.a With support, identify devices are to r devices can con the internet. NI.IOT.K.b With support, recogn devices connect data over the in demonstrate ho is shared.	n guidance and y what smart recognize what nnect to n guidance and nize how st and exchange nternet to ow information	 Expectations for Learning LEARNING PROGRESSION In Kindergarten, with guidance, students are introduced to the idea of what smart devices are and identify them. In grade 1, students will begin to develop an understanding of smart devices. IMPORTANT CONCEPTS A smart device (such as a virtual assistant) is a device that has connectivity, captures useful data and presents it. A basic technological device (such as a remote control) is missing at least one of these abilities. KEY SKILLS/PROCEDURES Identify smart devices. Differentiate between basic technological devices and smart devices.
			Content Elaborations CLARIFICATIONS A student could sort devices into groups of smart devices and basic technological devices. CONTENT FOCUS Introduce students to the concept of smart devices. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Ar	nalysis
Торіс	Data Collec	tion and Storage
DA.DCS.K.a Ide collect and sort. DA.DCS.K.b Wi support, demons can be collected variety of ways.	entify data to th guidance and strate how data and stored in a	 Expectations for Learning LEARNING PROGRESSION In kindergarten, students develop an understanding of what data is. With teacher support, students collect and sort data using a variety of methods. In grade 1, students will begin storing and retrieving data. IMPORTANT CONCEPTS Data is information. When using technology, data is often quantities, characters or symbols that are the inputs and outputs of computer programs (see Code.org). Data can be collected and represented in a variety of ways. KEY SKILL/PROCEDURES Identify what data is. With guidance and support, sort data in multiple ways (e.g., paper-pencil). With guidance and support, represent data through a variety of media. Content Elaborations CLARIFICATIONS Students can address this content with or without a computing device. A variety of media would include paper-pencil, manipulatives and physical models. CONTENT FOCUS The focus is on data identification, collection and organization. COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Levaluate existing technological functionalities and incorporate them into new designs.

Strand	Data and Analysis	
Торіс	Visualization	and Communication
DA.VC.K.a With organize and proventions formats make observation	n guidance, esent data in to ons.	Expectations for Learning LEARNING PROGRESSION In kindergarten, students are presenting data in various formats. In grade 1, they will continue presenting data in various formats.
		 Data can be sorted by attributes. Data can be presented in a variety of formats.
		 KEY SKILL/PROCEDURES Sort data by different attributes. Describe attributes of data. Explain sorting to peers.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Kindergarteners are working with physical objects and concrete manipulatives.
		 Various formats can include graphic organizers, categorical sort, modeling, drawings and sorting by different attributes.
		CONTENT FOCUS The focus is on the representation of data.

Strand	Data and Analysis	
Торіс	Visualization and Communication	
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it. Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Analysis	
Торіс	Inference & I	Nodeling
DA.IM.K.a With guidance, create a model of an object or process to identify patterns.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students are modeling data and identifying patterns with guidance. In grade 1, students will continue to model data and identify patterns and begin explaining their model.
		 IMPORTANT CONCEPTS Data can be represented through modeling. Patterns within the data can be discovered.
		 KEY SKILL/PROCEDURES With guidance, model data to discover and identify patterns.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Students model data through representation data visually; although, not necessarily using paper and pencil as in graphs. Data can be modeled using manipulatives and physical models.
		CONTENT FOCUS The focus is on modeling data and simple pattern detection.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic [®]	Thinking and Programming
Торіс	Algorithms	
ATP.A.K.a With guidance and support, model a real-world process by constructing and following step-by-step directions (i.e., algorithms) to complete tasks.		Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students will construct and/or follow directions to complete a task in a real-world context verbally and pictorially. In grade 1, students will construct and follow directions through pictures and words.
		 Step by step directions can be constructed to complete a real-world task. Directions can be given verbally or visually.
		 KEY SKILL/PROCEDURES With guidance and support, construct and complete a verbal and/or visual task in two steps.
		Content Elaborations
		CLARIFICATIONS Students will listen to directions to complete a task. Students should express their steps verbally or through pictures. During the learning process, students will understand that steps (i.e., algorithms) are required in various processes in their daily lives. Algorithms are commonly implemented using a precise language that computers can interpret.
		CONTENT FOCUS The focus is on three-step directions and the sequence of steps to complete a task.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Variables an	d Data Representation
ATP.VDR.K.a Recognize that a group of items (e.g., numbers, symbols or pictures) can be used to represent data.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students recognize that numbers, symbols and pictures represent information. In grade 1, students will use numbers, symbols and pictures to represent information.
		 IMPORTANT CONCEPTS Numbers, symbols and/or pictures can be recognized as a representation of information.
		 KEY SKILL/PROCEDURES Interchange information with a number, symbol or picture.
		Content Elaborations
		CLARIFICATIONS Information in the real world can be represented in computer programs. (K-12 Computer Science Framework, 2016)
		Recognize that attributes can be used to identify information and interchange them with numbers, symbols or pictures.
		CONTENT FOCUS The focus is on representing data using numbers, symbols and/or pictures.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Department of Education

Ohio

Strand	Algorithmic	Algorithmic Thinking and Programming	
Торіс	Control Stru	ctures	
ATP.CS.K.a With guidance and support, model a sequence of instructions (i.e., program) with a beginning, middle and end to solve a problem or express		Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students will model simple sequences and order steps of a sequence to solve a problem or express an idea. In grade 1, with guidance, students will extend their experiences with sequencing to involve loops (i.e., repetition) within their sequence.	
		 IMPORTANT CONCEPTS An algorithm is a sequence of steps. Programs may be modeled to express an idea or solve a problem. 	
		 KEY SKILL/PROCEDURES With guidance and support, model sequences to follow at least a three-step process (e.g., beginning, middle, end). 	
		Content Elaborations	
		CLARIFICATIONS Students can address this content with or without a computing device.	
		Sequences should be in logical order: beginning, middle and end. Modeling can be done visually or verbally.	
		CONTENT FOCUS The focus is on sequencing, process (i.e., steps) and problem-solving.	
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes. 	
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. 	

Strand	Algorithmic Thinking and Programming	
Торіс	Program Dev	velopment
ATP.PD.K.a With guidance and support, plan or create an artifact to illustrate thoughts, ideas and problems in a sequential (step-by-step) manner (e.g., story map, storyboard, sequential graphic organizer).		 Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students plan and/or create an artifact to illustrate thoughts, ideas and problems sequentially. In grade 1, with guidance, students will continue to plan and create, as well as begin to debug an artifact to sequentially illustrate thoughts, ideas and problems. IMPORTANT CONCEPTS
		 Artifacts illustrate thoughts, ideas and problems in a sequential manner. KEY SKILL/PROCEDURES With guidance and support, plan and create an artifact to sequentially illustrate thoughts, ideas and problems. Content Elaborations
		CLARIFICATIONS An artifact is anything created by a human. An artifact could be a visual program, story map, storyboard or sequential graphic organizer.
		CONTENT FOCUS The focus is on creating artifacts and programs.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating a Computational Artifact 1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering 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.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Artificial Ir	ntelligence
Торіс	Machine L	earning
AI.ML.K.a With guidance and support, use a classifier that recognizes drawings to see if a program can guess what they are drawing.		Expectations for Learning LEARNING PROGRESSION In kindergarten, with guidance and support, students use a classifier that recognizes drawings to see if a program can guess what they are drawing. In grade 1, students will discuss how machine learning uses classifiers to recognize drawings.
		 IMPORTANT CONCEPTS Computers can learn from examples.
		 KEY SKILLS/PROCEDURES Artificial Intelligence (AI), or the science and engineering of making intelligent machines and computer programs, can assist humans in problem-solving using a classifier.
		Content Elaborations
		CLARIFICATIONS Demonstrate how to train a computer to recognize something.
		CONTENT FOCUS Computers can learn from data.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intelligence	
Торіс	Natural Int	eractions
AI.NI.K.a With guidance and		Expectations for Learning
can recognize differ using some form of software to see how interact with human	w computers rent humans recognition v computers s.	LEARNING PROGRESSION In kindergarten, with guidance and support, students identify how computers can recognize different humans using some form of recognition software to understand how computers interact with humans. In grade 1, students will identify attributes computers use to identify humans.
		 IMPORTANT CONCEPTS Facial recognition Thumbprint recognition Iris recognition Other concepts
		 KEY SKILLS/PROCEDURES Use various forms of recognition software to demonstrate Artificial Intelligence (AI) is working.
		Content Elaborations
		CLARIFICATIONS AI can use recognition software to recognize humans.
		CONTENT FOCUS The focus of the content is how computers use recognition software to recognize humans.
		 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	
Торіс	Perception	
AI.P.K.a With guidance and		Expectations for Learning
computers, rob appliances to u devices use se gather informat	nderstand that noterstand that noterstand that	LEARNING PROGRESSION In kindergarten, students identify and are introduced to what sensors are and where they may be located. In grade 1, with guidance, students recognize sensors on computers, robots and intelligent appliances to understand their function (motion, pressure/pouch, temperature, proximity, light, sound, moisture, gases).
gaarer mennaaen		 IMPORTANT CONCEPTS Computers use sensors to get information from the world around them. Sensors are placed in certain spots.
		 KEY SKILLS/PROCEDURES Identify sensors to understand why they are placed where they are placed.
		Content Elaborations
		CLARIFICATIONS Sensors gather information and use that information to interact with us.
		CONTENT FOCUS Sensors are needed for computers to gather information.
		 COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.

Strand	Artificial Intelligence	
Торіс	Perception	
AI.P.K.b With guidance and		Expectations for Learning
to demonstrate	how they work.	LEARNING PROGRESSION In kindergarten, students are introduced to intelligent agents. In grade 1, students will use intelligent agents to help answer questions.
		 IMPORTANT CONCEPTS Intelligent agents are a form of Artificial Intelligence (AI).
		 KEY SKILLS/PROCEDURES Use intelligent agents to answer a question.
		Content Elaborations
		CLARIFICATIONS Examples of intelligent agents are virtual assistant technology that can play music, deliver news, control smart homes and provide other information.
		CONTENT FOCUS Using an intelligent agent can help students answer simple questions like how to spell a word.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intelligence	
Торіс	Representatio	n & Reasoning
AI.RR.K.a With	n guidance and	Expectations for Learning
to decide to visually and explicitly represent decisions and decision-		LEARNING PROGRESSION In kindergarten, students use a simple decision tree to decide to visually and explicitly represent decisions and decision making. In grade 1, students will use decision trees to make decisions.
5		 IMPORTANT CONCEPTS Define the meaning of a decision tree.
		 KEY SKILLS/PROCEDURES Use a decision tree to make a decision.
		Content Elaborations
		CLARIFICATIONS Many types of data could be placed on a branch. For a decision tree, the data would be questions and answers.
		CONTENT FOCUS Using a decision tree can answer a question, such as what to do if your computer does not turn on or what to do if all your letters are capitalized.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intelligence	
Торіс	Societal Impa	cts
AI.SI.K.a With guidance and support, locate AI applications used in daily life to understand how humans use AI.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students locate Artificial Intelligence (AI) applications used in daily life to understand how humans use AI. In grade 1, students will identify an application that is used in daily life.
		 IMPORTANT CONCEPTS Explore all the ways humans use AI.
		 KEY SKILLS/PROCEDURES Create a list of the ways humans use intelligent devices to demonstrate that humans use AI to assist them with everyday tasks (e.g., facial recognition, self-driving cars).
		Content Elaborations CLARIFICATIONS • Al is all around us and learning from us.
		CONTENT FOCUS Students will learn about various forms of new and emerging AI technology.
		 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		
Торіс	Societal Impa	ocietal Impacts	
AI.SI.K.b Discuss if artificial intelligence is good or bad (see impacts of computing).		Expectations for Learning LEARNING PROGRESSION In kindergarten, students will discuss if something is good or bad to understand the concepts. In grade 1, students will discuss if computers/technology is good or bad.	
		 IMPORTANT CONCEPTS Artificial Intelligence (AI) is a type of technology and it is a tool for humans to use. 	
		 KEY SKILLS/PROCEDURES Create lists of how technology makes life better or worse to see differences in the use of technology. 	
		Content Elaborations	
		CLARIFICATIONS Technology is not always positive and sometimes non-technological ways are better.	
		CONTENT FOCUS The focus of the content is on the ways that technology can help us or harm us.	
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.	

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.K.a With g support, identify impact one's own IC.Cu.K.b With g support, recogniz computing device regularly to under technology's imp daily life.	guidance and technologies that n everyday life. guidance and ze different ways es are used erstand pact on one's own	 Expectations for Learning LEARNING PROGRESSION In kindergarten, students identify what technology is and how it has changed and impacted their lives. In grade 1, they will recognize the different ways technology impacts and the role technology plays in their lives. IMPORTANT CONCEPTS Technology can be unplugged or plugged. Technology is constantly changing and affects how we live. KEY SKILL/PROCEDURES With guidance and support, identify technology in their lives. With guidance and support, explain how the technology impacts their life. Content Elaborations CLARIFICATIONS Students can identify and explain the connections between their lives and technology and how technology affects their lives. CONTENT FOCUS The focus is on how technology has changed and the impact on students' lives. COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills
Strand	Impacts of C	omputing
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		<i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
Торіс	Social Intera	ctions
IC.SI.K.a With guidance and support, identify and use safe and responsible behaviors concerning information and technology.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students use technology responsibly and safely with teacher support. In grade 1, with guidance, students will be able to describe how to be safe and responsible using technology.
		 IMPORTANT CONCEPTS Schools develop their own technology rules, regulations and etiquette.
		 KEY SKILL/PROCEDURES With guidance and support, demonstrate the use of the technology available within the framework of the school's technology rules, regulations and etiquette.
		Content Elaborations
		CLARIFICATIONS Etiquette topics might include cyberbullying, school policy and safe privacy practices.
		CONTENT FOCUS The focus is on the responsible use of technology in and out of the classroom.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	computing
Торіс	Safety, Law	and Ethics
IC.SLE.K.a With discuss appropries technology to su informed decision	h guidance, riate uses of upport ons.	Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students identify and explain basic security practices that should be applied when using the internet. With support, students identify the personal information and explain why it is important to use security measures and protect personal information. In grade 1, with guidance, students will continue to develop their understanding of private information, security practices when using the internet, and the importance of both.
		 IMPORTANT CONCEPTS Guidelines and practices to stay safe on the internet should be discussed and practiced. Awareness of what private information is, what students should and should not share and the potential consequences of sharing private information.
		 KEY SKILL/PROCEDURES With guidance and support, identify practices to stay safe on the internet.
		Content Elaborations
		CLARIFICATIONS Provide students guidelines for safe navigation of the internet. Provide students opportunities to practice these guidelines by using teacher-selected internet sites.
		Provide students guidelines on what constitutes personal information and the consequences of misuse.
		Students have the opportunity to apply basic security practices as part of their activities addressing cybersecurity (NI.C.K.a).
		CONTENT FOCUS The focus is to keep students safe when using the internet.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand	Impacts of Computing	
		<i>Practice 2.</i> Collaborating Around Computing 1. Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
IC.SLE.K.b With	n guidance and	Expectations for Learning
support, discuss examples of appropriate and inappropriate behavior online, including cyberbullying, and the steps to keep yourself and others safe and out of harm's way.		LEARNING PROGRESSION In kindergarten through grade 2, student discussions should focus on examples of what to do when someone is hurtful online and what behavior should be modeled when online.
		 IMPORTANT CONCEPTS Students should be aware of guidelines and practices to stay safe on the internet. Students should be aware of what private information is, what students should and should not share and the potential consequences of sharing private information.
		 KEY SKILLS/PROCEDURES Identify appropriate and inappropriate online behavior. Apply the concepts of online safety.
		Content Elaborations
		CLARIFICATIONS Students need to make good choices when they interact with others online. They also need to understand that in addition to interacting with others, it is important that they use websites and other apps as they were intended.
		Some online behavior is illegal, and students could be held responsible for their actions online.
		CONTENT FOCUS Students should understand the appropriate and inappropriate behavior to use when operating online. Students should also know who to talk to if they feel threatened or report inappropriate behavior.

Strand	Impacts of Computing	
		 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.
		 Practice 6. Testing and Refining Computational Artifacts. 1. Systematically test computational artifacts by considering all scenarios and using test cases.

GRADE 1

Strand	Computing S	Systems
Торіс	Devices	
CS.D.1.a Operate commonly used devices and their components to perform a variety of tasks.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students named and used common devices with guidance. In grade 1, students begin operating the devices independently. In grade 2, students will begin selecting devices with a purpose in mind.
		 IMPORTANT CONCEPTS Different devices operate in different ways.
		 KEY SKILL/PROCEDURES Operate teacher-selected devices for a specific task. Navigate digital learning tools.
		Content Elaborations
		CLARIFICATIONS Students will recognize software/hardware and operate digital learning tools.
		CONTENT FOCUS The focus is on the student operating devices and software/hardware.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing S	Systems
Торіс	Hardware/So	oftware
CS.HS.1.a With guidance, describe and use hardware and software necessary for accomplishing a task.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students named and used hardware and software with teacher support to perform functions. In grade 1, with guidance, students begin comparing hardware and software and their functions. In grade 2, students will use their knowledge of hardware and software to select what is needed to perform a task.
		 IMPORTANT CONCEPTS Identify hardware and software, and the function they perform. Hardware and software interact to work together.
		 KEY SKILL/PROCEDURES With guidance, identify the differences between hardware and software, their functions and purpose. With guidance, identify hardware and software interactions.
		Content Elaborations
		CLARIFICATIONS Students will compare and contrast hardware and software and their interactions.
		CONTENT FOCUS The focus is on the characteristics, functions and interactions of hardware and software.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing Systems	
Торіс	Troubleshoo	ting
CS.T.1.a With guidance, use problem-solving strategies to troubleshoot a problem.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students used a problem-solving process with teacher support to identify problems and begin troubleshooting. In grade 1, with guidance, and in grade 2, they will continue using a problem-solving process to troubleshoot.
		 IMPORTANT CONCEPTS There are a variety of problem-solving processes. A problem-solving process typically includes identifying the problem, brainstorming solutions, planning, testing solutions and revising.
		 KEY SKILL/PROCEDURES With guidance, apply a problem-solving process, using appropriate terminology to solve a problem.
		Content Elaborations
		CLARIFICATIONS Students will identify problems (e.g., left-click or right-click, no audio, no power, navigating windows) and attempt to solve them using a problem-solving process.
		CONTENT FOCUS The focus is on solving a problem using a problem-solving process.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

	Strand	Networks and	d the Internet
	Торіс	Networking	
	 NI.N.1.a Create a list of ways information can be shared electronically to gain a deeper understanding of how information is transmitted (e.g., email, social media). NI.N.1.b Recognize that computing devices can be connected to retrieve information from the global community. 		Expectations for Learning LEARNING PROGRESSION In kindergarten, students were introduced to the idea of what a network is and how people use it. In grade 1, students begin to develop an understanding of concepts of networking and unique identifiers within a global community. They also begin to develop an understanding of what devices people use to network and how each device people network with has a unique identifier. In addition, students recognize
			that computing devices with unique identifiers can be connected to access and retrieve information. In grade 2, students will describe what a network is, the devices we use to network, how devices can be identified, and how they can be connected. Additionally, students can network using devices to access and retrieve information within a global community.
			 IMPORTANT CONCEPTS Users of the internet communicate with a global community. All devices that are connected to the network have a unique identifier. A variety of information can be communicated electronically.
			 KEY SKILL/PROCEDURES Interact with the global community. Create communications that could be transmitted electronically. Match devices with unique identifiers.
			Content Elaborations
			CLARIFICATIONS Students will communicate and retrieve information. They will identify the devices we use to communicate.
			The internet is global. Each device has a unique identifier. This is not limited to IP addresses. A person's phone number can serve as a metaphor for a unique identifier. For example, two people can exchange information using their phones providing they call or connect to the correct phone number.

Strand	Networks an	d the Internet
Торіс	Networking	
		CONTENT FOCUS The focus is on understanding networks, unique identifiers and electronic communication.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
		Career Connections
		CAREER AWARENESS The teacher describes the ways they share information electronically in their workplace and then students discuss the ways they share information at school. Students ask a trusted adult about what types of digital information they share in their workplace and how that information is shared. Students create an artifact with examples they discovered to share with the class.

Strand	Networks and the Internet	
Торіс	Cybersecuri	ty
NI.C.1.a Identify practices (e.g., p protect private in	and use secure passwords) to formation.	Expectations for Learning LEARNING PROGRESSION In kindergarten through grade 2, students work on being able to explain why it is important to use technology in a responsible way to make decisions about its use. Students also work to demonstrate how to use technology appropriately and safely and how to protect login information.
		 IMPORTANT CONCEPTS Use technology to make a decision.
		 KEY SKILL/PROCEDURES Create and use passwords appropriately. Log in and out of apps and devices.
		Content Elaborations
		CLARIFICATIONS In grade 1, some students may still require assistance with their passwords. Focus on the importance of passwords staying in the classroom. This provides peer assistance with passwords but allows the teacher to focus on the importance of not sharing passwords.
		CONTENT FOCUS The focus is on using passwords and devices appropriately.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Strand	Networks and the Internet	
Торіс	Cybersecurit	y .
NI.C.1.b Identify, use and discuss examples of how devices can be used with good and bad intentions.		Expectations for Learning LEARNING PROGRESSION Building on NI.C.1.a, students will discover the use of devices, specifically that devices can be used with both good and bad intentions. This concept will progress through grade 5.
		 IMPORTANT CONCEPTS Exhibit decision-making when using technology. There are intended and unintended consequences of device use.
		 KEY SKILLS/PROCEDURES Use devices appropriately. Log in and out of applications (apps) and devices.
		Content Elaborations
		CLARIFICATIONS In grade 1, students may still require assistance with their passwords and online navigation. Focus on the names and purposes of different devices and their uses. Students should be able to recognize bad intentions, such as taking unwanted photos and sharing personal information.
		CONTENT FOCUS The focus is on appropriate device intentions and use. Students will begin to use devices and digital resources as a natural part of their educational experience.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution

Strand	Networks and	d the Internet
Торіс	Internet of Th	nings
NI.IOT.1.a Identiti devices are and to the internet. NI.IOT.1.b Recog connect and excl the internet to de	ify what smart how they connect ognize how devices change data over emonstrate how	Expectations for Learning LEARNING PROGRESSION In kindergarten, with guidance, students were introduced to the idea of what smart devices are and how to identify them. In grade 1, students begin to develop an understanding of smart devices. In grade 2, they will explain how devices connect and exchange data. Additionally, they will explore different network connectivity.
information is shared.		 IMPORTANT CONCEPTS Smart devices connect to the internet using Wi-Fi or mobile networks. Information over a network is broken down into small chunks. KEY SKILLS/PROCEDURES Recognize if a smart device is connected to the internet to access shared information.
		Content Elaborations CLARIFICATIONS Networks can be demonstrated unplugged using ideas like the telephone game or a string to simulate information getting shared.
		CONTENT FOCUS Smart devices get their information from the internet and other devices.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Analysis	
Торіс	Data Collec	tion and Storage
DA.DCS.1.a Wit collect and orga retrieve for later DA.DCS.1.b Wit demonstrate how collected and ste of ways.	th guidance, nize data to use. th guidance, w data can be ored in a variety	 Expectations for Learning LEARNING PROGRESSION In kindergarten, students collected and sorted data in a variety of ways with teacher support. In grade 1, students begin storing and retrieving data with guidance. In grade 2, students will begin to retrieve data to modify. IMPORTANT CONCEPTS Data is information. When using technology, data is often quantities, characters or symbols that are the inputs and outputs of computer programs (see Code.org). Data can be organized, collected, stored and retrieved in a variety of ways. KEY SKILL/PROCEDURES Use appropriate tools to organize data. Use appropriate tools to collect data with guidance. With guidance, store, retrieve and save data. Content Elaborations Students can create and, with guidance, retrieve files. Students can organize files (i.e., file structure). CONTENT FOCUS The focus is on storing and retrieving data. COMPUTER SCIENCE PRACTICES Practice 4. Developing and Dising Abstractions Evaluate existing technological functionalities and incorporate them into new designs.

Strand D	Data and An	alysis
Торіс	Visualizatior	n and Communication
DA.VC.1.a Organized data in various form make observations.	ze and present nats to ,	Expectations for Learning LEARNING PROGRESSION In kindergarten, students are presenting data in various formats. In grade 1, students will make observations of representations of data. In grade 2, they will continue to analyze data in various formats. IMPORTANT CONCEPTS • Data can be sorted by attributes. • Data can be presented in a variety of formats. KEY SKILL/PROCEDURES • Collect with guidance and organize data for peer understanding. • Describe and sort data by different attributes to create multiple representations of the same data sets. • Transfer data between grids to lists. Content Elaborations Students can address this content with or without a computing device. Various formats can include • graphic organizers, • categorical sort, • modeling, • drawings and • sorting by different attributes. CONTENT FOCUS The focus is to make observations on representations of data.

Strand	Data and An	nalysis
Торіс	Visualizatio	n and Communication
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it. Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology

Strand	Data and Analysis	
Торіс	Inference ar	nd Modeling
DA.IM.1.a Creat model of an objet that includes pat key elements.	e and explain a act or process tterns and	 Expectations for Learning EARNING PROGRESSION In kindergarten, students modeled data and identified patterns with guidance. In grade 1, students continue to model data and identify patterns and begin explaining their model. In grade 2, students will begin interpreting models. IMPORTANT CONCEPTS Data can be represented through modeling. Patterns within the data can be discovered and explained. KEY SKILL/PROCEDURES Model data to discover and identify patterns. Explain the model and patterns discovered. Content Elaborations Students can address this content with or without a computing device.
		 as in graphs. Data can be modeled using manipulatives and physical models. CONTENT FOCUS The focus is on modeling data, pattern detection and explanation of the model. COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it. Practice 6. Testing and Refining Computational Artifacts Systematically test computational artifacts by considering all scenarios and using test cases.

Strand	Data and Analysis	
Торіс	Inference an	nd Modeling
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Algorithms	
ATP.A.1.a With guidance, model a real-world process by constructing and following step-by-step directions (i.e., algorithms) to complete tasks.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students constructed and followed instructions verbally and/or pictorially with teacher support. In grade 1, students construct and follow directions with guidance to complete a task in a real- world context through pictures and written words. In Grade 2, students will construct and follow instructions to complete a task through pictorial symbols and written words.
		 IMPORTANT CONCEPTS Step by step directions can be constructed to complete a real-world task. Directions can be given verbally or visually.
		 KEY SKILL/PROCEDURES With guidance, complete a verbal and/or visual task with multiple steps.
		Content Elaborations
		CLARIFICATIONS Students will follow multiple-step directions with precision to complete a task. Students should be able to use a task from their daily lives (e.g., brushing teeth, washing hands, getting ready for school) and create the multiple steps necessary to complete that task. Students should articulate the steps to a task using visual representations, such as simple flow charts or diagrams, and written expression. Algorithms are commonly implemented using a precise language that computers can interpret.
		CONTENT FOCUS The focus is on multi-step directions and the sequence of steps to complete a task.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Variables and	d Data Representation
ATP.VDR.1.a Categorize a group of items (e.g., numbers, symbols or pictures) based on the attributes or actions of each item, with or without a computing device.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students recognized that numbers, symbols and pictures represent information. In grade 1, students use numbers, symbols and pictures to represent information. In grade 2, students will model the use of numbers, symbols and pictures to manipulate and store information.
		 IMPORTANT CONCEPTS Numbers, symbols or pictures can be categorized by attributes or actions.
		 KEY SKILL/PROCEDURES Categorize numbers, symbols and/or pictures based on multiple attributes or actions.
		Content Elaborations
		CLARIFICATIONS Information in the real world can be represented in computer programs. (K-12 Computer Science Framework, 2016).
		Students will manipulate numbers, symbols and pictures to categorize information.
		CONTENT FOCUS The focus is on categorizing data based on attributes and/or actions.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Control Strue	ctures
ATP.CS.1.a With guidance, model a sequence of instructions (i.e., program) that includes repetition (i.e., loops) to solve a problem or express ideas.		Expectations for Learning LEARNING PROGRESSION In kindergarten, with teacher support, students modeled simple sequences and ordered steps of an algorithm to solve a problem and express ideas. In grade 1, with guidance, students include loops in their sequence to express an idea or solve a problem. Students utilize loops in a sequence to demonstrate repetition in their sequence and to simplify the steps to create or model their algorithm. In grade 2, students will create a program that utilizes sequencing and loops.
		 IMPORTANT CONCEPTS An algorithm is a sequence of steps. Programs may be modeled to express an idea or solve a problem. A loop is a repeated sequence of steps.
		 KEY SKILL/PROCEDURES Identify a sequence as an algorithm. With guidance, identify a repeated sequence as a loop. With guidance, model algorithms and loops to follow a process.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Loops are repeated sequences.
		Modeling a program means the students are provided the program to follow; they are not creating it. Modeling can be done visually or verbally.
		CONTENT FOCUS The focus is on sequencing, process (i.e., steps), loops and problem-solving.

Strand	Algorithmic	Thinking and Programming
Торіс	Control Structures	
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic Thinking and Programming	
Торіс	Modularity	
ATP.M.1.a With guidance, break down (i.e., decompose) a series of steps and separate the necessary from the unnecessary steps to create a precise sequence of instructions to solve a problem or		Expectations for Learning LEARNING PROGRESSION In grade 1, with guidance, students determine what information is necessary to complete a sequence or process. In grade 2, students will determine what information is necessary to complete a more complex sequence or process.
express an idea	à. '	 IMPORTANT CONCEPTS Decomposition is to break down a series of steps. Abstraction is to determine the information that is relevant to solving a problem.
		 KEY SKILL/PROCEDURES With guidance, decompose a problem into a series of steps. With guidance, abstract information that is relevant to solving the problem.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Students will start with a simple sequence of at least three steps (e.g., beginning, middle and end) and move to a more complex sequence of more than three steps.
		Abstraction is to determine which information is relevant or irrelevant to the problem. Decomposition is taking a problem and breaking it into steps.
		CONTENT FOCUS The focus is on decomposing and the abstraction of information in a sequence of instructions to solve a problem.
		 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.

Strand

Algorithmic Thinking and Programming

Topic Program Development

ATP.PD.1.a With guidance, plan and create an artifact to illustrate thoughts, ideas and problems in a sequential (step-by-step) manner (e.g., story map, storyboard, sequential graphic organizer).

ATP.PD.1.b With guidance, identify and fix (i.e., debug) a multi-step process that includes sequencing.

Expectations for Learning

LEARNING PROGRESSION

In kindergarten, with teacher support, students planned and/or created an artifact to illustrate thoughts, ideas, and problems in a sequential manner. In grade 1, with guidance, students continue to plan and create, as well as begin to debug an artifact to illustrate thoughts, ideas and problems sequentially. In grade 2, students will continue to plan, create and/or debug an artifact to sequentially illustrate thoughts, ideas and problems.

IMPORTANT CONCEPTS

- Artifacts illustrate thoughts, ideas and problems in a sequential manner.
- When creating artifacts, it is important to review your artifact for errors.

KEY SKILL/PROCEDURES

- With guidance, plan and create an artifact to sequentially illustrate thoughts, ideas and problems.
- With guidance, evaluate an artifact for errors.

Content Elaborations

CLARIFICATIONS

An artifact is anything created by a human. An artifact could be a visual program, story map, storyboard or sequential graphic organizer.

Debug is defined as "to identify and fix."

CONTENT FOCUS

The focus is on creating and debugging artifacts and programs.

COMPUTER SCIENCE PRACTICES

Practice 5. Creating a Computational Artifact

- 1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering 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.

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Strand	Algorithmic Thinking and Programming	
Торіс	Program De	velopment
		 Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process. Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand Artificial Intelligence		
Topic Machine Learning		
AI.ML.1.a With guidance and	Expectations for Learning	
support, discuss how a classifier recognizes drawings to gain an understanding of how machine learning works.	LEARNING PROGRESSION In kindergarten, students were introduced to machine learning through classifiers. In grade 1, students discuss how a classifier recognizes drawings to gain an understanding of how machine learning works. In grade 2, students will discuss how the machine knows what they are drawing.	
	 IMPORTANT CONCEPTS Explore how Artificial Intelligence (AI) can recognize a drawing. 	
	 KEY SKILLS/PROCEDURES Apply the use of AI in a classifier to gain knowledge of how machine learning works. 	
	Content Elaborations	
	CLARIFICATIONS Al can recognize human inputs.	
	CONTENT FOCUS Students can address this content with or without a computing device. For example, the class can all draw the same thing and look at the differences.	
	 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 Intel	ligence
Торіс	Natural Intera	ctions
AI.NI.1.a Using recognition software, identify attributes that computers use for identification to explain how computers recognize humans.		Expectations for Learning
		LEARNING PROGRESSION In kindergarten, students were introduced to recognition software. In grade 1, students use recognition software to identify attributes that computers use for identification to explain how computers recognize humans. In grade 2, students will list possible attributes used by computers to distinguish humans from each other.
		 IMPORTANT CONCEPTS Explore how Artificial Intelligence (AI) uses attributions to recognize humans.
		 KEY SKILLS/PROCEDURES Create lists of attributions AI might use to identify humans to describe how computers recognize human faces from each other.
		Content Elaborations
		CLARIFICATIONS The process of identifying a minimal set of informative features or attributes from the provided data set is called feature extraction. The performance of machine learning processes can be improved by properly choosing a meaningful set of features.
		CONTENT FOCUS The focus of the content is on how computers can recognize humans. Attributions are necessary for AI to identify humans.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Artificial Intelligence

Perception

Strand

Торіс

AI.P.1.a With guidance and support, recognize sensors on computers, robots and intelligent appliances to understand their	Expectations for Learning	
	LEARNING PROGRESSION In kindergarten, students are introduced to sensors. In grade 1, students recognize sensors on computers, robots and intelligent appliances with guidance. In grade 2, students will relate the sensor to the function.	
	function, such as motion, pressure/touch, temperature, proximity, light, sound, moisture	 IMPORTANT CONCEPTS Computers use specific types of sensors to gather data.
	or gases.	 KEY SKILLS/PROCEDURES Identify different sensors to examine the data they can gather.
		Content Elaborations
	CLARIFICATIONS Examples of data sensors that can gather data are motion (computer games, tablets), pressure/touch (temperature), proximity (self-driving car), light, sound, moisture (lawn watering) and gases.	
		CONTENT FOCUS Sensors are needed for computers to gather information.
	 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	
Торіс	Perception	
AI.P.1.b With guidance and support, use intelligent agents to help answer simple questions.		Expectations for Learning
		LEARNING PROGRESSION In kindergarten, students were introduced to intelligent agents. In grade 1, students use intelligent agents to help answer simple questions with guidance. In grade 2, they will use the intelligent agent to assist in basic research.
		 IMPORTANT CONCEPTS Intelligent agents are a form of Artificial Intelligence (AI).
		 KEY SKILLS/PROCEDURES Use intelligent agents to answer questions.
		Content Elaborations
		CLARIFICATIONS Examples of intelligent agents are virtual assistant technology which can play music, provide information, deliver news, control your smart home and give you other information.
		CONTENT FOCUS Students can use an intelligent agent to help them answer questions, for example, how to spell a word.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intelligence		
Торіс	Representation & Reasoning		
AI.RR.1.a Use	a decision tree to n.	Expectations for Learning	
make a decisio		LEARNING PROGRESSION In kindergarten, students were introduced to decision trees. In grade 1, students use a decision tree to make a decision. In grade 2, students will create simple decision trees.	
		 IMPORTANT CONCEPTS Students can use decision trees to make decisions. 	
		 KEY SKILLS/PROCEDURES Identify that decision trees are ways to come up with reasonable answers. 	
		Content Elaborations	
		CLARIFICATIONS Decision trees have binary answers. This means there are only two choices as input.	
		CONTENT FOCUS The focus is to participate in creating a decision tree to solve simple technical problems.	
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.	

Strand	Artificial	Intelligence
Торіс	Societal I	mpacts
AI.SI.1.a Identify AI applications that are used in daily lives to predict AI use in the future.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students located Artificial Intelligence (AI) applications to understand how humans use AI. In grade 1, students identify AI applications that are used in daily life. In grade 2, students will group applications as AI or not AI.
		 IMPORTANT CONCEPTS List and discuss applications that use artificial intelligence. Give ideas of how AI might help in the future.
		 KEY SKILLS/PROCEDURES Create a list or ideas on AI that might work in the future to demonstrate that AI is a growing and changing field.
		Content Elaborations
		CLARIFICATIONS Al is a new and emerging technology that is constantly changing and adapting to humans use.
		CONTENT FOCUS The focus is on AI applications and how they are used in our daily lives.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
AI.SI.1.b Discuss if c	computers	Expectations for Learning
and other technology bad to create a work	/ are good or ing construct.	LEARNING PROGRESSION In kindergarten, students discussed if something is good or bad in terms of computers. In grade 1, students discuss if computers and other technology are good or bad. In grade 2, students will discuss if Artificial Intelligence (AI) is good or bad.
		 IMPORTANT CONCEPTS Discuss ways technology can help or harm us.
		 KEY SKILLS/PROCEDURES Create lists of how technology makes life better or worse to see differences in the use of technology.

Strand	Artificial Intelligence	
Торіс	Societal I	mpacts
		Content Elaborations
		CLARIFICATIONS Technology is not always positive and sometimes non-technological ways are better.
		CONTENT FOCUS Al is a type of technology and it is a tool for humans to use.
		COMPUTER SCIENCE PRACTICES
		 Practice 3. Recognizing and Defining Computational Problems 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand Impacts of C	Impacts of Computing	
Topic Culture		
IC.Cu.1.a Discuss different technologies and their impact on everyday life. IC.Cu.1.b Identify how people use and are impacted by many types of technologies in their daily work and personal lives.	 Expectations for Learning LEARNING PROGRESSION In kindergarten, students identified what technology is and how it has changed and impacted their lives. In grade 1, they recognize the different ways technology impacts, and the role technology plays in their lives. In grade 2, students will compare and contrast how technology use has changed and the impact it has on their lives positively and negatively. IMPORTANT CONCEPTS Technology plays a role in our everyday life. Technology is constantly changing and affects how we live. KEY SKILL/PROCEDURES Compare past and present technology and how it affects our lives. Content Elaborations ClaRIFICATIONS Students can identify and explain the connections between their lives and technology and how technology affects their lives. COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. 	

Strand	Impacts of Computing	
Торіс	Culture	
		<i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	Computing
Торіс	Social Intera	actions
IC.SI.1.a With gui safe and responsi the use of informa and technology.	dance, describe ble behaviors for ation	 Expectations for Learning LEARNING PROGRESSION In kindergarten, students used technology responsibly and safely with teacher support. In grade 1, with guidance, students can describe how to be safe and responsible using technology. In grade 2, students will be able to compare and contrast safe and responsible technology behaviors. IMPORTANT CONCEPTS Schools develop their own technology rules, regulations and etiquette. KEY SKILL/PROCEDURES With guidance, describe appropriate behaviors on how to use technology and apply those rules, regulations and etiquette within the classroom. Content Elaborations CLARIFICATIONS Etiquette topics might include cyberbullying, school policy and safe privacy practices. COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. Practice 7. Communicating About Computing Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.1.a With guidance, discuss appropriate and ethical uses of technology to guide informed decisions.		Expectations for Learning LEARNING PROGRESSION In kindergarten, students used technology responsibly and safely with teacher support. In grade 1, with guidance, students should be able to describe how to be safe and responsible using technology. In grade 2, students will be able to compare and contrast safe and responsible technology behaviors.
		 IMPORTANT CONCEPTS Guidelines and practices to stay safe on the internet should be discussed and practiced. Awareness of what private information is, what should and should not be shared and what are the potential consequences of sharing private information.
		 KEY SKILL/PROCEDURES With guidance, identify practices to stay safe on the internet and provide examples of situations where these practices should be applied.
		Content Elaborations
		CLARIFICATIONS Provide students guidelines for safe navigation of the internet. Provide students opportunities to practice these guidelines by using teacher-selected internet sites.
		Provide students guidelines on what constitutes personal information and the consequences of misuse.
		Students have the opportunity to apply basic security practices as part of their activities addressing cybersecurity (NI.C.1.a).
		CONTENT FOCUS The focus is to keep students safe when using the internet.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		 Practice 2. Collaborating Around Computing 1. Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
IC.SLE.1.b Discuss examples of appropriate and inappropriate behavior online, including cyberbullying, and the steps to keep yourself and others safe and out of harm's way.		 Expectations for Learning LEARNING PROGRESSION In kindergarten through second grade, student discussions should focus on examples of what to do when someone is hurtful online and what behavior should be modeled when online. IMPORTANT CONCEPTS Students give examples of people in authority, such as a principal, teacher or police officer with whom they might share private (privileged) information. Students know who to contact for help when they feel unsafe or witness inappropriate online behavior. KEY SKILLS/PROCEDURES Recognize when students should report observed inappropriate online behavior to those in authority. Understand and discuss ways to keep yourself and others safe online. Students should understand the concept of cyberbullying.
Strand	Impacts of Computing	
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Торіс	Safety, Law and Ethics	
		 Content Elaborations CLARIFICATIONS Students need to make good choices when they interact with others online. They also need to understand that in addition to interacting with others, it is important that they use websites and other apps as they were intended. Students could be held responsible for their actions online because some online behavior is illegal. CONTENT FOCUS Students should understand the appropriate and inappropriate behavior to use when operating online. Students should also know who to talk to if they feel threatened or report inappropriate behavior. 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. Practice 6. Testing and Refining Computational Artifacts. 1. Systematically test computational artifacts by considering all scenarios and using test cases.

GRADE 2

Strand	Computing	Systems
Торіс	Devices	
CS.D.2.a Select a commonly used of perform a variety	and operate levices to of tasks.	Expectations for Learning LEARNING PROGRESSION In grade 1, students began operating devices independently. In grade 2, students begin selecting devices with a purpose in mind. In grade 3, students will develop an understanding that the device they selected for a specific task has components that all play a role in the computer system. The data is entered into an external device and is then placed into the computer system where it can be shared locally and globally.
		 IMPORTANT CONCEPTS Different devices can be used to perform specific tasks.
		 KEY SKILL/PROCEDURES Choose between devices that can perform specific tasks.
		Content Elaborations
		CLARIFICATIONS Students will use their knowledge of hardware and software from kindergarten and grade 1 to make a selection to complete a task.
		CONTENT FOCUS The focus is on the student making a selection (i.e., device, software, hardware) to complete a task.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		 Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing Systems	
Торіс	Hardware ar	nd Software
CS.HS.2.a Select and use hardware and software necessa for accomplishing a task.		Expectations for Learning LEARNING PROGRESSION In grade 1, students began comparing hardware and software and their functions with guidance. In grade 2, students begin selecting devices with a purpose in mind. In grade 3, students will select learning tools or devices to plan, implement and reflect upon tasks.
		 IMPORTANT CONCEPTS Select hardware and software to perform a specific task. Hardware and software interact to work together.
		 KEY SKILL/PROCEDURES Identify hardware and software interactions. Select hardware and/or software to perform a specific task.
		Content Elaborations
		CLARIFICATIONS Students will select hardware and software with a specific purpose in mind.
		CONTENT FOCUS The focus is on the selection of a tool to complete a specific task.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		<i>Practice 2.</i> Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Computing Systems	
Торіс	Troublesh	ooting
Topic CS.T.2.a Use probles strategies to trouble a problem.	Troublesho em-solving eshoot	Expectations for Learning LEARNING PROGRESSION In grade1, with guidance, and in grade 2, students continue using a problem-solving process to troubleshoot. In grade 3, students will begin to move beyond trial and error to apply more strategic troubleshooting techniques to fix their problems. IMPORTANT CONCEPTS • There are a variety of problem-solving processes. A problem-solving process typically includes identifying the problem, brainstorming solutions, making a plan, testing solutions and revising. KEY SKILL/PROCEDURES • Apply a problem-solving process, using appropriate terminology to solve a problem. Content Elaborations Students will identify problems (e.g., left- or right-click, no audio, no power, navigating windows) and attempt to solve them using a problem-solving process. CONTENT FOCUS The focus is on solving a problem using a problem-solving process. COMPUTER SCIENCE PRACTICES Bractice 6, Testing and Pefining Computational Addifacte
		 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks and the Internet	
Торіс	Networking	
 NI.N.2.a Describe can be communic electronically to g understanding of is transmitted (e.g social media). NI.N.2.b Use com that are connecte receive informatio global community 	e how information cated ain a deeper how information g., email, nputing devices d to share and on from the	Expectations for Learning LEARNING PROGRESSION In grade 1, students began to develop an understanding of concepts of networking and unique identifiers within a global community. Students also began to develop an understanding of what devices people use to network and how each device people network with has a unique identifier. In addition, students recognized that computing devices with unique identifiers can be connected to access and retrieve information. In grade 2, students can describe what a network is, the devices we use to network, how devices can be identified, and how they can be connected. Additionally, students can network using devices to access and retrieve information within a global community. In grade 3, students will explore how information is sent and received over the internet. Students will continue to build an understanding of how information is shared, received and stored.
		 IMPORTANT CONCEPTS Users of the internet communicate with a global community. All devices that are connected to the network have a unique identifier. A variety of information can be communicated electronically.
		 KEY SKILL/PROCEDURES Interact with the global community. Create and use communications that are transmitted electronically. Match devices with unique identifiers.
		Content Elaborations
		CLARIFICATIONS Students will communicate and retrieve information. They will identify the devices we use to communicate.
		The internet is global. Each device has a unique identifier. This is not limited to IP addresses. A person's phone number can serve as a metaphor for a unique identifier. For example, two people can exchange information using their phones providing they call or connect to the correct phone number.
		CONTENT FOCUS The focus is on understanding and using networks, unique identifiers and electronic communication.

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Strand	Networks and the Internet	
Торіс	Networking	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Practice 7. Communicating About Computing Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks a	nd the Internet
Торіс	Cybersecu	rity
NI.C.2.a Explain and demonstrate secure practices (e.g., creating strong passwords) to protect private information.		Expectations for Learning LEARNING PROGRESSION In kindergarten through grade 2, students work to explain why it is important to use technology in a responsible way to make decisions about its use. Students also work to demonstrate how to use technology appropriately and safely and how to protect login information. In grade 3, students will identify personal information and how passwords are used to protect that information.
		 IMPORTANT CONCEPTS Use technology in decision-making. KEY SKILL/PROCEDURES Create and use passwords appropriately. Log in and out of apps and devices. Explain and demonstrate secure practices.
		Content Elaborations CLARIFICATIONS Students need to be able to apply the skills below to demonstrate understanding of the content statement. Protecting their password Making strong passwords Logging in and out of apps and devices Being responsible Discussing impacts of poorly secured information
		 CONTENT FOCUS The focus is on using passwords and devices appropriately and explaining the importance of secure practices. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Strand	Networks and the Internet
Торіс	Internet of Things
NI.IOT.2.a With guidance and support, will explain how devices connect and exchange data over different environments to explore how information is shared.	 Expectations for Learning LEARNING PROGRESSION In grade 1, students began developing an understanding of smart devices. In grade 2 they explain how devices connect and exchange data. Additionally, they will explore different network connectivity. In grade 3, students will describe information transmission and explore and explain the difference between smart and intelligent devices.
	 IMPORTANT CONCEPTS Some networks are public and some are private. Public networks are less secure than private networks.
	 KEY SKILLS/PROCEDURES Explain the difference between common types of network connections (such as the school Wi-Fi vs. home Wi-Fi) and which is more secure.
	Content Elaborations
	CLARIFICATIONS Information can be shared via public or private internet connections, such as home, school or library.
	CONTENT FOCUS Public internet connections are less secure than private internet connections.
	 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and A	nalysis
Торіс	Data Collec	tion and Storage
DA.DCS.2.a Collect and organize data to store, retrieve and modify. DA.DCS.2.b Manipulate data to perform various tasks.		Expectations for Learning LEARNING PROGRESSION In grade 1, students began storing and retrieving data with guidance. In grade 2, students begin to retrieve data to modify. In grade 3, students will use different software tools to access data and store it in different locations. In grade 3, students will collect, record and maintain data, over time, using various tools, such as a thermometer, ruler, scale and surveys.
		 IMPORTANT CONCEPTS Data is information. When using technology, data is often quantities, characters or symbols that are the inputs and outputs of computer programs. Data can be organized, collected, stored and retrieved in a variety of ways.
		 KEY SKILL/PROCEDURES Use appropriate tools to organize data. Use appropriate tools to collect data. Store, retrieve and save data. Edit, revise and rename data.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		A structured set of data can be used to help students learn the skills of retrieving and organizing data.
		CONTENT FOCUS The focus is on modifying retrieved data.
		COMPUTER SCIENCE PRACTICES <i>Practice 4.</i> Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.

Strand	Data and Analysis	
Торіс	Visualizatio	on and Communication
DA.VC.2.a Organize, analyze and present data in various formats.		Expectations for Learning LEARNING PROGRESSION In grade 1 students will make observations of representations of data. In grade 2, they will continue to analyze data in various formats. In grade 3, students will extend their knowledge by creating scaled pictures and bar graphs. They will also create line plots using scales that include whole numbers and fractions (e.g., halves and fourths).
		 IMPORTANT CONCEPTS Data can be sorted by attributes. Data can be presented in a variety of formats.
		 KEY SKILL/PROCEDURES Collect, organize and analyze data for peer understanding. Describe and sort data by different attributes to create multiple representations of the same data sets. Transfer data between grids to lists.
		Content Elaborations CLARIFICATIONS Students can address this content with or without a computing device
		 Various formats can include: concept maps, Venn diagrams, categorical sort, modeling, drawings and sorting by different attributes.
		Students can analyze data by looking at the data of two mammals, for example. What traits do they have in common? What traits are different?
		CONTENT FOCUS The focus is on the analysis of representations of data.

Strand	Data and Analysis	
Торіс	Visualization and Communication	
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it. Practice 6. Testing and Refining Computational Artifacts Systematically test computational artifacts by considering all scenarios and using test cases. Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Analysis	
Торіс	Inference a	nd Modeling
DA.IM.2.a Interpret and analyze data, graphs, models or charts.		Expectations for Learning LEARNING PROGRESSION In grade 1, students continued to model data and identify patterns and began explaining their model. In grade 2, students begin interpreting models. In grade 3, students will analyze and explain relationships or patterns and predict an unknown.
		Data can be represented through modeling.Patterns within the data can be discovered, explained and interpreted.
		 KEY SKILL/PROCEDURES Model data to discover and identify patterns. Explain the model and patterns discovered. Interpret the meaning of the patterns discovered.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Students model data through representation data visually; although, not necessarily using paper and pencil as in graphs. Data can be modeled using manipulatives and physical models.
		CONTENT FOCUS The focus is on the interpretation and analysis of the model.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user experience. Create a computational artifact for practical intent, personal expression or to address a societal issue. Modify an existing artifact to improve or customize it.

Strand	Data and Analysis	
Торіс	Inference a	nd Modeling
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic Thinking and Programming	
Торіс	Algorithms	
ATP.A.2.a Model a real-world process by constructing and following step-by-step instructions (i.e., algorithms) to complete tasks.		Expectations for Learning In grade 1, students constructed and followed directions through pictures and written words with guidance. In grade 2, students construct and follow directions in a real-world context through written words, statements and visual symbols. In grade 3, students will create step-by-step tasks (i.e., algorithms) and find errors within an algorithm.
		 IMPORTANT CONCEPTS Step by step directions can be constructed to complete a real-world task. Directions can be given verbally or visually.
		 KEY SKILL/PROCEDURES Construct and complete a verbal and/or visual task with multiple steps.
		Content Elaborations CLARIFICATIONS Students identify a task from their daily life (e.g., brushing teeth, getting ready for school, walking home from school) and break it into a sequence of steps (i.e., algorithm). Students should construct a sequence of steps to complete a task using precise language and visuals/symbols, to see the effects of a sequence. Students should compare sequences for the same task, to identify similarities and differences within the sequence. Algorithms are commonly implemented using a precise language that computers can interpret.
		CONTENT FOCUS The focus is on the construction of multi-step directions and the sequence of steps to complete a task.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic	Thinking and Programming
Торіс	Variables a	nd Data Representation
ATP.VDR.2.a Construct a model that shows the way programs store and manipulate data by using numbers or other symbols to represent information.		Expectations for Learning LEARNING PROGRESSION In grade 1, students used numbers, symbols and pictures to represent information. In grade 2, students model the use of numbers, symbols and pictures to manipulate and store information. In grade 3, students will define and identify variables to understand how they are used in algorithms.
		 IMPORTANT CONCEPTS Numbers, symbols or pictures can be used to model programming. Information is stored in a variety of ways.
		 KEY SKILL/PROCEDURES Model programming using symbols, numbers or pictures. Store information in a variety of ways.
		Content Elaborations
		CLARIFICATIONS Information in the real world can be represented in computer programs. (K-12 Computer Science Framework, 2016)
		Computers use stored information by choosing only relevant information.
		CONTENT FOCUS The focus is on modeling the way programs store and manipulate data.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Algorithmic	c Thinking and Programming
Торіс	Control Str	uctures
ATP.CS.2.a Devel that uses sequence repetition (i.e., loop problem or express	op a program ing and ps) to solve a s ideas.	Expectations for Learning LEARNING PROGRESSION In grade 1, with guidance, students modeled loops in their sequence of steps or programs to show repetition. In grade 2, students create a program that utilizes sequencing and loops. In grade 3, students will build on their skills and knowledge to create programs with more refined strategies, such as loops and conditionals, and consider the components of an event. IMPORTANT CONCEPTS • Programs are made of algorithms and loops. KEY SKILL/PROCEDURES • Create a program utilizing algorithms and loops. Content Elaborations CLARIFICATIONS Students create, or construct a program. Loops are repeated sequences. CONTENT FOCUS The focus is on using sequencing, process, loops and problem solving to create an algorithm (i.e., program). COMPUTER SCIENCE PRACTICES Practice 5. Creating a Computational Artifact 1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering 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. Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology

Strand	Algorithmic	c Thinking and Programming
Торіс	Modularity	
ATP.M.2.a Break down (i.e., decompose) a series of steps and separate the necessary from the unnecessary steps to create a precise sequence of instructions to solve a problem or express an idea		Expectations for Learning LEARNING PROGRESSION In grade 1, students determined what information is necessary to complete a sequence or process with guidance. In grade 2, students determine what information is necessary to complete a more complex sequence or process. In grade 3, students will decompose abstractions into sequences to design algorithms.
		 IMPORTANT CONCEPTS Decomposition is to break down a series of steps. Abstraction is to use the relevant information.
		 KEY SKILL/PROCEDURES Decompose a problem into a series of steps. Abstract information relevant to the problem being solved.
		Content Elaborations
		CLARIFICATIONS Students can address this content with or without a computing device.
		Students will work with a more complex sequence of more than three steps.
		Abstraction is to determine which information is relevant or irrelevant to the problem. Decomposition is taking a problem and breaking it into steps.
		CONTENT FOCUS The focus is on decomposing and the abstraction of information in a sequence of instructions to solve a problem.
		 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.

(step-by-step) manner (e.g., story illustrate thoughts, ideas, and problems in a sequential manner. In grade 2, students continue to plan, map, storyboard, sequential create or fix an artifact to illustrate thoughts, ideas and problems sequentially. In grade 3, students will use graphic organizer). these skills to design and create programs to solve a problem. In grade 3, guided questions will be asked to ATP.PD.2.b Identify and fix help students think more strategically about how to solve a problem in their program (i.e., debug) a multi-step process **IMPORTANT CONCEPTS** that includes sequencing. • Artifacts illustrate thoughts, ideas and problems in a sequential manner. • When creating artifacts, it is important to review your artifact for errors. **KEY SKILL/PROCEDURES** Plan and create an artifact to illustrate thoughts, ideas and problems sequentially. Evaluate an artifact for errors. **Content Elaborations CLARIFICATIONS** An artifact is anything created by a human. An artifact could be a visual program, story map, storyboard or sequential graphic organizer. Debug is defined as "to identify and fix." CONTENT FOCUS The focus is on creating and debugging artifacts and programs. **COMPUTER SCIENCE PRACTICES** Practice 5. Creating a Computational Artifact 1. Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering 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. Practice 6. Testing and Refining Computational Artifacts

Algorithmic Thinking and Programming

Program Development Topic

ATP.PD.2.a Plan and create an artifact to illustrate thoughts, ideas and problems in a sequential

Strand

Expectations for Learning

LEARNING PROGRESSION

In grade 1, with guidance, students continued to plan and create, as well as began to debug an artifact to

2. Identify and fix errors using a systematic process.

Strand	Algorithmic Thinking and Programming	
Торіс	Program Development	
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Artificial Intelligence	
Торіс	Machine Lea	rning
AI.ML.2.a Use a recognizes drawi how the program are drawing.	Machine Lean classifier that ings and discuss knows what they	 Expectations for Learning LEARNING PROGRESSION In grade 1, students discuss how machine learning uses classifiers to recognize drawings. In grade 2, students use a classifier that recognizes drawings and discuss how the program knows what they are drawing. In grade 3, students will be introduced to specific forms of machine learning. IMPORTANT CONCEPTS Define and understand the uses of classifiers. Discuss how Artificial Intelligence (AI) can recognize various drawings as a form of machine learning. KEY SKILLS/PROCEDURES Apply the use of AI in a classifier to gain knowledge of how machine learning works. Content Elaborations Al can recognize human inputs through the use of classifiers. CONTENT FOCUS Al uses machine learning to learn new things. COMPUTER SCIENCE PRACTICES
		<i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Artificial Intelligence	
Торіс	Natural Intera	actions
AI.NI.2.a List por	ssible attributions	Expectations for Learning
humans from ea comparing these	ch other by attributions.	LEARNING PROGRESSION In grade 1, students used recognition software and describe attributes of the software used. In grade 2, students list possible attributions computers can use to distinguish humans from each other. In grade 3, students identify tasks Artificial Intelligence (AI) does that humans used to do.
		 IMPORTANT CONCEPTS List and discuss attributes that can be used to identify individuals. Explore variations in attributions.
		 KEY SKILLS/PROCEDURES List attributions AI might use to describe how computers recognize human faces from each other.
		Content Elaborations
		CLARIFICATIONS Exploring attributions and changes in them such as faces and expressions.
		CONTENT FOCUS The focus of the content is on how computers can recognize humans even if humans change their expressions.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.



Strand	Artificial Inte	elligence
Торіс	Perception	
AI.P.2.a Tell who are on computer intelligent applia their location wit such as motion, pressure/touch, proximity, light, s moisture or gase	ere sensors rs, robots and nces to relate h their function temperature, sound, es.	 Expectations for Learning LEARNING PROGRESSION In grade 1, students will recognize various sensors and their functions. In grade 2, students tell where sensors are on computers and intelligent appliances. In grade 3, students will understand the difference in sensor inputs. IMPORTANT CONCEPTS Computers use specific sensors in specific places to gather data. Each type of sensor captures specific information such as motion, pressure/touch, temperature, proximity, light, sound, moisture or gases. KEY SKILLS/PROCEDURES Tell where the sensors are and why they are placed there. Content Elaborations Students will discover why sensors are placed where they are. For example, accelerometer sensors are placed in smartphones that can track steps. CONTENT FOCUS Sensors are needed for computers to gather information and then use that data to give or process information. COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems

Strand	Artificial Intelligence	
Торіс	Perception	
AI.P.2.b Apply the use of intelligent agents to assist in basic research (look up answers to specific questions).		Expectations for Learning LEARNING PROGRESSION In grade 1, students used intelligent agents to answer simple questions. In grade 2, apply the use of intelligent agents to assist in basic research. In grade 3, they will begin to see that there are limitations to intelligent agents.
		 IMPORTANT CONCEPTS Intelligent agents are a form of Artificial Intelligence (AI).
		 KEY SKILLS/PROCEDURES Use intelligent agents to assist in research.
		Content Elaborations
		CLARIFICATIONS Examples of intelligent agents are virtual assistant technology that can play music, provide information, deliver news, control smart homes and give other information.
		CONTENT FOCUS Students can use an intelligent agent to help them do simple research that can be used to report back to the class.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Artificial Inte	elligence
Торіс	Representat	ion & Reasoning
AI.RR.2.a With g support, create a tree (conditionals pathway for decis	uidance and simple decision b) to create a sions.	Expectations for Learning LEARNING PROGRESSION In grade 1, students used simple decision trees. In grade 2, students create a simple decision tree with guidance and support. In grade 3, students will create a decision tree to help them understand how computers "think." IMPORTANT CONCEPTS With guidance and support, create decision trees
		 With guidance and support, create decision trees. KEY SKILLS/PROCEDURES Demonstrate the creation of a decision tree to find a logical solution to a problem. Content Elaborations
		CLARIFICATIONS Decision trees are a way of organizing information.
		CONTENT FOCUS Students can draw a tree by repeatedly splitting each branch into sub-branches multiple times and putting a piece of data at each branch.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations.

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Strand	Artificial Intelligence	
Торіс	Societal Imp	acts
Al.SI.2.a To dete	ermine how Al	Expectations for Learning
applications used categories: "Al" a	d into two and "Not AI."	LEARNING PROGRESSION In grade 1, students identified Artificial Intelligence (AI) applications in their daily life. In grade 2, students group applications used as AI or not AI to determine how AI can help in daily life. In grade 3, students will discuss how AI can be inclusive.
		 IMPORTANT CONCEPTS Al devices are used to help everyone have equal access to technology.
		 KEY SKILLS/PROCEDURES Identify the use of AI in daily life and show how it can help everyone have equal access to technology.
		Content Elaborations
		CLARIFICATIONS Some of the different ways humans can access technology include speech, typing, motion and thought.
		CONTENT FOCUS Not everyone accesses technology the same way. Al can help everyone access technology equally.
		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	
Торіс	Societal Imp	acts
AI.SI.2.b Discuss can be used for o discuss the ethic	s AI and how it good or bad to al use of AI.	Expectations for Learning LEARNING PROGRESSION In grade 1, students discussed if computers and/or technology are good or bad. In grade 2, students discuss Artificial Intelligence (AI) and how it can be used for good or bad. In grade 3, students are introduced to the concept of bias.
		 IMPORTANT CONCEPTS Technology can help or harm us depending on how we interact with AI and its data sets.
		 KEY SKILLS/PROCEDURES Demonstrate the use of a data set to show that AI's use data sets. Data sets can be incorrect and may make our life better or worse.
		Content Elaborations
		CLARIFICATIONS Technology has faults. For example, facial recognition, various skin colors and accents may or may not be recognizable.
		CONTENT FOCUS Al uses data sets to learn more about its surroundings and those data sets can be incomplete.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.2.a Comp how the use of t changed to unde on everyday life IC.Cu.2.b Descr people use tech daily work and p understand tech on one's commu	are and contrast echnology has erstand its impact ibe the ways hologies in their ersonal lives to nology's impact nity.	 Expectations for Learning LEARNING PROGRESSION In grade 1, students recognized the different ways technology impacts and the role technology plays in their lives. In grade 2, students compare and contrast how technology use has changed and the impact it has on their lives positively and negatively. In grade 3, students will identify the impact technology has on everyday life in the local community. Students will identify diverse user needs and how computing devices have features built in to increase accessibility to all users. IMPORTANT CONCEPTS Technology is always changing. These changes affect our communities and the role it plays in our lives. KEY SKILL/PROCEDURES Describe the changes in technology and how we interact with technology over time. Demonstrate how humans adapt technology to serve their needs. Demonstrate how technology can have negative consequences.
		Content Elaborations CLARIFICATIONS Students can identify and explain the connections between their lives and technology and how technology affects their lives.
		CONTENT FOCUS The focus is on how technology has changed and the impact on students' lives.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand	Impacts of Computing	
Торіс	Culture	
		<i>Practice 2</i> . Collaborating Around Computing 1. Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities.
		<i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of	Computing		
Topic Social In		eractions		
IC.SI.2.a Compare and contrast safe and responsible behaviors to those that are not when using information and technology.		Expectations for Learning LEARNING PROGRESSION In grade 1, with guidance, students were able to explain safe and responsible behaviors associated with using information and technology while working with others online. In grade 2, students should be able to compare and contrast safe and responsible technology behaviors. In grade 3, students will apply a code of conduct to use technology safely and responsibly within an online community. In grade 3, students will collaborate through feedback and reflection to improve a digital artifact and begin to explore how diverse perspectives improve a digital product.		
		 IMPORTANT CONCEPTS Schools develop their own technology rules, regulations and etiquette. 		
		 KEY SKILL/PROCEDURES Create rules based on the school technology rules, regulations and etiquette on how to use technology. Apply created rules within the classroom and during students' use of technology. Identify inappropriate actions and the consequences. 		
		Content Elaborations		
		CLARIFICATIONS Etiquette topics might include cyberbullying, school policy, and safe privacy practices.		
		CONTENT FOCUS The focus is on the responsible use of technology in and out of the classroom.		
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 		
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. 		

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Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
IC.SLE.2.a Discus and ethical uses o guide informed de	es appropriate f technology to cisions.	Expectations for Learning LEARNING PROGRESSION In grade 1, with guidance, students continued to identify and explain basic security practices that should be applied when using the internet. In grade 2, in concert with cybersecurity activities, students can recognize weak security practices, implement secure practices to protect private information to ensure security is not compromised and explain why it is important to apply these measures. In grade 3, the focus will continue to focus on security, while also giving students more explanations regarding why it is important to keep information secure. Information security and the concept of a digital footprint will be introduced in grade 3.
		 IMPORTANT CONCEPTS Guidelines and practices to stay safe on the internet should be discussed and practiced. Awareness of what private information is, what should and should not be shared and the potential consequences of sharing private information.
		 KEY SKILL/PROCEDURES Identify practices to stay safe on the internet; Provide examples of situations where these practices should be applied and describe different consequences that may result from not using safe practices.
		Content Elaborations
		CLARIFICATIONS Provide students guidelines for safe navigation of the internet. Provide students opportunities to practice these guidelines by using teacher-selected internet sites.
		Provide students guidelines on what constitutes personal information and the consequences of misuse. Provide them guidelines on how to create strong passwords.
		Students have the opportunity to apply security practices as part of their activities addressing cybersecurity (NI.C.2.a)
		CONTENT FOCUS The focus is to keep students safe when using the internet.

Strand	Impacts of	Computing
Торіс	Safety, Law	and Ethics
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		<i>Practice 2.</i> Collaborating Around Computing 1. Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities.
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
IC.SLE.2.b Compare and contrast appropriate and inappropriate behavior online, including cyberbullying, and the steps to keep yourself and others safe and out of harm's way.		 Expectations for Learning LEARNING PROGRESSION In kindergarten through second grade, student discussions should focus on examples of what to do when someone is acting inappropriately online and what behavior should be modeled when online. IMPORTANT CONCEPTS Students know whom to contact if they experience inappropriate behavior while online. Students know what steps to take when they experience inappropriate behavior online. KEY SKILLS/PROCEDURES Recognize when students should report observed inappropriate online behavior to those in authority. Understand and discuss ways to keep yourself and others safe online. Content Elaborations Students need to make good choices when they interact with others online. They also need to understand that in addition to interacting with others, it is important that they use websites and other apps as they were intended. Some online behavior is illegal, and students could be held responsible for their actions online.

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		CONTENT FOCUS Students should understand the appropriate and inappropriate behavior to use when operating online. Students should also know who to talk to if they feel threatened or report inappropriate behavior.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 3. Employ self and peer advocacy to address bias in interactions, product design and development methods.

Grades 3-5

GRADE 3

Strand	Computing	Systems
Торіс	Devices	
CS.D.3.a Explore common components (i.e., parts) of a computing system and their function to understand and describe the role they play in a computer system.		Expectations for Learning LEARNING PROGRESSION In grade 2, students began selecting devices with a purpose in mind. In grade 3, students develop an understanding that the device they selected for a specific task has components (i.e., parts) that play a role in the computer system. In grade 4, students will develop their understanding of what external components are used to share information locally and globally.
		 IMPORTANT CONCEPTS External devices are used to input data into the computer. Different devices have different purposes. Each external component (i.e., part) has a different function in a computer system.
		 KEY SKILL/PROCEDURES Identify key components (i.e., parts) such as keyboard, trackpad/mouse, monitor, printer, tablet, etc. Select an appropriate device to accomplish a task. Describe the components of the selected device.
		Content Elaborations
		CLARIFICATIONS Different devices may include a personal computer, tablet, laptop, or smartphone. External components (i.e., parts) include a keyboard, mouse/trackpad, monitor/screen, USB port and drive. Sometimes, a component (part) on a device can have multiple functions. For example, a screen can have multiple functions when the screen also serves as the trackpad or keyboard.
		CONTENT FOCUS The focus should be on students understanding the components (i.e., parts) of the device that they select for their task. If they selected a tablet, students should understand that various parts may perform multiple tasks. For example, the screen serves as a monitor and input device with a keyboard.
		COMPUTER SCIENCE PRACTICES <i>Practice 2.</i> Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.

Strand	Computing Systems	
Торіс	Hardware a	and Software
CS.HS.3.a Identify learning tools/devic planning, implemen reflecting upon a de	and use digital es to support ting and efined task.	Expectations for Learning LEARNING PROGRESSION In grade 2, students began selecting devices with a purpose in mind. In grade 3, students select learning tools or devices to plan, implement and reflect upon tasks. In grade 4, students will continue to select learning tools and devices and will use them to aid in planning, implementing and reflecting upon given tasks.
		 IMPORTANT CONCEPTS Different types of software and hardware can be used to accomplish a task. Learning tools should support the planning, implementation and reflection of a task.
		 KEY SKILL/PROCEDURES Select and use a tool, such as a presentation software program, document, graphic design program or video editing software, to accomplish a given task. Select and use an appropriate device, such as a tablet, laptop or desktop to accomplish a given task.
		Content Elaborations
		CLARIFICATIONS Tools can range from basic programs, such as word processing and presentation software to other online tools.
		CONTENT FOCUS The focus is on students selecting and using a tool or device to accomplish a task. Students should be given opportunities to self-select a tool to accomplish a task.
		COMPUTER SCIENCE PRACTICES <i>Practice 2.</i> Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.

Strand	Computing	Systems
Торіс	Troublesho	oting
CS.T.3.a Apply tro strategies given pr solutions to resolve software problems	Ibleshooting Iblems and hardware and	Expectations for Learning LEARNING PROGRESSION In grade 2, students continued to work on their use of problem-solving. In grade 3, students begin to move beyond trial and error to apply more strategic troubleshooting techniques to fix their problems. In grade 4, students will focus on diagnosing and describing potential hardware and software problems.
		 IMPORTANT CONCEPTS Troubleshooting strategies can be used to solve hardware and software issues.
		 KEY SKILL/PROCEDURES Use a troubleshooting technique to solve a given problem.
		Content Elaborations
		CLARIFICATIONS Examples of problems to troubleshoot at this level may be a computer not connecting to the network or not turning on. Students should state what the problem is instead of just referring to the problem as "the computer is broken."
		CONTENT FOCUS The focus is on students using targeted troubleshooting techniques to solve given problems.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand	Strand Networks and the Internet	
Topic Networking		
NI.N.3.a Describe communication occ information is sent over physical or wi explain communica (e.g., sending an e a website).	how curs when and received ireless paths to ation systems email or visiting	Expectations for Learning LEARNING PROGRESSION In grade 2, students described what a network was, the devices we use to network, how devices can be identified, and how they can be connected. Additionally, students networked using devices to access and retrieve information within a global community. In grade 3, students explore how information is sent and received over the internet. In grade 4, students will elaborate on how information is broken down and transmitted before it is received.
		 IMPORTANT CONCEPTS A web address or URL has a different function than searching for content. Information is communicated through a wired or wireless connection.
		 KEY SKILL/PROCEDURES Enter a precise address to reach a site. Recognize whether a network (i.e., internet) connection is present. Conduct basic troubleshooting techniques based on network connectivity.
		Content Elaborations
		CLARIFICATIONS Students often confuse the address bar for the search bar when attempting to access a website. Students should understand that these have two different functions, and a web address should be accessed through an address bar. The web address should be typed in exactly to access the site they are attempting to reach.
		Students should understand that online information cannot be accessed without a network connection. They should be able to recognize whether a network connection is present.
		Basic troubleshooting techniques for network connectivity could include restarting a device, refreshing a webpage or attempting to reconnect to the network.
		CONTENT FOCUS The focus is on students entering a precise URL (web address) into the address bar to reach a site and recognizing that reaching this site cannot be done without a network connection.
Strand	Networks and the Internet	
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Торіс	Networking	
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.3.b Recognize that every device on a network has a unique identifier to share or receive information from the global community.		Expectations for Learning LEARNING PROGRESSION In grade 2, students described what a network is, the devices we use to network, how devices can be identified and how they can be connected. Additionally, students networked using devices to access and retrieve information within a global community. In grade 3, students continue to build an understanding of how information is shared, received and stored. In grade 4, students will build their vocabulary around these concepts.
		 IMPORTANT CONCEPTS Similar to a personal mailing address, every device has a unique address for sending or receiving information.
		 KEY SKILL/PROCEDURES Recognize that every device has a unique network address.
		Content Elaborations
		CLARIFICATIONS Students should understand that their device has a unique address. This is like their mailing address in the sense that the information knows where to travel based on the address.
		CONTENT FOCUS The focus is on students recognizing that devices have unique web addresses.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Networks and the Internet

Strand

Department of Education

Ohio

Topic Cybersecur	rity
NI.C.3.a Explore digital safety concepts in order to explain that information can be both public and private, to determine what information can safely be shared and to know how to use passwords to protect information.	Expectations for Learning LEARNING PROGRESSION In K-2, students have had experience identifying private and public information. In grade 3, students explore and understand personal information and how passwords are used to protect that information. In grade 4, students will describe the importance of using a secure password to protect personal information.
	 IMPORTANT CONCEPTS Personal information is valuable and both private and sharable. Personal (private) information should be protected by passwords.
	 KEY SKILL/PROCEDURES Explain private vs. public information and that this is called personal information. Explain why passwords are used.
	Content Elaborations
	CLARIFICATIONS Students struggle with what to share or not to share, which is private or public information. They should make the connection between that and personal information.
	Students often think it is okay to share their passwords with their peers. They need to connect passwords with something that needs to be private.
	CONTENT FOCUS The focus is on students exploring and understanding different types of personal and public information and why passwords are important.
	COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Networks a	ind the Internet
Торіс	Cybersecu	rity
NI.C.3.b Explore and explain grade-appropriate examples of unsafe content, such as pop-ups and malicious links.		Expectations for Learning LEARNING PROGRESSION In grade 3, students will explore and explain grade-appropriate examples of unsafe content. In grade 4, students describe the effects of malicious content. In grade 5, students will analyze the inappropriate use of online services.
		 IMPORTANT CONCEPTS Personal information is valuable and both private and sharable. Personal (private) information should be protected. Threats including malware, ransomware and others are connected to the online environment.
		 KEY SKILLS/PROCEDURES Describe malware and pop-ups. Describe and identify online threats. Describe and identify social engineering concepts. Understand and practice cyber hygiene.
		Content Elaborations CLARIFICATIONS Students often do not know what happens when you click a link on a web page and should be taught that links could lead to inappropriate websites. Students should know the different types of pop-up messages and their meaning. Students need to know that some pop-up messages are not safe and could lead to improper websites or downloading malicious content. Students should know that there are many appropriate uses for pop-up messages and windows.
		CONTENT FOCUS The focus is on students understanding different types of digital threats to personal and public information and why understanding basic cyber hygiene and awareness is important for all students. Students should be able to discuss examples of mitigation of digital threats including malware and pop-ups.
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Networks and the Internet	
Торіс	Internet of	Things
NI.IOT.3.a Descril devices send and information over p wireless paths to i information is tran NI.IOT.3.b Define devices and descri difference betwee devices and intelli to identify the diffe in their capabilities	be how receive obysical or identify how smitted. intelligent ribe the n smart gent devices erence s.	 Expectations for Learning EARNING PROGRESSION In grade 2 students explained how devices connect and exchange data. Additionally, they explored different network connectivity. In grade 3, students describe information transmission, explore, and explain the difference between smart and intelligent devices. In grade 4, students will recognize how smart devices communicate over the internet and see how network communication can be traced. IMPORTANT CONCEPTS Devices send and receive information both wirelessly (Wi-Fi, Bluetooth, etc.) and through wired connections. A smart device (such as a Virtual Assistant) is a device that has connectivity, captures useful data and presents it. An intelligent device is a smart device that adapts or learns. KEY SKILLS/PROCEDURES Describe the basic difference between smart and intelligent devices, as well as how humans interact with them differently. Content Elaborations CLARIFICATIONS Explain and distinguish between smart devices such as Bluetooth, Wi-Fi and Virtual Assistants. Provide examples of Smart vs. Intelligent devices. CONTENT FOCUS Explore the difference between smart and intelligent devices and understand how they communicate using networks. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the internet one purpose.

Strand	Data and Analysis	
Торіс	Data Colle	ction and Storage
DA.DCS.3.a Collect quantitative data over time from multiple sources to perform various tasks.		Expectations for Learning LEARNING PROGRESSION In grade 2, students had experience collecting, sorting and organizing data. In grade 3, students collect, record and maintain data over time using various tools, such as a thermometer, ruler, scale and survey. In grade 4, students will begin to explore various computational tools for collecting data from multiple sources over time.
		 IMPORTANT CONCEPTS Keeping an organized record of data over time is critical to analyzing data. Various tools can be used to collect data. Different tools are used to collect different types of data.
		 KEY SKILL/PROCEDURES Use appropriate tools to collect data. Use appropriate tools to organize data. Maintain accurate data over some time. Collect data by making repeated observations over time.
		Content Elaborations
		CLARIFICATIONS Tools that may be explored are digital thermometers, GPS sensors, calculators, scales, digital forms (survey tools), length measurement tools, a stopwatch, etc.
		Data can be organized by using various digital and non-digital tables. Digital organizational resources could include spreadsheets and online graphing programs.
		CONTENT FOCUS The focus is on students collecting, recording, maintaining and organizing data over time, rather than communicating data through graphs and charts.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Analysis	
Торіс	Data Collec	tion and Storage
DA.DCS.3.b Iden types of informat different formats.	ntify different ion to store in	 Expectations for Learning LEARNING PROGRESSION In grade 2, students had experience collecting, sorting, and organizing data. In grade 3, students can use different software tools to access data and store it in different locations. In grade 4, students will begin to gain an understanding that different file types may require different storage. IMPORTANT CONCEPTS Data is stored in different locations on a computing device. Data can be stored locally, on a computing device or online. Where data is stored impacts accessibility. KEY SKILL/PROCEDURES Store, locate and retrieve data on a computing device. Content Elaborations CLARIFICATIONS Examples of data storage could include saving to a device, local network or the cloud. Accessibility refers to the ability to retrieve data. Students should understand that data saved to a device will not be accessible without that same device. Accessibility also refers to the ability to open file formats on different devices. Information refers to data, which could include pictures, audio, video and documents. CONTENT FOCUS The focus is that data storage impacts the accessibility of information. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Ana	alysis
Торіс	Visualization	and Communications
DA.VC.3.a Create a chart or graph to inform a target audience about observations and data collected.		Expectations for Learning LEARNING PROGRESSION In grade 2, students continued to analyze data in various visual formats. In grade 3, students extend their knowledge by creating scaled pictures and bar graphs. They will also create line plots using scales that include whole numbers and fractions (e.g., halves and fourths). In grade 4, students will interpret data in self-created graphs to present insights.
		 IMPORTANT CONCEPTS A symbol on a graph (e.g., picture, bar) can represent more than one item. A key on a graph indicates how many items a symbol represents. A scale on a bar graph varies depending on the data available. Symbols used in picture graphs should be evenly spaced to present visually accurate data.
		 KEY SKILL/PROCEDURES Record data with several categories on a scaled bar graph or picture graph. Determine the appropriate scale for the data given.
		Content Elaborations
		CLARIFICATIONS An important concept for students to begin understanding is that the visual representation of their data impacts how that data will be interpreted. For example, on a bar graph, the bars must be the same size and symbols on a picture graph should be evenly spaced.
		CONTENT FOCUS The focus is on students taking data they have collected and using a visual representation to communicate the data.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and An	alysis
Торіс	Inference an	d Modeling
DA.IM.3.a Utilize data to make predictions and discuss whether there is adequate data to make reliable predictions.		Expectations for Learning LEARNING PROGRESSION In grade 2, students interpreted and analyzed graphs. In grade 3, students analyze and explain relationships or patterns and predict an unknown. In grade 4, students will determine if adequate data has been collected and run simulations to explore outcomes.
		 IMPORTANT CONCEPTS Data from a graph can be used to determine patterns. Data can be used to make predictions about outcomes or to find a missing value.
		 KEY SKILL/PROCEDURES Explain patterns in a data set and determine missing values. Analyze patterns and make predictions about outcomes. Create a model to identify patterns and essential elements.
		Content Elaborations
		CLARIFICATIONS Students explore data and look for patterns. A mathematical connection would be to use in/out (function) machines to find missing values. They solve and make predictions. They begin to discover a pattern cannot continue without a significant number of occurrences.
		CONTENT FOCUS The focus is on students manipulating data to explore patterns and make predictions.
		COMPUTER SCIENCE PRACTICES <i>Practice 4.</i> Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
ATP.A.3.a Cons on errors in an a accomplish a giv	truct and reflect lgorithm to ⁄en task.	 Expectations for Learning LEARNING PROGRESSION In Grade 2, students constructed and followed directions in a real-world context through written words, statements, and visual symbols. In grade 3, students create algorithms and find errors within an algorithm (i.e., step-by-step task). In grade 4, students will begin refining their created algorithms to accomplish a task. IMPORTANT CONCEPTS An algorithm is a series of steps that will complete a process. Logical patterns of progression exist within an algorithm. KEY SKILL/PROCEDURES Utilize logical patterns of progression within an algorithm. Recognize and identify errors within an algorithm. Recognize pseudocode and flow charts.
		 Content Elaborations CLARIFICATIONS Processes of computational thinking (i.e., logical thought) or beginning, middle and end to create organized steps should be emphasized to decompose an algorithm. Computational thinking also needs to be emphasized to identify where an error has occurred. This can be written in code, pseudocode, real language or flowcharts. CONTENT FOCUS The focus is on students using computation thinking (i.e., logical thought) as they work through an algorithm, breaking it into smaller components and determining if an error has occurred somewhere within an algorithm. COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 2. Decompose real-world problems.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Variables an	d Data Representation
ATP.VDR.3.a Define and identify a variable, a placeholder for storing a value, to understand how it is used in a multi-step process (i.e., algorithm).		Expectations for Learning LEARNING PROGRESSION In grade 2, students modeled the use of numbers, symbols and pictures to manipulate and store information. In grade 3, students define and identify variables to understand how they are used in algorithms. In grade 4, students will elaborate on defining and identifying variables.
		 IMPORTANT CONCEPTS Symbols can represent a variable within an algorithm. Data can be stored in the variable.
		 KEY SKILL/PROCEDURES Use logical variable representations (symbols). Identify where an algorithm might include a variable instead of a value.
		Content Elaborations
		CLARIFICATIONS Symbols (e.g., ?, □) are used in programming to hold values. For example, a cloze activity allows students to choose varying words for a single blank within a passage. This is a variable (i.e., a placeholder that can change).
		Students are not required to know and recognize the formal terms "variable" and "algorithm."
		CONTENT FOCUS The focus is on students being able to define and identify variables as symbols with an understanding of how they are used in algorithms to store data.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic	Thinking and Programming
Торіс	Control Stru	ctures
ATP.CS.3.a Create a program using sequences, events, loops and conditionals to solve a problem.		Expectations for Learning LEARNING PROGRESSION In grade 2, students created a program that utilizes sequencing and loops. In grade 3, students build on their skills and knowledge to create programs with more refined strategies, such as loops and conditionals and consider the components of an event. In grade 4, students will continue to refine their programming skills using established structures, such as loops and conditionals.
		 IMPORTANT CONCEPTS Loops are statements that repeat and make programming more efficient for the computer and the programmer. Conditionals are typically in the form of "if/ then" statements and enable the program to follow different paths. Events are structures that programmers can use to explain how the program will react when the user interacts. Proper sequencing of steps within the program ensures efficiency.
		 KEY SKILL/PROCEDURES Insert a loop in a program to avoid typing a command several times. Insert a conditional in a program to create several paths (if/then). Create an event in the format "When (action), then (result) occurs." Diagram the flow of a program to demonstrate the sequence of events and products. Use statements that are introductory level (e.g., if/then, and/or).
		Content Elaborations
		CLARIFICATIONS Loops can occur in programming by having the robot or pen repeat a motion several times, such as going forward ten paces and then turning thirty degrees. In an algorithm, students can program to have a number added several times.
		Conditionals occur in a program by inserting a command to complete when a condition is met. For instance, if a condition states "If n=5," when the value n=5 is achieved, then the program will execute the command given.
		Events can be thought of as an action because of an action such as, "When I click the mouse, the image rotates."

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Control Strue	ctures
		Sequencing of events and commands is an important part of programming when creating a program from scratch or remixing an existing one. Students can diagram or describe the steps of a program using a flowchart or other graphic organizer.
		CONTENT FOCUS Focus on students using a loop, conditional and/or event. Students should also diagram or describe the flow of a program.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Algorithmic 7	Thinking and Programming
Modularity	
mpose the steps eded into precise tructions to nm.	 Expectations for Learning LEARNING PROGRESSION ATP.M.3.a Decompose (break down) the steps needed or not needed (abstraction) into precise sequences of instructions to design an algorithm. IMPORTANT CONCEPTS Modularity refers to smaller portions of a program that may complete their procedure. These modules (smaller portions) may be copied and used in other programs. A program can be decomposed to find its modules. These may be used in other programs. A program can be decomposed to find its modules. These may be used in other programs. KEY SKILL/PROCEDURES Utilize logical patterns of progression within an algorithm to make the best use of a series of steps. Utilize chunking strategies to group sets of a decomposed algorithm to modify the result of the algorithm. Recognize pseudocode and flow charts. Content Elaborations CLARIFICATIONS Processes of logical thought should include the dissection of a whole into its parts. Solve smaller sections of a larger equation to determine its functionality toward the end goal. Chunking strategies help ensure that sets of instructions include all needed parts to reach the end goal. This can be written in code, pseudocode, real language or flowcharts. CONTENT FOCUS The focus is on students thinking logically as they work through an algorithm, determining if it should be decomposed, then breaking an algorithm into its smaller components and logically determining if an error
	Algorithmic Modularity npose the steps eded into precise ructions to im.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Modularity	
		 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.
		 Practice 4. Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
		<i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

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Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Program Dev	velopment
ATP.PD.3.a Use to plan the deve program that sol	e a design process lopment of a ves problems.	 Expectations for Learning LEARNING PROGRESSION In grade 2, students began to plan and sequentially create simple programs using graphic organizer tools. In grade 3, students use these skills to design and create programs to solve a problem. In grade 4, students will design programs that include the preferences of the end-user. IMPORTANT CONCEPTS A flow chart is one type of organizational tool that can be used to plan a program considering the sequence of its features. An algorithm can be used to plan a program. KEY SKILL/PROCEDURES Design a program that can solve a problem. Use the design process when planning a program. Content Elaborations CLARIFICATIONS Programs can be designed in a plugged (i.e., using a computer) or unplugged environment (i.e., not using a computer). Programs can be designed using a block-based environment. Programs can address a one-step problem or a more complex one. A flow chart is a type of organizational tool that can be used to plan a program. The flow chart is a visual representation of decisions and directions throughout the program. Students can design instructions for a simple game (e.g., tic-tac-toe). CONTENT FOCUS The focus is on designing a program that can solve a problem using one or two steps.

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Program Dev	velopment
		 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, considering 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.

Strand	Algorithmic	Thinking and Programming
Торіс	Program Dev	velopment
ATP.PD.3.b Using a given program known to contain errors, identify and debug errors to ensure it works.		Expectations for Learning LEARNING PROGRESSION In grade 2, students described their problems and came up with possible solutions. In grade 3, guided questions will be asked to help students think more strategically about how to solve a problem in their program. In grade 4, students will continue with guided questions that assist them in debugging their program.
		 IMPORTANT CONCEPTS A computer bug is a series of commands that do not properly interact with each other and cause an interruption in the program execution (i.e., an error in the program). To "debug" is to find the error within a program and then apply an appropriate fix.
		 KEY SKILL/PROCEDURES Identify errors in a program. Apply a fix to errors in a program.
		Content Elaborations
		CLARIFICATIONS If a program that is written will not execute properly, programmers often refer to the issue as the program "breaks" or the program has a "bug" (i.e., error). "Debugging" a program refers to scanning through the program code to find the error in the commands and then correcting or repairing that programming code.
		Students might look at a set of instructions that are not in the correct order and determine the correct order to fix the debug "fix" the instructions.
		Guided questions are questions that prompt the programmer to think more about their error and problem solve potential solutions without being given the answer.
		CONTENT FOCUS The focus is on locating, determining solutions and fixing errors in block-based through guided questioning.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand Artificial Intelligence		
Topic Machine Learning		
AI.ML.3.a Label three different	Expectations for Learning	
machine learning approaches to identify them to see different approaches.	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 <i>Practice 3.</i> Recognizing and Defining Computational Problems	
AI.ML.3.b Give examples of bias	Expectations for Learning	
to understand what it is and how it affects machine learning.	LEARNING PROGRESSION This concept is introduced in grade 3. In grade 4, students will explain how machine learning can create bias.	
	 IMPORTANT CONCEPTS Identify what a bias is and how it can influence machine learning. 	
	 KEY SKILL/PROCEDURES Identify what a bias is to understand the concept and how it might affect machine learning. 	

Strand Artificial Intelligence		
Topic 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. 	
AI.ML.3.c Identify tasks that use	Expectations for Learning	
Al to perform human tasks to understand how humans rely on Al.	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 Al can complete many 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 Al can perform tasks that humans once did. As Al grows, it can take over more human tasks; for example, self-driving cars and using a search engine versus looking in books.	
	CONTENT FOCUS Al is a growing field that performs some human tasks.	

Strand	Artificial Intelligen	ce
Торіс	Machine Learning	
		 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 Intellig	gence
Торіс	Natural Interac	tions
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 Artificial Intelligence (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 Al systems can create equal access.
		 KEY SKILLS/PROCEDURES List ways in which AI makes it more inclusive to promote equity.
		Content Elaborations
		CLARIFICATIONS Al systems include adaptive tools like text to speech, speech to text and translation programs.
		CONTENT FOCUS Al 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.

Strand	Artificial Intelligence	
Торіс	Perception	
AI.P.3.a Use different sensors, analog and digital, and discuss the difference between them.		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 Students should know what types of sensors do and how they are similar and different from other sensors.
		 KEY SKILLS/PROCEDURES Recognize the difference between analog and digital sensors. Explain how different sensors gather data. Explain the differences between analog sensors including accelerometers, light sensors, sound sensors, pressure sensors, analog temperature sensors and digital sensors which consist of three components, a sensor, cable and transmitter. In digital sensors, the signal measured is directly converted into digital signal output inside the digital sensor itself.
		Content Elaborations
		Recognize the difference between analog and digital clocks and thermometers. Discuss how these sensors are similar and different.
		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.

Strand	Artificial Intelli	igence
Торіс	Perception	
AI.P.3.b Describe what computer perception is and how it affects computers to see how it compares to human perception.		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 their 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 There are similiarities and differences between human sensors and computer 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 Intellig	gence
Торіс	Representation	& Reasoning
AI.RR.3.a Wi support, crea system using understand h	th guidance and te a classification a tree structure to ow 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 of 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 Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intell	Artificial Intelligence	
Торіс	Representatio	on & Reasoning	
Al.RR.3.b Use	AI to answer	Expectations for Learning	
questions and o answer is reaso	describe how the onable.	LEARNING PROGRESSION This concept was introduced in grade 3. In grade 4, students will describe how Artificial Intelligence (AI) uses knowledge to make a reasonable answer.	
		 IMPORTANT CONCEPTS Al gives a reasonable answer based on programming and input. 	
		KEY SKILLS/PROCEDURES	
		 Create a sentence using words with multiple meanings to see how the AI defines the words. o For example, the word pitcher could mean a baseball player 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 Al is complex and has to make lots of decisions to differentiate between multiple meanings.	
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes. 	

Strand	Artificial Intelligence	
Торіс	Societal Impac	cts
AI.SI.3.a Definition to understand linfluence huma	e what a bias is now it can ins.	Expectations for Learning LEARNING PROGRESSION In grade 2 students discussed if Artificial Intelligence (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 artificial intelligence.
		 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.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.3.a Identify computing technologies that have changed the world and express how those technologies influence and are influenced by cultural practice.		Expectations for Learning LEARNING PROGRESSION In grade 2, students compared and contrasted how technology use has changed and the impact it has had on their personal lives. In grade 3, students identify the impact technology has on everyday life in the local community. In grade 4, students will recognize the impact of technology on the global community.
		 IMPORTANT CONCEPTS People within a local community use technology in various ways. Daily life is influenced by the technology in a community.
		 KEY SKILL/PROCEDURES Identify specific types of technology used in the local community. Describe ways that various technology resources impact daily life in a local community.
		Content Elaborations
		CLARIFICATIONS New computing technology is created, and existing technologies are modified for many reasons, including to increase their benefits, decrease their risks and meet societal needs. Students explore topics that relate to the history of technology and the changes in the world due to technology. Topics could be based on current news content, such as robotics, wireless internet, mobile computing devices, GPS systems, wearable computing or ways social media has influenced social and political changes. (CSTA K-12 Computer Science Standards, 2017)
		CONTENT FOCUS The focus is on the impacts of technology on the local community.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspective of others and reflect on one's perspectives when designing and developing computational products.

Strand	Impacts of Computing	
Торіс	Culture	
		Career Connections CAREER AWARENESS Using a resource such as Smithsonian Institute, students learn about computing technologies from the past. Students choose one type of technology to research to see how it has changed society and how people work. Students create an artifact such as a timeline or presentation to share their findings.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.3.b Identi devices have bu increase access	fy how computing illt-in features to ibility to all users.	Expectations for Learning LEARNING PROGRESSION In grade 2, students compared and contrasted how technology use has changed and the impact it has had on their personal lives. In grade 3, students identify diverse user needs and how computing devices have features built in to increase accessibility. In grade 4, students will identify and anticipate diverse needs and ways to improve devices to make them more accessible to users.
		 IMPORTANT CONCEPTS Users have diverse needs that impact accessibility. Computing devices have built-in features to increase accessibility for all users.
		 KEY SKILL/PROCEDURES Identify built-in features to increase accessibility. Recognize that users have diverse needs.
		Content Elaborations
		CLARIFICATIONS Anticipating the needs and wants of diverse end-users requires students to purposefully consider potential perspectives of users with different backgrounds, ability levels, points of view and disabilities. Examples of built-in features to increase accessibility include voice command, text-to-speech and magnify text.
		CONTENT FOCUS The focus is on the diverse needs of users and how those needs impact accessibility.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand	Impacts of Co	omputing
Торіс	Social Intera	ctions
IC.SI.3.a Collabo diverse perspect digital artifacts.	orate and consider tives to improve	Expectations for Learning LEARNING PROGRESSION In grade 2, students were able to compare and contrast safe and responsible technology behaviors. In grade 3, students collaborate through feedback and reflection to improve a digital artifact and begin to explore how diverse perspectives improve artifacts. In grade 4, students will collaborate with others to share the workload and increase diverse perspectives to improve a digital artifact.
		 IMPORTANT CONCEPTS Collaborating with peers to include diverse perspectives can improve digital artifacts. Reflecting on feedback from others can improve digital artifacts. Providing feedback to others can help to improve the quality of their work.
		 KEY SKILL/PROCEDURES Leave thoughtful feedback for peers that will help improve their digital artifacts. Reflect on feedback from peers to improve digital artifacts.
		Content Elaborations
		CLARIFICATIONS Teachers can support students to leave thoughtful feedback by modeling this process. Teachers should conduct whole group discussions after students have left feedback to determine if the feedback was productive.
		CONTENT FOCUS The focus is on providing and reflecting on feedback to improve digital artifacts.
		 COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Create team norms, expectations and equitable workloads to increase efficiency and effectiveness. Solicit and incorporate feedback from and provide constructive feedback to team members and other stakeholders.

Impacts of Computing

Topic Safety, Law and Ethics		
IC.SLE.3.a Use public domain or Creative Commons media, and refrain from copying or using material created by others without permission.	Expectations for Learning LEARNING PROGRESSION In K-2, students were able to explain why it is important to use technology in the correct way to make decisions about appropriate use and protecting login information. In grade 3, students are introduced to the concept that some resources can be shared (e.g., public domain, Creative Commons) while others must be used only with proper citations or permission. In grade 4, students will be introduced to formal procedures used when sharing materials. Students will be expected to identify the type of source and give credit to the source.	
	 IMPORTANT CONCEPTS Certain resources can be shared freely; some resources can be shared with proper citation and others can only be shared with permission from the creator. 	
	 KEY SKILL/PROCEDURES Determine whether a source can or cannot be used freely. Express where online resources are found. 	
	Content Elaborations	
	CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet (e.g., video, photos, music) creates the opportunity for unauthorized use, such as online piracy, and disregard of copyrights. Students should consider the licenses on computational artifacts that they wish to use. For example, the license on a downloaded image or audio file may have restrictions that prohibit modification, require attribution, or prohibit use entirely. (CSTA K-12 Computer Science Standards, 2017)	
	CONTENT FOCUS The focus is on recognizing that some resources are public domain and can be used freely and other materials need to be cited properly.	
	COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.	

Strand

Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
IC.SLE.3.b Deter information shouk kept private to p student identity.	ermine whether uld be shared or rotect	Expectations for Learning LEARNING PROGRESSION In grade 2, students have learned how to use the internet responsibly. In grade 3, students learn the importance of keeping personal information secure. In grade 4, students will start to make distinctions between what information should be shared and what information should be kept private.
		 IMPORTANT CONCEPTS For safety and security, personal information should be kept private.
		 KEY SKILL/PROCEDURES Determine whether information should or should not be shared digitally. Recognize that keeping information private protects your identity.
		Content Elaborations
		CLARIFICATIONS Examples of information to be kept private are first and last name, birthday, addresses, phone numbers or other personal identifiers. Students should also understand that they should not share the personal information of others.
		CONTENT FOCUS The focus is on knowing the difference between information that can be shared and information that should be kept private.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of Computing	
Торіс	Safety, Law a	and Ethics
IC.SLE.3.c Communicate the importance of information security to protect one's own digital footprint.		Expectations for Learning LEARNING PROGRESSION In grade 2, students have learned how to use the internet responsibly. In grade 3, information security and the concept of a digital footprint are introduced. In grade 4, students will spend time considering their digital footprint and the impact of their decisions.
		 IMPORTANT CONCEPTS Every person has a digital footprint that includes all aspects of their online behavior. Keeping information secure is important to consider when using the internet.
		 KEY SKILL/PROCEDURES Define digital footprint and give examples of online activity that contributes to a person's digital footprint. Communicate examples of ways to keep information secure (e.g., not staying logged into public computers, not sharing passwords, not sharing personal information online).
		Content Elaborations
		CLARIFICATIONS At grade 3, the term "digital footprint" is first introduced. While making personal connections to this term is encouraged, instruction should be more focused on understanding what information should and should not be shared and how this impacts a person.
		CONTENT FOCUS The focus is on understanding what should be shared online and the effect of sharing different types of information.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.3.d Explain why different types of information might need to be protected, describing common safeguards for protecting personal information.		Expectations for Learning LEARNING PROGRESSION In grade 3, students will learn about what information should be shared and how to keep their information secure. In grade 4, students are introduced to the idea that there are tradeoffs between allowing information to be public versus keeping information private. In grade 5, students will learn about their digital footprint.
		 IMPORTANT CONCEPTS Students should be able to define personally identifiable information (PII). Individuals should be careful what personally identifiable information (PII) they share online or in-person.
		 KEY SKILLS/PROCEDURES List examples of personally identifiable information (PII). Explain the dangers of sharing personally identifiable information.
		Content Elaborations
		CLARIFICATIONS At this level, student discussions focus on examples of personally identifiable information and how to keep personal information, including private and public information, safe online.
		CONTENT FOCUS Research and describe the potential effects of the positives and negatives of making the information public.
		 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.
		<i>Practice 6.</i> Testing and Refining Computational Artifacts. 1. Systematically test computational artifacts by considering all scenarios and using test cases.

GRADE 4

Strand	Computing Systems	
Торіс	Devices	
CS.D.4.a Explore external components (i.e., parts) of a computing system and their function to understand and describe the role they play in a computer system.		Expectations for Learning LEARNING PROGRESSION In grade 3, students developed an understanding that the device they selected for a specific task has components that all play a role in the computer system. In grade 4, students develop their understanding of what external components are used to share information. In grade 5, students will develop their understanding of the internal parts of the computer and how they play a role in the computer system.
		 IMPORTANT CONCEPTS External devices are used to input, store and transfer data into the computer. Different devices have different purposes. Each external component (i.e., part) has a different function in a computer system.
		 KEY SKILL/PROCEDURES Identify key external components (i.e., parts) such as USB port, HDMI, network cable, power supply, etc. Select the appropriate device to accomplish a task. Describe the components of the selected device.
		Content Elaborations
		CLARIFICATIONS External components (i.e., parts) in this grade level may focus on things plugged-in or attached to the computer.
		External components can include a USB port and drive, power supply, network cable or HDMI port. Depending on the device, some of these components may or may not exist. For example, on some tablets, a USB port is not available. Mobile devices do not always require the device to be plugged into the power source.
		CONTENT FOCUS The focus should be on students understanding the components (i.e., parts) of the device that they select for their task. For example, if they select a networked computer, this can allow them to communicate with others globally. If their computer is not connected to a network, their communication is limited.
Strand	Computing S	Systems
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Торіс	Devices	
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.

Strand	Computing S	Systems
Торіс	Hardware an	d Software
CS.HS.4.a Select learning tools/de planning, implem reflecting upon a	ct and use digital evices to support nenting and a defined task.	Expectations for Learning LEARNING PROGRESSION In grade 3, students selected learning tools or devices to plan, implement, and reflect upon tasks. In grade 4, students continue to select learning tools/devices and use them to aid in planning, implementing and reflecting on given tasks. In grade 5, students will use and evaluate the digital learning tools and devices they've chosen and consider the planning, implementation and reflection across curricular areas.
		 IMPORTANT CONCEPTS Different types of software and hardware can be used to accomplish a task. Learning tools should support the planning, implementation and reflection of a task.
		 KEY SKILL/PROCEDURES Select and use a tool such as a presentation software program, document, graphic design program or video creating software to accomplish a given task. Select and use an appropriate device, such as a tablet, laptop or desktop to accomplish a given task.
		Content Elaborations
		CLARIFICATIONS Tools should begin to extend to apps and programs beyond basic programs provided on the selected devices. Selection and use of a variety of devices such as tablets, desktops and laptops should be included.
		CONTENT FOCUS The focus is on students selecting and using their tools or devices. Tasks should increase in complexity from third grade and focus on specific curricular goals in the subject content.
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		Career Connections
		CAREER AWARENESS Students select a career and identify the digital tools used in the career. Students then choose a task that a person in that career would perform. Students create a presentation reflecting their research.

Strand	Computing	Systems
Торіс	Troubleshoo	oting
CS.T.4.a Diagnose problems and select an appropriate solution from a list of problems and solutions to resolve hardware and software issues.		Expectations for Learning LEARNING PROGRESSION In grade 3, students began to move beyond trial and error to apply more strategic troubleshooting techniques to fix their problems. In grade 4, students focus on diagnosing and describing potential hardware and software problems. In grade 5, students will work to diagnose problems, describe the problem and develop strategies to resolve technology issues.
		 IMPORTANT CONCEPTS Troubleshooting strategies can be used to solve hardware and software issues.
		 KEY SKILL/PROCEDURES Diagnose problems in hardware and software. Select a solution for the problem from a given list.
		Content Elaborations
		CLARIFICATIONS Students should describe the reason for the problem. For example, if the computer does not turn on, maybe the battery is dead. If the program does not work, maybe the username or password is wrong. If needed, students should be able to select solutions from a list of potential solutions. Students should be exposed to specific problems so they can develop the skills to troubleshoot in the future (i.e., disconnecting a computer from the network so that students can see what this looks like).
		CONTENT FOCUS The focus is on students diagnosing and describing problems. Students should be able to select solutions.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.4.a Describe how information is broken down to be transmitted over a network to help students gain a better understanding of the internet and networks.		Expectations for Learning LEARNING PROGRESSION In grade 3, students explored how information is sent and received over the internet. In grade 4, students explain how information is broken apart, sent and received over the internet. In grade 5, students will demonstrate how information is broken apart, sent and received over the internet.
		 IMPORTANT CONCEPTS Manipulating a URL (i.e., web address) even slightly can change what information is accessed. Information is broken into parts at the sending point and reassembled at the receiving point.
		 KEY SKILL/PROCEDURES Modify a URL (i.e., web address) to access the content. Describe what occurs when a URL is modified. Use a metaphorical example to describe how information is broken down into parts and reassembled.
		Content Elaborations
		CLARIFICATIONS Students should understand that altering a URL will change the information that is displayed. An example of metaphorical connection students could make to describe how information is transmitted would be a roller coaster ride. The track could be seen as the internet connection and the cars and the people are the information traveling through the connection.
		CONTENT FOCUS The focus is on students modifying a URL to reach a specific site and describing how the modification impacts the information accessed. Students communicate how information is transmitted.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks and the Internet	
Торіс	Networking	
NI.N.4.b Describe network addresses, names and rules (i.e., protocols) to share or receive information from the global community.		Expectations for Learning LEARNING PROGRESSION In grade 3, students have developed an understanding of how information is shared, received and stored. In grade 4, students identify that different naming techniques are related to the type of information accessed. In grade 5, students will continue applying this knowledge.
		 IMPORTANT CONCEPTS Different types of rules for naming a web address identify different types of sites. The search terms or the web address is converted to a format that the computer can read to reach the desired site.
		 KEY SKILL/PROCEDURES Identify the reliability of a site based on the naming rule (e.g., top-level domain). Use search techniques (Boolean) to allow the computer to understand what is being searched.
		Content Elaborations
		CLARIFICATIONS Students identify reliability based on the top-level domain naming such as ".edu" for education purposes, ".com" for commercial purposes, ".gov" for government purposes, and ".org" for organizations.
		Boolean searches use " ", <i>and, or</i> , etc.
		CONTENT FOCUS The focus is on identifying informational reliability and making a connection between search terms and website addresses.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	y .
NI.C.4.a Describe what information should be and the importance of password to protect in	e what Ild be protected nce of a secure tect information.	Expectations for Learning LEARNING PROGRESSION In grade 3, students explored and understood personal information and how passwords are used to protect information. In grade 4, students describe types of private information and the importance of protecting that information. In grade 5, students will create secure passwords to protect personal information and store them securely.
		 IMPORTANT CONCEPTS Personal information should be protected by secure passwords. Potential consequences of personal information being unsecured.
		 KEY SKILL/PROCEDURES Describe why personal information needs to be protected. Describe what could happen if personal information is unsecured.
		Content Elaborations
		CLARIFICATIONS Students often only associate the worst-case scenario with sharing information. They need to understand the real-world dangers of personal information being shared in an unsecured environment. Students need to know what a secure password looks like and why they should use a secure password.
		CONTENT FOCUS The focus is on students identifying why information needs to be protected and being aware of consequences related to data security.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ty
NI.C.4.b Describe and explain safe usage of various online services such as web, email, video, gaming, cloud services and networked drives.		Expectations for Learning LEARNING PROGRESSION In grade 3, students learned to explore and explain grade-appropriate examples of unsafe content. In grade 4, students describe the effects of malicious content. In grade 5, students will analyze the appropriate and inappropriate use of online services.
		 IMPORTANT CONCEPTS Online services have different purposes and methods of use. Devices can be used for proper or improper purposes. Not all online services are safe.
		 KEY SKILLS/PROCEDURES Define and describe malware and pop-ups. Explain how to protect yourself from malware, pop-ups and other threat vectors. Describe the effects of malware and the use of malware to access private information.
		Content Elaborations
		CLARIFICATIONS Many devices can connect to the internet (cloud services) to share information and access applications (Apps). Students should understand that using websites, email, video gaming, cloud services and networked drives that share information adds to the need for security practices.
		CONTENT FOCUS The focus is on students identifying and securing personal information and being aware of the consequences of data security, malware and other online threat vectors.
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing Practice 4. Evaluate and select technological tools that can be used to collaborate on a project.
		 Practice 5. Creating Computational Artifacts 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.

Networks and the Internet

Internet of Things

transferred information is tagged using identifiers to transmit information about the user so students begin to learn no information on the internet is anonymous.	 The information collected by smart and intelligent devices to be transferred over the internet can be identified by the user. No information that is transmitted over the internet is anonymous. KEY SKILLS/PROCEDURES Describe how information can be identified when transmitted over a network. Explain how information is sent over a network from a smart or intelligent device. 	
		Content Elaborations
		CLARIFICATIONS Smart devices know how to create packets of information that have a "sender" and "recipient." Devices on the internet know how to route those packets to the correct recipient.
		Explain how data is transmitted across the internet and that anyone is allowed to look at it. Discuss that the act of sending information implies that the sender is permitting anyone who can see the data stream to examine its contents.
		An example is the letter metaphor: Anyone can see the address on an envelope. If you open it and read it, you will know the contents. You can use coded (encrypted) messages to prevent people from knowing what the letter says.
		CONTENT FOCUS Describe how information is split into packets for communication and how those packets can be traced back to the sender.

Expectations for Learning

LEARNING PROGRESSION

In grade 3, students described information transmission, explored and explained the difference between smart and intelligent devices. In grade 4, students recognize how smart and intelligent devices communicate over the internet and see how network communication can be traced. In grade 5, students will explore how information is transmitted over the internet and identify the risks and benefits of using the internet.

IMPORTANT CONCEPTS

Strand

Topic

NI.IOT.4.a Explore how information is transferred to

how the internet and

networks operate.

the internet from smart and

NI.IOT.4.b Describe how

intelligent devices to recognize

Strand	Networks and	the Internet
Торіс	Internet of Thi	ings
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicate About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Strand	Data and Ana	alysis
Торіс	Data Collecti	ion and Storage
DA.DCS.4.a Ga multiple quantita elements using a various tasks.	ther and organize itive data a tool to perform	Expectations for Learning LEARNING PROGRESSION In grade 3, students collected, recorded and maintained data over time using various tools, such as a thermometer, ruler, scale and survey. In grade 4, students build upon the use of tools from grade 3, to collect data from multiple sources within a singular topic over time. In grade 5, students will select appropriate tools to collect data from multiple sources within a singular topic over time.
		 IMPORTANT CONCEPTS Keeping an organized record of data over time is critical to analyzing data. Various tools can be used to generate data. Different tools are used to collect different types of data.
		 KEY SKILL/PROCEDURES Use appropriate tools to collect data. Use appropriate tools to organize data. Maintain accurate data from multiple sources within a singular topic over some time. Collect data from multiple sources within a singular topic, by making repeated observations over time.
		Content Elaborations
		CLARIFICATIONS Tools that may be explored are digital thermometers, GPS sensors, calculators, scales, digital forms (i.e., survey tools), length measurement tools, a stopwatch, etc.
		Data can be organized by using various digital and non-digital tables and charts. Digital organizational resources could include spreadsheets, online graphing programs, etc.
		An example of collecting data from multiple sources within a singular topic could be collecting the height of students in three different classes throughout the school year.
		CONTENT FOCUS The focus is on students collecting, recording, maintaining and organizing data from multiple sources within a singular topic over time.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Ana	alysis
Торіс	Data Collecti	ion and Storage
DA.DCS.4.b Identify techniques and formats to store, process and retrieve different types of information.		Expectations for Learning LEARNING PROGRESSION In grade 3, students used different software tools to access data and store it in different locations. In grade 4, students begin to gain an understanding that different file types may require different storage. In grade 5, students will use their knowledge of file types to explore how file size impacts storage.
		 IMPORTANT CONCEPTS Different data is stored in different ways on a computing device. Data can be stored locally, on a computing device or online. How data is stored impacts accessibility.
		 KEY SKILL/PROCEDURES Store data as a specific file type. Locate and retrieve data on a computing device.
		Content Elaborations
		CLARIFICATIONS Examples of data storage could include saving to a device, local network or the cloud. Accessibility refers to the ability to retrieve data. Students should understand that data saved to a device will not be accessible without that same device. Accessibility also refers to the ability to open file formats on different devices. Information refers to data, which could include pictures, audio, video, or documents. Examples of file types would be image (i.e., .jpg, .png, .gif .bmp), document (e.g., .doc, .docx, .pages, .txt), multi-media (e.g., .mov, mp4, .wmb) and presentation (e.g., .ppt, .pptx, .key).
		CONTENT FOCUS The focus is that data storage impacts the accessibility of information and that different data types are stored in different formats.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Visualization and Communication

Expectations for Learning

LEARNING PROGRESSION

Data and Analysis

created line plots using scales that include whole numbers and fractions (e.g., halves and fourths). In grade 4, students interpret data in self-created graphs to present insights. In grade 5, students will use graphs created to highlight and support a claim they have made.
 IMPORTANT CONCEPTS A symbol on a graph (picture, bar, etc.) can represent more than one item. A key on a graph indicates how many items a symbol represents. A scale on a bar graph varies depending on the data available. Symbols used in picture graphs should be evenly spaced to present visually accurate data. Data from a graph can be used to gain insights or solve a problem.
 KEY SKILL/PROCEDURES Record data with several categories on a scaled bar graph or picture graph. Determine the appropriate scale for the data given. Interpret and answer questions regarding data presented in a bar or picture graph.
Content Elaborations
CLARIFICATIONS An important concept for students to begin to understand is that a scale is chosen based on the data available. Students should begin understanding that data is used to solve problems. For example, if many people report they do not recycle due to a lack of recycling bins, we can conclude that providing recycling bins to people will increase recycling and improve the environment.
CONTENT FOCUS The focus is on students using a visual representation to communicate the data they have collected and interpreting the data to answer questions.
COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand

Topic

DA.VC.4.a Organize data into

subsets to provide different views

Strand	Data and Analysis	
Торіс	Inference an	d Modeling
DA.IM.4.a Utilize data to make predictions and discuss whether there is adequate data to make reliable predictions.		Expectations for Learning LEARNING PROGRESSION In grade 3, students analyzed and explained relationships or patterns and predicted an unknown. In grade 4, students determine if adequate data has been collected and run simulations to explore outcomes. In grade 5, students will run simulations to test theories and make predictions about how larger data sets affect outcomes.
		 IMPORTANT CONCEPTS Data from a graph can be used to determine patterns. Patterns can be analyzed to determine a missing value and predict outcomes. A data set can be modified to manipulate outcomes. Analyze trends based on the number of data sets.
		 KEY SKILL/PROCEDURES Answer questions about missing variables in a data set. Use data to make predictions about outcomes. Manipulate data and explain how quantity affects outcomes.
		Content Elaborations
		CLARIFICATIONS Students explain patterns in data and identify missing values. They begin to manipulate data and reflect on how the quantity of data affects outcomes. Students will use software tools such as spreadsheets to manipulate the quantity of data and reflect on changes that occur.
		CONTENT FOCUS The focus is on students identifying patterns in data to find missing values. They predict outcomes to continue patterns.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic Think and Programming	
Торіс	Algorithms	
ATP.A.4.a Construct and refine an algorithm to accomplish a given task.		Expectations for Learning LEARNING PROGRESSION In grade 3, students experienced designing algorithms. In grade 4, students refine an algorithm to accomplish a given task. In grade 5, students will compare and refine algorithms with a focus on efficiency.
		 IMPORTANT CONCEPTS An algorithm is a series of steps to complete a process or task. Once algorithms are created and written, they need to be tested and possibly revised based on the results. Pseudocode and flowcharts can be used to create and modify an algorithm.
		 KEY SKILL/PROCEDURES Utilize logical patterns of progression within an algorithm to modify it to accomplish a given task. Recognize and identify errors within an algorithm to modify it to accomplish a given task. Utilize pseudocode and flow charts to assist with creating and modifying an algorithm to accomplish a given task.
		Content Elaborations CLARIFICATIONS Processes of computational thinking (i.e., logical thought) or beginning, middle and end to create organized steps should be emphasized to decompose, abstract, and reassemble an algorithm. Use proper editing for modifying algorithms (i.e., conditional, loops). Computational thinking also needs to be emphasized to identify where an error has occurred and the process needed to fix it. This can be written in code, pseudocode, real language or flowcharts.
		 CONTENT FOCUS The focus is on students modifying the algorithm to fix it and reconstructing it to accomplish a given task. COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 2. Decompose real-world problems.

Strand	Algorithmic	I NINK and Programming
Topic Variables and Data Representation		d Data Representation
ATP.VDR.4.a variable, a pla a value, to un works in a mu (i.e., algorithm	I Identify and use a aceholder for storing iderstand how it ulti-step process n).	Expectations for Learning LEARNING PROGRESSION In grade 3, students defined and identified variables to understand how they are used in algorithms. In grade 4, students further expand on defining and identifying variables and begin to use them. In grade 5, students will create a variable to store and modify data.
		 IMPORTANT CONCEPTS Letters or symbols are used to represent a variable within an algorithm. Data can be stored in the variable. Variables represent a changing value.
		 KEY SKILL/PROCEDURES Explain and identify variables within algorithms. Write an algorithm that substitutes a variable for a value. Edit the algorithm to show how it changes the algorithm's result.
		Content Elaborations
		CLARIFICATIONS Symbols such as letters are used in programming to hold values. Students need to learn that the syntax (i.e., the order of symbols in the equation) may impact the success of a program. Students can explore what happens when the data stored in a variable is changed.
		For example, a cloze activity allows students to choose varying words for a single blank within a passage. Students would examine how this changes the meaning of the passage. This is a variable (i.e., a placeholder that can change).
		Students are not required to know and recognize the formal terms "variable" and "algorithm."
		CONTENT FOCUS The focus is on students being able to define and identify unknown variables as symbols, such as letters, and understanding how they are used in algorithms to store data. Students should begin using variables within equations.
		COMPUTER SCIENCE PRACTICES <i>Practice 4</i> . Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic	Think and Programming
Торіс	Control Stru	uctures
ATP.CS.4.a Create a program using sequences, events, loops and conditionals to solve a problem.		Expectations for Learning LEARNING PROGRESSION In grade 3, students built upon their skills and knowledge to create programs with more refined strategies, such as loops and conditionals, and considered the components of an event. In grade 4, students continue to refine their programming skills using established structures such as loops and conditionals. In grade 5, students will apply these new skills in increasingly complex ways and will continue to refine these to work towards programming efficiency.
		 Loops are statements that repeat and make programming more efficient for the computer and the programmer. Conditionals are typically in the form of "if/then" statements and enable the program to follow different paths. Events are structures that programmers can use to explain how the program will react when the user interacts with it. Proper sequencing of steps within the program ensures efficiency.
		 KEY SKILL/PROCEDURES Insert a loop in a program to avoid typing a command several times. Insert a conditional in a program to create several paths (if/then). Create an event in the format "When (action), then (result) occurs." Diagram the flow of a program to demonstrate the sequence of its events and products. Combine statements to make a length of code shorter (i.e. if/else/then).
		 Content Elaborations CLARIFICATIONS Loops can occur in programming by having the robot or pen repeat a motion several times, such as going forward ten paces and then turning thirty degrees. In an algorithm, students can program to have a number added several times. Conditionals occur in a program by inserting a command to complete when a condition is met. For instance, if a condition states "If n=5," when the value n=5 is achieved, then the program will execute the command given.

Strand	Algorithmic Think and Programming	
Торіс	Control Structures	
		Events can be thought of as an action because of an action. Such as, "When I click the mouse, the the image rotates."
		Sequencing of events and commands is an important part of programming when creating a program from scratch or remixing an existing one.
		Students can diagram or describe the steps of a program using a flowchart or other graphic organizer.
		CONTENT FOCUS The focus is on students using a loop, conditional, and/or event. Students should also diagram or describe the flow of a program.
		The complexity of the loops, conditionals, events, and sequences continues to increase from the prior grade level.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic Think and Programming	
Торіс	Modularity	
ATP.M.4.a Decompose (i.e., break down) the steps needed or not needed (i.e., abstraction) into precise sequences of instructions to design an algorithm.		Expectations for Learning LEARNING PROGRESSION In grade 3, students experienced decomposing abstractions into sequences to design algorithms. In grade 4, students continue to refine the decomposition, abstraction and algorithm creation process. In grade 5, students will begin to compare and refine multiple algorithms for efficiency.
		 IMPORTANT CONCEPTS Modularity refers to components of programs that complete a procedure or task. Modules within a program may need to be evaluated, refined and/or copied.
		 KEY SKILL/PROCEDURES Utilize logical patterns of progression within an algorithm to make the best use of a series of steps to decompose the algorithm into functional sections. Regroup or redesign sets of a decomposed algorithm to modify the result of the algorithm. Determine if the logic of an algorithm requires decomposition or abstraction. Utilize pseudocode and flow charts as related to the algorithm.
		Content Elaborations CLARIFICATIONS Processes of logical thought should include the dissection of a whole into its parts. Solve smaller sections of a larger equation to determine its functionality toward the end goal. Ensure that sets of instructions include all needed parts to modify the result to reach the end goal. This can be written in code, pseudocode, real language or flowcharts related to the language of the algorithm.
		CONTENT FOCUS The focus is on students using computational thinking as they work through an algorithm and then breaking an algorithm into its smaller components (i.e., parts) and logically determining if an error has occurred somewhere within an 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.

Strand	Algorithmic Think and Programming	
Торіс	Modularity	
		 Practice 4. Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
		<i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Algorithmic	Think and Programming
Торіс	Program Dev	velopment
ATP.PD.4.a Use a design process to plan and develop a program that addresses a multi-step problem.		Expectations for Learning LEARNING PROGRESSION In grade 3, students began to design and create a program to solve a problem. In grade 4, students design and create a program for a multi-step problem. In grade 5, students will design and create a program that addresses a multi-step problem and the preferences of the end user.
		 IMPORTANT CONCEPTS A flow chart is one type of organizational tool that can be used to plan a program considering the sequence of its features. An algorithm can be used to plan a program. Programs can execute multiple steps.
		 KEY SKILL/PROCEDURES Design a program that can solve a problem. Use the design process when planning a program. Create a program for a multi-step problem.
		Content Elaborations
		CLARIFICATIONS Programs can be designed in a plugged (i.e., using a computer) or unplugged environment (i.e., not using a computer).
		Programs can be designed using a block-based environment.
		Multi-step problems will ask the user to complete two or more tasks.
		A flow chart is a type of organizational tool that can be used to plan a program.
		CONTENT FOCUS The focus is on designing a program that can solve a problem with two or three steps.

Strand	Algorithmic Think and Programming	
Торіс	Program Development	
		 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, considering 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.

Program Development

Algorithmic Think and Programming

ATP.PD.4.b Using guided	Expectations for Learning
questions, work through a program to identify errors and discuss possible solutions to repair the program.	LEARNING PROGRESSION In grade 3, guided questions were asked to help students think more strategically about how to solve a problem in their program. In grade 4, students continue with guided questions that assist them in debugging their program. In grade 5, students will become less dependent upon guided questions and will begin to debug more complex programs.
	 IMPORTANT CONCEPTS A computer bug is a series of commands that do not properly interact with each other and causes interruptions in the program execution (i.e., an error in the program). To "debug" is to find the error within a program and then apply an appropriate fix.
	 KEY SKILL/PROCEDURES Identify errors in a program. Apply a fix to errors in a program.
	Content Elaborations
	CLARIFICATIONS If a program that is written will not execute properly, programmers often refer to the issue as the program "breaks" or the program has a "bug" error. "Debugging" a program refers to scanning through the program code to find the error in the commands and then correcting or repairing that programming code.
	Guided questions are questions that prompt the programmer to think more about their error and problem solve potential solutions without being given the answer.
	Program complexity increases from grade level to grade level.
	CONTENT FOCUS The focus is on locating errors in a block-based environment program and through guided questioning determining solutions and applying the fix.
	COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand

Topic

Strand	Artificial Intelli	gence
Торіс	Machine Learn	ing
AI.ML.4.a Expla	ain three different	Expectations for Learning
machine learning approaches to choose which may be best for a given situation.		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 and reinforcement learning).
		 KEY SKILLS/PROCEDURES List problems Artificial Intelligence (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. 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	
Торіс	Machine Learr	ning
AI.ML.4.b Explain how machine learning can create a bias to understand how computers can be biased.		 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. 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	
Торіс	Machine Learn	ning
AI.ML.4.c Describe tasks where Al outperforms human tasks and when it does not to describe how humans rely on Al.		Expectations for Learning LEARNING PROGRESSION In grade 3, students identified tasks that use Artificial Intelligence (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 Al is a growing field that can replicate some human tasks. Al takes a long time to develop and is not perfect.
		 COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems Identify complex, interdisciplinary, real-world problems that can be solved computationally. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intelligence	
Торіс	Natural Interac	tions
AI.NI.4.a Use AI systems that are designed to be inclusive and describe how they affect the humans who use them.		Expectations for Learning LEARNING PROGRESSION In grade 3 students located Artificial Intelligence (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, such as 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. Al can assist in making technology accessible to all.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Artificial Intelligence	
Торіс	Natural Interac	ctions
AI.NI.4.b Give demonstrate ho decision-makin	examples of bias to ow it can affect g.	Expectations for Learning LEARNING PROGRESSION In grade 4, students gave examples of bias and how it affects decision-making. In grade 6, students will identify and explain how humans have agency in curating training data sets to identify bias in machine learning
		 IMPORTANT CONCEPTS Data input for Artificial Intelligence (AI) and how it creates bias.
		 KEY SKILLS/PROCEDURES Explore the various types of bias based on data sets. Give examples of bias found in machine learning including sample bias, exclusion bias, recall bias, observer bias, racial bias and association bias. Explore bias in advertising based on Big Data, Netflix, TikTok and YouTube, and make recommendations to defend how data is used to create biased recommendations.
		Content Elaborations
		CLARIFICATIONS The type of bias can affect the outcome of AI.
		CONTENT FOCUS Bias in data input can have negative consequences.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions

Department of Education

Ohio

Strand	Artificial Intel	ligence
Торіс	Perception	
AI.P.4.a Descr	ibe the difference	Expectations for Learning
between analo signals to unde	g and digital erstand their uses.	LEARNING PROGRESSION In grade 3, students moved from intelligent agents as a form of perception to how computers perceive the
AI.P.4.b Give computer perc	e examples of rception to	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.
understand ho the environme	w it is affected by nt.	 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. 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 Intel	Artificial Intelligence	
Торіс	Representatio	on & Reasoning	
AI.RR.4.a Crea system using a understand bin	te a classification tree structure to ary 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 Artificial Intelligence (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 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. Create a computational artifact for practical intent, personal expression, or to address a societal issue. Modify an existing artifact to improve or customize it. 	

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.4.b Dese represents kno reasonable ans	cribe how Al wledge to make a swer.	Expectations for Learning LEARNING PROGRESSION In grade 3, students were introduced to the idea of reasonable answers with Artificial Intelligence (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 Al 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 Al is complex and must make many decisions to 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intelligence	
Торіс	Societal Impa	icts
AI.SI.4.a Give to demonstrate specific groups	examples of bias how it can affect of people.	Expectations for Learning LEARNING PROGRESSION 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 Artificial Intelligence (AI).
		IMPORTANT CONCEPTS Bias can affect decision-making.
		 KEY SKILLS/PROCEDURES Give examples of bias to demonstrate how affects humans and machines based on algorithms used.
		Content Elaborations
		CLARIFICATIONS Bias is a human trait and it has consequences.
		CONTENT FOCUS Bias is a way humans make quick decisions; these decisions have 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.4.a List examples of computing technologies that have changed the global community to express how those technologies influence and are influenced by cultural practice.		Expectations for Learning LEARNING PROGRESSION In grade 3, students identified the impact technology has on everyday life in the local community. In grade 4, students recognize the impact of technology on the global community. In grade 5, students will explain how technology has changed everyday life globally.
		 IMPORTANT CONCEPTS People within a local region use technology in various ways. Daily life is influenced by the technology within the community.
		 KEY SKILL/PROCEDURES Identify specific types of technology used in the global community. Describe ways that various technology resources impact daily life in a region.
		Content Elaborations
		CLARIFICATIONS New computing technology is created, and existing technologies are modified for many reasons, including to increase their benefits, decrease their risks, and meet societal needs. Students explore topics that relate to the history of technology and the changes in the world due to technology. Topics could be based on current news content, such as robotics, wireless internet, mobile computing devices, GPS systems, wearable computing, or ways social media has influenced social and political changes. (CSTA K-12 Computer Science Standards, 2017)
		CONTENT FOCUS The focus is on the impacts of technology in daily life and the influence of cultural practices within the community.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspective of others and reflect on one's own perspectives when designing and developing computational products.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.4.b Identif diverse user nee accessibility to a	fy and anticipate eds to increase Ill users.	Expectations for Learning LEARNING PROGRESSION In grade 3, students identified diverse user needs and how computing devices have features built in to increase accessibility. In grade 4, students identify and anticipate diverse needs and ways to improve devices to make them more accessible to users. In grade 5, students will modify artifacts to meet diverse user needs to increase accessibility.
		 IMPORTANT CONCEPTS Users have diverse needs that impact accessibility. Computing devices have built-in features to increase accessibility.
		 KEY SKILL/PROCEDURES Locate and use built-in features to increase accessibility. Identify the diverse needs of users.
		Content Elaborations
		CLARIFICATIONS Anticipating the needs and wants of diverse end-users requires students to purposefully consider potential perspectives of users with different backgrounds, ability levels, points of view and disabilities. Examples of built-in features to increase accessibility include voice command, text-to-speech and magnify text. (CSTA K-12 Computer Science Standards, 2017)
		CONTENT FOCUS The focus is on identifying the diverse needs of users to increase accessibility.
		 COMPUTER SCIENCE PRACTICES Practice 1 Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand	Impacts of Computing	
Торіс	Social Intera	ctions
IC.SI.4.a Collab diverse perspec digital artifacts.	orate and consider tives to improve	Expectations for Learning LEARNING PROGRESSION In grade 3, students collaborated through feedback and reflection to improve a digital artifact and begin to explore how diverse perspectives improve digital artifacts. In grade 4, students collaborate with others to share the workload, increase diverse perspectives and improve a digital artifact. In grade 5, students will collaborate with others outside of the classroom to share the workload, increase diverse perspectives and improve the artifact.
		 IMPORTANT CONCEPTS Collaborating with peers to include diverse perspectives can improve digital artifacts. Reflecting on feedback from others can improve digital artifacts. Providing feedback to others can help them improve the quality of their work. Sharing the workload with peers can increase productivity and improve the quality of artifacts. KEY SKILL/PROCEDURES
		 Leave thoughtful feedback for peers that will help improve their digital artifacts. Reflect on feedback from peers to improve digital artifacts. Work with a partner or group to produce a digital artifact.
		Content Elaborations
		CLARIFICATIONS Teachers can support students to leave thoughtful feedback through modeling this process. Teachers should conduct whole group discussions after students have left feedback to determine if the feedback was productive. As students collaborate, they should begin to understand that group members take on agreed-upon roles to share the workload.
		CONTENT FOCUS The focus is on collaborating as a group to produce digital artifacts. Students begin to understand that feedback can be provided to improve artifacts during the creation process.

Strand	Impacts of Computing	
Торіс	Social Interactions	
		 COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Create team norms, expectations and equitable workloads to increase efficiency and effectiveness. Solicit and incorporate feedback from and provide constructive feedback to team members and other stakeholders. Evaluate and select technological tools that can be used to collaborate on a project.

Impacts of Computing

Topic Safety, Law	and Ethics
IC.SLE.4.a Use public domain or Creative Commons media, and refrain from copying or using material created by others without permission.	Expectations for Learning LEARNING PROGRESSION In grade 3, students were introduced to the concept that some resources can be shared (e.g., public domain, Creative Commons), while others must be used only with proper citations or permission. In grade 4, students are introduced to formal procedures used when sharing materials. Students will be expected to identify the type of source and give credit to the source. In grade 5, students will apply proper procedures when giving credit to a source.
	 IMPORTANT CONCEPTS Certain resources can be shared freely; some resources can be shared with proper citation and others can only be shared with permission from the creator. Sources can be cited formally or informally to give credit for the use of these materials.
	 KEY SKILL/PROCEDURES Determine whether a source can or cannot be used freely. Informally site sources.
	Content Elaborations
	CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet (e.g., video, photos, music) creates the opportunity for unauthorized use, such as online piracy, and disregard of copyrights. Students should consider the licenses on computational artifacts that they wish to use. For example, the license on a downloaded image or audio file may have restrictions that prohibit modification, require attribution, or prohibit use entirely. (CSTA K-12 Computer Science Standards, 2017)
	CONTENT FOCUS The focus is on recognizing that some resources are public domain and can be used freely and other materials need to be cited properly.
	COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Strand
Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
IC.SLE.4.b Explain why information should be shared or kept private to protect student identity.		Expectations for Learning LEARNING PROGRESSION In grade 3, students learned the importance of keeping personal information secure. In grade 4, students start to make distinctions between what information should be shared and what information should be kept private. In grade 5, students will begin to consider the effects of sharing private information.
		 IMPORTANT CONCEPTS For safety and security, personal information should be kept private.
		 KEY SKILL/PROCEDURES Determine whether information should or should not be shared. Recognize that keeping information private protects your identity.
		Content Elaborations
		CLARIFICATIONS Examples of information to be kept private are first and last name, birthday, addresses, phone numbers or other personal identifiers. Students should also understand that they should not share the personal information of others.
		CONTENT FOCUS The focus is on knowing why some information can be shared and some should be kept private.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
IC.SLE.4.c Com importance of pr own digital footp	nunicate the tecting one's nt.	Expectations for Learning LEARNING PROGRESSION In grade 3, students were exposed to the vocabulary relating to information security and formed a basic understanding of a digital footprint. In grade 4, students consider how their current online behavior affects their digital footprint. In grade 5, students will expand on the subject by further examining their online behaviors and how they affect others.
		 IMPORTANT CONCEPTS Students already have a digital footprint and continue to add to it with online behavior. Sites that students are currently using are storing personal information. Sites that collect digital information store personal information for an infinite amount of time.
		 KEY SKILL/PROCEDURES List examples of what would be included in a personal digital footprint. Give examples of personal information that is appropriate to share. Determine the impact of contributions to your digital footprint.
		Content Elaborations
		CLARIFICATIONS Students should begin to consider their own digital footprint and have discussions about the specific impacts of sharing different types of content on one's digital footprint.
		CONTENT FOCUS The focus is on considering specific examples of safe practices regarding online sharing and having students consider their own online actions.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of (Computing
Торіс	Safety, Law	and Ethics
IC.SLE.4.d Dest between allowin be public and ke information priva	cribe tradeoffs g information to eeping ate and secure.	Expectations for Learning LEARNING PROGRESSION In grade 3, students will learn about what information should be shared and how to keep their information secure. In grade 4, students are introduced to the idea that there are tradeoffs between allowing information to be public versus keeping information private. In grade 5, students will learn about their digital footprint.
		 IMPORTANT CONCEPTS Students understand personally identifiable information (PII). Students should know steps to keeping personally identifiable information (PII) secure.
		 KEY SKILLS/PROCEDURES List examples of personally identifiable information (PII). Explain the dangers of sharing personally identifiable information.
		Content Elaborations
		CLARIFICATIONS Student discussions should focus on examples of personally identifiable information and how to keep personal information, both private and public, safe online.
		CONTENT FOCUS Students to be able to effectively manage their digital identities. Students should understand that online information does not go away and that information online can affect the students' real lives, even in future years.
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems. 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
IC.SLE.4.e Expl cyber bullying ar this is happening	ain the effect of nd who to tell if g.	Expectations for Learning In grade 4, students learn what cyberbullying is and what to do if they feel threatened online. In grade 5, students will learn about the forms of cyberbullying and strategies to use to stop this type of behavior.
		 IMPORTANT CONCEPTS Define cyberbullying. List the effects of cyberbullying. Know what to do if anyone is being cyberbullied.
		 KEY SKILLS/PROCEDURES Define the term cyberbully. Categorize the effects of cyberbullies on individuals and the online community. Create a plan for who to contact is you or someone else if being bullied in person or online.
		Content Elaborations A bully is a person that habitually seeks to intimidate or otherwise harm others. Similarly, a cyberbully seeks to harm others using communications through the Internet. Understanding the effects of cyberbullying and knowing what is appropriate versus inappropriate online behavior can help students how to handle situations of cyberbullying when it happens to them or someone else.
		CLARIFICATIONS Cyberbullying can occur during gaming; social media activities or any other time people interact on the computer. Knowing when to alert adults to online activities are skills all students should know and have when working online. There are many federal and state resources available online and are great resources for teachers.

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 3. Employ self and peer advocacy to address bias in interactions, product design and development methods.

GRADE 5

Strand	Computing Systems	
Торіс	Devices	
CS.D.5.a Explore the internal parts of the computing system and their function to understand and describe the role they play in a computer system.		Expectations for Learning LEARNING PROGRESSION In grade 4, students developed their understanding of what external components are used to share information. In grade 5, students develop their understanding of the internal parts of the computer and how they play a role in the computer system. In grade 6, students will apply knowledge to identify the benefits and limitations of devices.
		 IMPORTANT CONCEPTS Different internal parts of a computer have different purposes. Each internal component has a different function in a computer system.
		 KEY SKILL/PROCEDURES Identify key internal components (i.e., parts) such as RAM, hard drive, CPU, motherboard, etc. Describe the function of each of the key internal components. Describe the internal components of the selected device.
		Content Elaborations
		CLARIFICATIONS Internal components (i.e., parts) at this grade level focus on RAM, hard drive, CPU and the motherboard. Students do not need to have an in-depth understanding of these.
		CONTENT FOCUS The focus should be on students understanding the role major internal components (i.e., parts) play in a computing system. Unlike external components which are not all needed for a device to function, internal components are critical to the device running properly.
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.

Strand	Computing	Systems	
Topic Hardware/S		oftware	
CS.HS.5.a Eval learning tools/d planning, implei reflecting across	luate digital levices to support menting and s curricular areas.	Expectations for Learning LEARNING PROGRESSION In grade 4, students continued to select learning tools/devices and used them to aid in planning, implementing and reflecting on given tasks. In grade 5, students use and evaluate the digital learning tools and devices they've chosen and consider the planning, implementation and reflection across curricular areas. In grade 6, students will look at the ways hardware and software components come together in a computer system to complete a task.	
		 IMPORTANT CONCEPTS Software and hardware need to be chosen and evaluated to ensure they support the task. Learning tools should be used for planning, implementing and reflecting across curricular areas. 	
		 KEY SKILL/PROCEDURES Verbally evaluate the tools and devices chosen to accomplish tasks for their usefulness in planning, implementing and reflecting. Use and verbally evaluate tools across curricular areas. 	
		Content Elaborations	
		CLARIFICATIONS Students should recognize if the tool or device they have chosen is appropriate for the task. For example, if the assignment is to make a presentation, a word processing program would not be the best selection. Tasks should be cross-curricular (i.e., blending math, science and computer science, or tasks that require an analysis of data from science or social studies).	
		CONTENT FOCUS The focus is on students using and evaluating tools in cross-curricular tasks.	
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.	

Strand	Computing Systems	
Торіс	Troubleshoo	oting
CS.T.5.a Diagno develop strategi technology issue	ose problems and es to resolve es.	Expectations for Learning LEARNING PROGRESSION In grade 4, students focused on diagnosing and describing potential hardware and software problems. In grade 5, students work to diagnose problems, describe the problem, and develop strategies to resolve technology issues. In grade 6, the problems will become more advanced. It will require a combination of critical thinking skills and basic knowledge of computing hardware and software to identify the problem.
		 IMPORTANT CONCEPTS Multiple troubleshooting strategies exist for each issue.
		 KEY SKILL/PROCEDURES Diagnose problems in hardware and software. Apply a solution for the problem. Describe the problem and reason for the problem in detail.
		Content Elaborations
		CLARIFICATIONS Students are working on diagnosing problems, describing them and applying a solution where appropriate. Students should be able to describe the problem to a peer or adult. Students should be able to troubleshoot their problems. Problems may include an unplugged computer, a computer not connecting to the network or a program not loading. Troubleshooting should also occur within individual programs, such as a block-based coding environment or a word processing program.
		CONTENT FOCUS The focus is on students diagnosing problems, describing them and applying a potential fix.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.</i> Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand	Networks and	the Internet
Торіс	Networking	
NI.N.5.a Model how information is broken down to be transmitted and then reassembled to help students gain a better understanding of the internet and networks.		Expectations for Learning LEARNING PROGRESSION In grade 4, students described how information is broken apart, sent, and received over the internet. In grade 5, students demonstrate how information is broken apart, sent and reassembled when received over the internet. In grade 6, students will explore the protocols (i.e., rules) in transmitting data across the internet.
		 IMPORTANT CONCEPTS Manipulating a URL (i.e., web address) can change what information is accessed. Information is broken into packets (i.e., parts) at the sending point and reassembled at the receiving point. Information is sent to specific places based on web addresses.
		 KEY SKILL/PROCEDURES Modify a URL (i.e., web address) to access the content. Demonstrate what occurs when a URL is modified. Use a metaphorical example to describe how information is broken down into parts and reassembled.
		Content Elaborations
		CLARIFICATIONS Students begin manipulating a URL to access desired information within a site. Students begin using applications to shorten web addresses for ease of access.
		An example of a metaphorical connection that students could make to describe how information is transmitted would be a roller coaster ride. The track could be seen as the internet connection and the cars, and the people are the information traveling through the connection.
		CONTENT FOCUS The focus is on students modifying a URL, or web address, to reach a specific site and describing how the modification impacts the information accessed. Students model how information is transmitted.

Strand	Networks and the Internet	
Торіс	Networking	
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.5.b Apply k network address rules (i.e., protoc real-world scena	nowledge of es, names and ols) to discuss rios.	Expectations for Learning LEARNING PROGRESSION In grade 4, students described how different naming techniques are related to the type of information accessed. In grade 5, students apply this knowledge by interacting with networks appropriately and apply these concepts to real-world scenarios. In grade 6, students will continue to apply this knowledge to more advanced concepts of networks.
		 IMPORTANT CONCEPTS Information is broken into parts and reassembled at the endpoint. The endpoint is identified by an IP address.
		 KEY SKILL/PROCEDURES Use knowledge of top-level naming rules (.com, .edu, .gov) as it relates to the reliability of information. Explain the fundamental workings of the internet using appropriate terminology (e.g., packets, IP address).
		Content Elaborations
		CLARIFICATIONS Students need to explain the steps required to transmit information over the internet. Students should explain that information is broken into packets, transmitted to another place identified by an IP address and reassembled at the end site, similar to a puzzle being taken apart, given to other people, and assembled somewhere else. The IP address serves as the location where information is sent like a mailing address and a letter. No discussion on IP address components (i.e., parts) is needed at this level.
		CONTENT FOCUS The focus is on explaining the fundamental workings of the internet.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ε γ
NI.C.5.a Demon creation techniq and use a strong on personal acc	strate password ues to develop g password used ounts.	Expectations for Learning LEARNING PROGRESSION In grade 4, students described personal information and how passwords are used to protect that information. In grade 5, students create, implement, and store secure passwords to protect personal information. In grade 6, students will understand the concerns that information needs to be protected.
		 IMPORTANT CONCEPTS Students demonstrate password creation techniques. Apply personally created passwords to personal accounts. Protection techniques of passwords for personal accounts.
		 KEY SKILL/PROCEDURES Create secure passwords utilizing password creation techniques. Build a strong password using password creation techniques. Apply password protection techniques.
		Content Elaborations
		CLARIFICATIONS Explain alpha-numeric, symbols and non-dictionary words. Use alpha-numeric, symbols and non-dictionary words to build a secure password. Students often misuse password storage techniques. They need to understand the difference of using an online password storage system, saving passwords on the computer, writing down passwords or remembering them and the benefits of types of passwords and storage techniques.
		CONTENT FOCUS The focus is on students building strong, secure passwords using password creation techniques and protecting passwords using different protection techniques.
		 COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Networks and the Internet	
Торіс	Cybersecurit	ty
NI.C.5.b Explore and utilize safe online services such as web, email, video, gaming, cloud services and network attached storage devices.		Expectations for Learning LEARNING PROGRESSION In grade 4, students describe the effects of malicious content. In grade 5, students analyze the use of online services. In grade 6, students will recognize the effects of malicious content and other online threats.
		 IMPORTANT CONCEPTS Students utilize online services such as web, email, video, gaming, networked drives and cloud services. There are appropriate levels of information sharing appropriate to different online services.
		 KEY SKILLS/PROCEDURES Understand the use of devices and software in connected environments. Explore the use of different tools and uses of computing systems. Explore the need for security for these systems.
		Content Elaborations
		CLARIFICATIONS Students should understand that using websites, email, video gaming, cloud services and networked drives adds to the need for security practices.
		CONTENT FOCUS Explore and experiment with different uses of devices, software and connected systems. Students should discuss the information each of these systems stores and what they share with other systems. Students should also understand how the information in the systems is secured.
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		 Practice 5. Creating Computational Artifacts 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. C.5.b Explore and utilize various online services such as web, email, video, gaming, Cloud Services and networked drives.

Ohio

Expectations for Learning

LEARNING PROGRESSION

Networks and the Internet

Internet of Things

NI.IOT.5.a Learn and model how

information is broken down to be

transmitted by smart devices to

help students visualize how

information transfers over

NI.IOT.5.b Explore the benefits of the IoT with regards	blockchain to recognize how every bit of information shared over networks is personally identifiable. They will similarly explore the weaknesses in networks that allow programmers, both legitimate and illegitimate, to access that personal information.
health to gain an appreciation of the risks involved in using	 IMPORTANT CONCEPTS There are benefits and risks to using devices connected to the internet.
devices, including data theft, identity theft, tracking and other forms of criminality.	 KEY SKILLS/PROCEDURES Model and engage in safety practices while using the internet to reduce and avoid risks. Explain how information is transmitted over the internet in packets.
	Content Elaborations
	CLARIFICATIONS Explain how data is transmitted across the Internet, and that anyone is allowed to look at it. Discuss that the act of sending information implies that the sender is giving permission for anyone who can see the data stream to examine its contents.
	Explore methods that students can implement to reduce the risk of data theft.
	CONTENT FOCUS Apply the knowledge of networks to assess the risk factors, benefits and convenience when using smart devices.
	 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
	Practice 7. Communicating About Computing3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

In grade 4, students recognize how smart and intelligent devices communicate over the internet and see

how network communication can be traced. In grade 5, students explore how information is transmitted over

the internet and identify the risks and benefits of using the internet. In grade 6, students will define the term

Strand

Topic

the internet

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Strand	Data and Analysis	
Торіс	Data Collect	tion and Storage
DA.DCS.5.a Gather and organize multiple quantitative data elements using a tool to perform various tasks.		Expectations for Learning LEARNING PROGRESSION In grade 4, students built upon the use of tools from grade 3 to collect data from multiple sources within a singular topic over time. In grade 5, students begin to select appropriate tools to collect data from multiple sources within a singular topic over time. In grade 6, students will begin to evaluate the validity of data collection tools.
		 IMPORTANT CONCEPTS Keeping an organized record of data from multiple sources, over time, is critical to analyzing data. Different tools are used to collect different types of data. Tools impact the accuracy of data.
		 KEY SKILL/PROCEDURES Select and use appropriate tools to collect and organize data. Maintain accurate data from multiple sources, using multiple tools, within a singular topic over a period of time. Collect data from multiple sources within a singular topic, by making repeated observations over time.
		Content Elaborations
		CLARIFICATIONS Tools that may be explored are digital thermometers, GPS sensors, calculators, scales, digital forms (survey tools), length measurement tools, a stopwatch, etc. Data can be organized by using various digital and non-digital tables and charts. Digital organizational resources could include spreadsheets, online graphing programs, etc. An example of collecting data from multiple sources within a singular topic could be collecting the height of students in three different classes, throughout the school year. Students should select the most appropriate tool for data collection. Students could choose between an online form, table or simple document.
		CONTENT FOCUS The focus is on students selecting an appropriate data collection tool to improve the accuracy of data.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Analysis	
Торіс	Data Collect	tion and Storage
		Career Connections CAREER AWARENESS With guidance, students will compare quantitative job data (such as salary and number of yearly job openings) using the OhioMeansJobs <u>Career Cluster tool</u> and create an artifact to display the data. Students draw conclusions from that data and present their findings.
DA.DCS.5.b Compare and contrast file formats to demonstrate the advantages and disadvantages of each.		Expectations for Learning LEARNING PROGRESSION In grade 4, students began to gain an understanding that different file types may require different storage. In grade 5, students discuss the advantages and disadvantages of different file types. In grade 6, students will make choices about their file formats to organize data.
		 IMPORTANT CONCEPTS Different file types can be different sizes. Different file types have different purposes. How data is stored impacts accessibility. KEY SKILL/PROCEDURES
		 Locate and retrieve data on a computing device (i.e., computer). Consider file size when sharing and saving data.
		Content Elaborations
		CLARIFICATIONS Examples of file types would be image (i.e., .jpg, .png, .gif .bmp), document (e.g., .doc, .docx, .pages, .txt), multi-media (e.g., .mov, mp4,.wmb) and presentation (e.g., .ppt, .pptx, .key). For example, when creating a presentation, use slides instead of a document.
		Examples of data storage could include saving to a device, local network or the cloud. An example of file size impacting storage is the inability to download an app on a tablet due to lack of storage.
		Accessibility refers to the ability to retrieve data. Students should understand that data saved to a device will not be accessible without that same device. Accessibility also refers to the ability to open file formats on different devices.

Strand	Data and Analysis	
Торіс	Data Collection and Storage	
		Information refers to data, which could include pictures, audio, video and documents.
		CONTENT FOCUS The focus is on different file types accomplishing different tasks. There are pros and cons to using various file types.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Analysis	
Торіс	Visualization	and Communication
DA.VC.5.a Organize and present collected data using visual or other types of representations to highlight relationships and support a claim.		Expectations for Learning LEARNING PROGRESSION In grade 4, students interpreted data in self-created graphs to present insights. In grade 5, students use graphs created to highlight and support a claim they have made. In grade 6, students will look for patterns and communicate relationships between data sets.
		 IMPORTANT CONCEPTS Data from a graph can be used to gain insights or solve a problem. The way data is interpreted and highlighted from a graph can support or disprove a claim.
		 KEY SKILL/PROCEDURES Record data, with several categories, on a scaled bar graph or picture graph. Determine the appropriate scale for data given. Interpret and answer questions regarding data presented in a bar or picture graph. Use a visual representation of data (e.g., picture/bar graph, line plot) to support a claim.
		Content Elaborations CLARIFICATIONS An important concept for students to begin to understand is that a scale is chosen based on the data available. Students should begin understanding that data is used to solve problems. For example, if many people report they do not recycle due to lack of recycling bins, we can conclude that providing recycling bins to people will increase recycling and improve the environment.
		CONTENT FOCUS The focus is on students using a representation of data they have created to support a claim they have made.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

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Strand	Data and Analysis	
Торіс	Inference and	d Modeling
DA.IM.5.a Utilize cause and effect predict outcomes	e data to propose t relationships and s.	Expectations for Learning LEARNING PROGRESSION In grade 4, students determined if adequate data had been collected and ran simulations to explore outcomes. In grade 5, students run simulations to test theories and make predictions about how larger data sets affect outcomes. In grade 6, students will validate or invalidate a prediction about a collection of data. IMPORTANT CONCEPTS • Sample size affects outcomes. • Trends can be found by analyzing data sets. KEY SKILL/PROCEDURES • Use data to highlight or propose cause and effect relationships Predict outcomes using a data set. • Manipulate data and explain outcomes. Content Elaborations CLARIFICATIONS Students explain patterns in data and identify missing values. They begin to manipulate data and reflect on how the quantity of data affects outcomes. Students will use software tools, such as spreadsheets to manipulate the quantity of data and reflect on changes that occur. CONTENT FOCUS The focus is on students identifying patterns in data to find missing values. They predict outcomes to continue patterns. They manipulate the quantity of data and reflect on changes that occur.
		COMPUTER SCIENCE PRACTICES <i>Practice 4.</i> Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic Thinking and Programming	
Торіс	Algorithms	
ATP.A.5.a Evaluate a multi-ste process to diagram the proper steps to solve a problem.		Expectations for Learning LEARNING PROGRESSION In grade 4, students refined an algorithm to accomplish a given task. In grade 5, students compare and refine algorithms with a focus on the result. In grade 6, students will evaluate a multi-step process to diagram the proper steps to find the most efficient solution.
		 IMPORTANT CONCEPTS An algorithm is a series of steps to complete a process or task. Once algorithms are created and written, they need to be tested and possibly revised based on the results. Pseudocode and flowcharts can be used to create and modify an algorithm.
		 KEY SKILL/PROCEDURES Utilize logical patterns of progression within an algorithm to modify and refine the algorithm to efficiently accomplish a given task. Utilize pseudocode and flow charts to assist with communicating, creating and modifying an algorithm to accomplish a given task.
		Content Elaborations CLARIFICATIONS Students will utilize processes of computational thinking (i.e., logical thought) to sort through, identify errors, and modify algorithms. They will need to utilize communication techniques (i.e., pseudocode, flowcharts) to document the potential errors and solutions.
		CONTENT FOCUS The focus is on students determining the necessity of decomposition, abstraction, modification and reassembly of the algorithm with an emphasis on the resulting algorithm. Students should utilize communication strategies to further refine their algorithms.
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 2. Decompose real-world problems.

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Strand	Algorithmic Thinking and Programming	
Торіс	Variables an	d Data Representation
ATP.VDR.5.a Create a variable, a placeholder for storing a value, to understand how it is used in a multi-step process (i.e., algorithm).		Expectations for Learning LEARNING PROGRESSION In grade 4, students expanded on defining and identifying variables. In grade 5, students create variables to store and modify data. In grade 6, students will identify unknown values that need to be represented by a variable within a multi-step process.
		 IMPORTANT CONCEPTS Variables are placeholders for values that can be used in an algorithm. Data can be stored in the variable. Variables can represent multiple pieces of information from multiple lines. Coding language places the variable at the front of the algorithm.
		 KEY SKILL/PROCEDURES Use logical variable representations (i.e., letter or symbol). Write or edit an algorithm that substitutes a variable for a value. Edit the variable to show how it changes the algorithm's result. Determine if a variable is needed within an algorithm.
		Content Elaborations CLARIFICATIONS Symbols such as letters are used in programming to hold values. Students need to learn that the syntax (i.e., the order of symbols in the equation) may impact the success of a program. Students can explore what happens when the data stored in a variable is changed. For example, using a repetitive nursery rhyme (e.g., Five Little Monkeys), students can create a variable to change the number of monkeys. Here, the changing value is the number of monkeys.
		Students are not expected to only use the formal terms of "variable" and "algorithm."
		CONTENT FOCUS The focus is on students being able to define and identify variables as symbols such as letters and understand how they are used in algorithms to store data. Students should begin using variables within equations. Students should explore how variables store data and modify equations.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic	Thinking and Programming	
Торіс	Control Stru	Control Structures	
ATP.CS.5.a C using sequence and conditiona a problem.	create a program ces, events, loops als to solve	Expectations for Learning LEARNING PROGRESSION In grade 4, students refined their programming skills using established structures, such as loops and conditionals. In grade 5, students apply these new skills in increasingly complex ways and will continue to refine these to work towards programming efficiency. In grade 6, students will identify decisions and loops in programs to solve problems.	
		 IMPORTANT CONCEPTS Loops are statements that repeat and make programming more efficient for the computer and the programmer. Conditionals are typically in the form of "if/then" statements and enable the program to follow different paths. Events are structures that programmers can use to explain how the program will react when the user interacts. Proper sequencing of steps within the program ensures efficiency. 	
		 KEY SKILL/PROCEDURES Insert a loop in a program to avoid typing a command several times. Insert a conditional in a program to make the program more powerful by creating several paths (if/then or if/then/else). Create an event in the format "When (action), then (result) occurs". Diagram the flow of a program to demonstrate the sequence of its events and products. Combine statements within other statements (nesting) to make compound statements. 	
		Content Elaborations CLARIFICATIONS Loops can occur in programming by having the robot or pen repeat a motion several times, such as going forward ten paces and then turning thirty degrees. In an algorithm, students can program to have a number added several times. Conditionals occur in a program by inserting a command to complete when a condition is met. For instance, if a condition states "If n=5," when the value n=5 is achieved, then the program will execute the command given.	

Strand	Algorithmic Thinking and Programming	
Торіс	Control Structures	
		Events can be thought of as an action because of an action. Such as, "When I click the mouse, the image rotates."
		Sequencing of events and commands is an important part of programming when creating a program from scratch or remixing an existing one.
		Students can diagram or describe the steps of a program using a flowchart or other graphic organizer.
		CONTENT FOCUS The focus is on using a loop to eliminate several redundant commands, using a conditional to add complexity to a program and to program efficiently, creating an event in the format "When (action), then (result) occurs," and diagraming or describing the flow of a program. The complexity of the loops, conditionals, events and sequences continues to increase from the prior grade level.
		COMPUTER SCIENCE PRACTICES <i>Practice 4.</i> Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Modularity	
ATP.M.5.a Decompose (i.e., break down) the steps needed or not needed (i.e., abstraction) into precise sequences of instructions to design an algorithm.		 Expectations for Learning LEARNING PROGRESSION In grade 4, students refined the decomposition, abstraction and algorithm creation process. In grade 5, students begin to use abstraction to further refine and design an algorithm. In grade 6, students will utilize decomposition, abstraction, modification and creation of an algorithm to accomplish a given task. IMPORTANT CONCEPTS Modularity refers to components of a program that complete a procedure or task. Modules within a program may need to be evaluated, refined and/or copied. KEY SKILL/PROCEDURES Regroup or redesign sets of a decomposed algorithm to modify the result of the algorithm in the most efficient manner possible. Determine if the logic of an algorithm requires decomposition, abstraction or modification to efficiently accomplish a given task.
		 Content Elaborations CLARIFICATIONS Processes of logical thought should include the dissection of a whole into its parts. Solving smaller sections of a larger equation to determine its functionality toward the end goal. Ensure that sets of instructions include all needed parts to modify the result to reach the end goal. These instructions can be written in code, pseudocode, real language or flowcharts related to the language of the algorithm. CONTENT FOCUS The focus is on students utilizing processes of logical thought, decomposing the algorithm and abstracting, modifying, and reassembling it to accomplish a given task in the most efficient means possible. Students need to utilize communication strategies to document and reduce the algorithm to the most efficient result.

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Modularity	
		 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.
		 Practice 4. Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
		<i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

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Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Modularity	
ATP.M.5.b With grade appropriate complexity, modify, remix or incorporate portions of an existing program into one's own work, to develop something new or add		Expectations for Learning LEARNING PROGRESSION In grade 4, students modified and elaborated the portions of code used in their programs. In grade 5, students use portions of code to develop something new based on a given problem. In grade 6, students will be able to identify the parts of the program they designed.
more advanced leatures.		 IMPORTANT CONCEPTS Smaller portions of code should be grouped so the result will complete a task. These small portions should accomplish a task from start to finish independently of any other sections of code. These sections of code can then be reused to create a new program to solve a problem.
		 KEY SKILL/PROCEDURES Break down steps into repeatable chunks. Use chunks to repeat steps to accomplish a given task. Create a program using chunked code.
		Content Elaborations
		CLARIFICATIONS Chunks of code can be grouped, named, and used as a module (method, class, function) to build a new or modified version of a program (i.e., grouping a set of code used to accomplish the task of climbing stairs into a module that can be used anytime stairs need to be climbed).
		CONTENT FOCUS The focus is on students using chunks of code (i.e., modules), repeating and reorganizing them to create a new program to solve a different problem.
		 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.
		 Practice 4. Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
		<i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Algorithmic T	hinking and Programming
Торіс	Program Dev	elopment
ATP.PD.5.a Use a design proce to plan and develop a program that includes multiple steps and end user preferences.		Expectations for Learning LEARNING PROGRESSION In grade 4, students designed and created a program for a multi-step problem. In grade 5, students design and create a program that addresses a multi-step problem and the preferences of the end user. In grade 6, students will advance in designing and creating their own code-based program using block-based languages. Students may begin using text-based coding to program.
		 IMPORTANT CONCEPTS A flow chart is one type of organizational tool that can be used to plan a program considering the sequence of its features. An algorithm can be used to build a program. Programs can execute multiple steps. The end user's preferences can be considered in the creation of a program.
		 KEY SKILL/PROCEDURES Design a program that can solve a problem. Use the design process when planning a program. Create a program for a multi-step problem. Incorporate the preferences of the end-user into the program.
		Content Elaborations
		CLARIFICATIONS Programs can be designed in a plugged (i.e., using a computer) or unplugged environment (i.e., not using a computer).
		Programs can be designed using a block-based environment.
		Programs should address a multi-step problem.
		A flow chart is a type of organizational tool that can be used to plan a program.
		End-user preferences are additional components included in the problem.

Strand	Algorithmic T	Thinking and Programming
Торіс	Program Dev	elopment
		CONTENT FOCUS The focus is on designing a program that can solve a problem with 3 or more steps and incorporating the preferences of the end-user.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations. Create a computational artifact for practical intent, personal expression or to address a societal issue.
AI.ML.5.a Con	npare three different	Expectations for Learning
solve a proble	m.	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 Artificial Intelligence (AI) encounter and which machine learning might work best to see the 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.

Strand	Algorithmic Thinking and Programming	
Торіс	Program Development	
		 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 Intel	Artificial Intelligence	
Торіс	Machine Lear	ning	
AI.ML.5.b. Describe how		Expectations for Learning	
algorithms and m can exhibit biase how humans intro algorithms and m	nachine learning es to be aware of roduce bias into machine 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. 	

Strand	Artificial Intelligence	
Торіс	Machine Learn	ning
AI.ML.5.c Describe tasks where Al 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 Artificial Intelligence (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 performs 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 Al can perform tasks that humans once did. As Al grows, it can take over more human tasks like driving cars.
		CONTENT FOCUS Al 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.

Strand	Artificial Intelli	igence
Торіс	Natural Interac	ctions
AI.NI.5.a Describe ways that AI		Expectations for Learning
systems can be support inclusiv	e designed to vity.	LEARNING PROGRESSION In grade 4, students used Artificial Intelligence (AI) systems designed to be inclusive and learned how it affects the humans that use them. 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 Al has to be designed with the end-user in mind, including those with special needs.
		CONTENT FOCUS Al 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.

Strand	Artificial Intel	ligence
Торіс	Perception	
AI.P.5.a Describe how sensor inputs are converted as analog or digital signals to describe their uses.		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 Identify 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intel	ligence
Торіс	Perception	
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 using 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.

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.5.a Create a classification system using a tree structure to demonstrate binary solutions.		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, create a 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 Artificial Intelligence 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 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. Create a computational artifact for practical intent, personal expression, or to address a societal issue. Modify an existing artifact to improve or customize it.

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.5.b Describe how Al representations support reasor to answer questions.	ribe how Al support reasoning ions.	Expectations for Learning LEARNING PROGRESSION In grade 4, students were describing how Artificial Intelligence (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, create a route on a map or reason about
		 concepts in a knowledge graph by drawing a search tree. IMPORTANT CONCEPTS Al 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 Al to give a reasonable answer.
		CONTENT FOCUS Al is complex and has to make lots of decisions to 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
Strand	Artificial Intelli	gence
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Торіс	Societal Impac	ets
AI.SI.5.a Explore how data is influenced by bias and how it affects decision-making to defend arguments in AI		Expectations for Learning LEARNING PROGRESSION In grade 4, students gave examples of bias and how it affects decision-making. In grade 5, students explore how data is influenced by bias. In grade 6, students will identify and explain how humans have agency in curating training data sets to identify bias in machine learning.
		 IMPORTANT CONCEPTS Data input for Artificial Intelligence (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 corporate data pools, 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 Identify complex, interdisciplinary, real-world problems that can be solved computationally. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Program Dev	velopment
ATP.PD.5.b Using guided questions, work through a program to identify errors and discuss possible solutions to repair the program.		Expectations for Learning LEARNING PROGRESSION In grade 4, students continued with guided questions that assisted them in debugging their program. In grade 5, students become less dependent upon guided questions and begin to debug more complex programs. In grade 6, students will modify and fix their own errors in a block-based environment and will begin the debugging process in a text-based environment.
		 IMPORTANT CONCEPTS A computer bug is a series of commands that do not properly interact with each other and causes interruptions in the program execution (i.e., error in the program). To "debug" is to find the error within a program and then apply an appropriate fix.
		 KEY SKILL/PROCEDURES Identify errors in a program. Apply a fix to errors in a program.
		Content Elaborations
		CLARIFICATIONS If a program will not execute properly, programmers often refer to the issue as the program "breaks" or the program has a "bug" error. "Debugging" a program refers to scanning through the program code to find the error in the commands and then correcting or repairing that programming code.
		Guided questions are questions that prompt the programmer to think more about their error and problem solve potential solutions without being given the answer.
		CONTENT FOCUS The focus is on locating errors in a block-based environment program and determining solutions and applying the fix.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 2. Identify and fix errors using a systematic process.

Strand	Impacts of C	Computing
Торіс	Culture	
IC.Cu.5.a Explain how computing technologies have changed the global community and express how those technologies influence and are influenced by cultural practices		Expectations for Learning LEARNING PROGRESSION In grade 4, students recognized the impact of technology on the global community. In grade 5, students explain how technology has changed everyday life globally. In grade 6, students will develop a better understanding of how we connect to people around the world.
		 IMPORTANT CONCEPTS People within a region use technology in various ways. Daily life is influenced by the technology within the community.
		 KEY SKILL/PROCEDURES Identify specific types of technology used globally. Describe ways that various technology resources impact daily life. Compare and contrast the use of technology and the impacts it has on different communities.
		Content Elaborations
		CLARIFICATIONS New computing technology is created, and existing technologies are modified for many reasons, including to increase their benefits, decrease their risks, and meet societal needs. Students explore topics that relate to the history of technology and the changes in the world due to technology. Topics could be based on current news content, such as robotics, wireless internet, mobile computing devices, GPS systems, wearable computing or ways social media has influenced social and political changes. (CSTA K-12 Computer Science Standards, 2017)
		Students should begin to realize that the effects of technology on their community or region are not necessarily the same as the effects on other communities or regions. For example, one community may be experiencing the effects of having clean energy (e.g., solar power, wind power), whereas another community may not have the same experience.
		CONTENT FOCUS The focus is on the history and influence of technology in the world.

Strand	Impacts of Computing	
Торіс	Culture	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspective of others and reflect on one's own perspectives when designing and developing computational products.

Strand	Impacts of C	omputing
Торіс	Culture	
IC.Cu.5.b Develop, test and refine digital artifacts to improve accessibility and usability.		Expectations for Learning LEARNING PROGRESSION In grade 4, students identified and anticipated diverse needs and ways to improve devices to make them more accessible to users. In grade 5, students are modifying artifacts to meet diverse user needs to increase accessibility. In grade 6, students will identify issues of bias and accessibility in the design of existing technologies to address equality and equity in society.
		 IMPORTANT CONCEPTS Users have diverse needs that impact accessibility. Computing devices have built-in features to increase accessibility for all users. Artifacts can be modified to increase accessibility for diverse users.
		 KEY SKILL/PROCEDURES Locate and use built-in features to increase accessibility. Identify the diverse needs of users. Modify artifacts to meet diverse needs and to increase accessibility.
		Content Elaborations CLARIFICATIONS Students may consider using both speech and text when they wish to convey information in a game. They may also wish to vary the types of programs they create, knowing that not everyone shares their tastes. (CSTA K-12 Computer Science Standards, 2017)
		CONTENT FOCUS The focus is on the diverse needs of users, the impact needs have on accessibility, and the modification of artifacts to improve accessibility.
		 COMPUTER SCIENCE PRACTICES Practice 1 Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand	Impacts of C	Computing
Торіс	Social Intera	actions
IC.SI.5.a Collaborate and consider diverse perspectives to improve digital artifacts.		Expectations for Learning LEARNING PROGRESSION In grade 4, students collaborated with others to share the workload, increase diverse perspectives, and improve the artifact. In grade 5, students collaborate with others outside of the classroom to share the workload, increase diverse perspectives and improve the artifact. In grade 6, students will analyze and present the beneficial and harmful effects of communicating using technology. They will begin to examine their impacts on the global, economic, political, business and cultural interactions.
	1	 IMPORTANT CONCEPTS Collaborating with peers to include diverse perspectives can improve digital artifacts. Reflecting on feedback from others can improve digital artifacts. Providing feedback to others can help them improve the quality of their work. Collaborating with others outside of the classroom can provide a different cultural aspect. People use technology to work together remotely (i.e., in different buildings, cities, states, countries).
		 KEY SKILL/PROCEDURES Leave thoughtful feedback for peers that will help improve their digital artifacts. Reflect on feedback from peers to improve digital artifacts. Collaborate with others digitally (i.e., different buildings, cities, states, countries), to improve an artifact.
		Content Elaborations CLARIFICATIONS Seeking feedback from people from diverse backgrounds and geographical areas can provide insights for improving a project.
		Students can collaborate digitally through various means, such as online video chats, online word processing programs, surveys or forms and social networking sites. CONTENT FOCUS The focus is on collaborating digitally with people from diverse backgrounds and geographic areas.

Strand	Impacts of Computing	
Торіс	Social Interactions	
		 COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Create team norms expectations and equitable workloads to increase efficiency and effectiveness Solicit and incorporate feedback from and provide constructive feedback to team members and other stakeholders. Evaluate and select technological tools that can be used to collaborate on a project.

Impact of Computing

Topic Safety, Law	and Ethics
IC.SLE.5.a Use public domain or Creative Commons media, and refrain from copying or using material created by others without permission.	Expectations for Learning LEARNING PROGRESSION In grade 4, students were introduced to more formal terminology used when evaluating the sharing of resources. Students identified the type of source and give credit to the source. In grade 5, students apply proper procedures when giving credit to a source. In grade 6, students will be exposed to a broader range of resources that must be given proper credit.
	 IMPORTANT CONCEPTS Certain resources can be shared freely; some resources can be shared with proper citation and others can only be shared with permission from the creator. Sources must be cited formally to give credit for the use of materials. Citations should consider copyright, Creative Commons, fair use, open-source, etc.
	 KEY SKILL/PROCEDURES Determine whether a source can or cannot be used freely. Use proper format to cite online sources.
	Content Elaborations CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet (e.g., video, photos, music) creates the opportunity for unauthorized use, such as online piracy and disregard of copyrights. Students should consider the licenses on computational artifacts that they wish to use. For example, the license on a downloaded image or audio file may have restrictions that prohibit modification, require attribution or prohibit use entirely. (CSTA K-12 Computer Science Standards, 2017)
	CONTENT FOCUS The focus is on recognizing that some resources are public domain and can be used freely and other materials need to be cited properly.
	COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Strand

Strand	Impacts of C	Computing
Торіс	Safety, Law	and Ethics
IC.SLE.5.b Communicate the effects of sharing personal information on the safety of student identity to determine how to protect students.		Expectations for Learning LEARNING PROGRESSION In grade 4, students started to make distinctions between what information should be shared and what information should be kept private. In grade 5, students consider the effects of sharing private information. In grade 6, students should evaluate shareable information in a broader context relating to society.
		 IMPORTANT CONCEPTS For safety and security, personal information should be kept private. Sharing personal information could have a positive or negative effect on a person.
		 KEY SKILL/PROCEDURES Determine whether information should or should not be shared digitally. Recognize that keeping information private protects your identity. Recognize the consequences of sharing too much personal information online as well as the consequences of sharing others' information. Protect the identity of others by protecting their personal information.
		Content Elaborations CLARIFICATIONS Examples of information to be kept private are first and last name, birthday, addresses, phone numbers or other personal identifiers. Students should also understand that they should not share the personal information of others.
		CONTENT FOCUS The focus is on understanding and identifying the consequences of sharing personal information online. COMPUTER SCIENCE PRACTICES
		 Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.5.c Evalution keep personal in and protect the c	uate the need to formation secure digital footprint.	Expectations for Learning LEARNING PROGRESSION In grade 4, students considered how their current online behavior affects their digital footprint. In grade 5, students expand on the subject by further examining their online behaviors and how they affect others. In grade 6, students will describe tradeoffs between allowing information to be public and keeping information private and secure to inform decision-making. In addition, they will consider the effect of third parties on their personal information.
		 IMPORTANT CONCEPTS When information is not shared properly, it can become an issue of ethics, safety and security and have an impact on your digital footprint. Ongoing evaluation of one's digital footprint is important.
		 KEY SKILL/PROCEDURES List examples of what would be included in your digital footprint and evaluate the security of what is already a part of your footprint.
		Content Elaborations
		CLARIFICATIONS Students should evaluate their digital footprint and consider the security of their online behavior. If needed, students should take steps to secure online information. Students should be able to evaluate the security of personal information shared online. For instance, it might be safe to share only a first name, whereas sharing a first name, last name and birthdate would not be secure or safe.
		CONTENT FOCUS The focus is on making personal connections to online security and social media privacy. Students should evaluate their online and social media activity.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.5.d Anal forms of cyberbu strategies to stop	yze different ıllying and identity p cyberbullying.	Expectations for Learning In grade 4, students learn what a cyberbully is and what to do if they feel threatened online. In grade 5, students will learn about the forms of cyberbullying and strategies to use to stop this type of behavior.
		 IMPORTANT CONCEPTS List the forms of cyberbullying. Discuss and practice strategies to stop cyberbullying.
		 KEY SKILLS/PROCEDURES Compare different forms of cyberbullying. Identify and practice strategies to stop cyberbullying.
		Content Elaborations
		It is important to understand the different forms of inappropriate online behavior including cyberbullying. The more knowledge students have about the strategies and methods bullies use online, the quicker inappropriate activities can be identified and mitigated.
		 CLARIFICATIONS Cyberbully tactics include, but are not limited to many different behaviors like the following: Posting comments or rumors that are hurtful or embarrassing, Threats against themselves or others, Pretending to be someone else, and Any other form of online harassment.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 3. Employ self- and peer advocacy to address bias in interactions, product design and development methods.

Grades 6-8

GRADE 6

Strand	Computing	Systems
Торіс	Devices	
CS.D.6.a Identify the benefits and limitations of a given computing device's functions (including individual components) to explain how the functions and components work together to		Expectations for Learning LEARNING PROGRESSION In previous grades, students learned about the internal components of a computer. By the end of 6th grade, students apply that knowledge to identify the benefits and limitations of devices. In future grades, students will evaluate devices dependent on personal needs.
create the computing system.	uting system.	 IMPORTANT CONCEPTS There are benefits to the functionality of major hardware and software components of a system. Understand how changes in these components will benefit or limit the device.
		 KEY SKILL/PROCEDURES Explain the limitations and benefits of devices. Explain the functionality of a component of a system (hardware/software) and describe its benefits or limitations.
		Content Elaborations
		CLARIFICATIONS Students will be able to take a particular device and know what it can or cannot do. For example, connecting a device to Wi-Fi, printing from a device and how much memory a file will take up.
		CONTENT FOCUS Students can determine which computing devices can be used for a particular task or to make every day life easier.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 3. Employ self- and peer advocacy to address bias in interactions, product design and development methods

Strand	Computing	Systems
Торіс	Hardware/Se	oftware
CS.HS.6.a Identify ways that hardware and software work together as a system to collect and exchange data.		Expectations for Learning LEARNING PROGRESSION In previous grades, students evaluated the digital learning tools and devices they had chosen across curricular areas. By the end of 6th grade, students look at the ways the hardware and software components come together to collect and exchange data. In future grades, students will evaluate hardware and software components to accomplish a task.
		 IMPORTANT CONCEPTS Identify functionalities of major hardware and software components of a system. Know a basic flow and order of how the data moves through the components.
		 KEY SKILL/PROCEDURES Evaluate input devices and software to determine which combination(s) will produce a proper outcome based on a request. Identify how the data is input, processed and output.
		Content Elaborations
		CLARIFICATIONS Consider multiple components, such as functionality, cost, size, speed, accessibility and aesthetics, to select the appropriate hardware or software for a given task. Understand how data moves from input to output in a system.
		CONTENT FOCUS Students can determine computing devices and software that should be used to create a product and understand how the data flows through the system.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.

Торіс	Troubleshoo	oting
CS.T.6.a Use a sprocess to identifing the source of a roproblem. Select to solve the compand communicate to others.	systematic by and evaluate outine computing he best solution outing problem the solution	Expectations for Learning LEARNING PROGRESSION In previous grades, students worked to diagnose problems, describe the problem, and develop strategies to resolve technology issues. By the end of 8th grade, students will be able to identify and evaluate problems, determine the best solution and also communicate with others to help them solve those problems. In future grades, students will understand the troubleshooting process to evaluate a pre-determined situation. IMPORTANT CONCEPTS • Use a basic troubleshooting process.

Have a working knowledge of computing devices. ٠

Communicate to others via electronic and/or in-person communication. •

KEY SKILL/PROCEDURES

- Utilize knowledge of computing devices, hardware and software to locate and solve a problem. •
- Create a list of possible solutions to implement. •
- Evaluate solutions to determine the best one.
- Communicate a solution to others. .

Content Elaborations

CLARIFICATIONS

As students gain more experience listing possible solutions, they need to be able to test the solutions and determine the best solution. They also need to learn how to communicate these solutions to others via electronic or in-person communication to help guide others to a solution.

CONTENT FOCUS

Students can identify troubleshooting steps that are key to solving the software/hardware problem. This process involves collaboratively working through the troubleshooting steps.

COMPUTER SCIENCE PRACTICES

Practice 6. Testing and Refining Computational Artifacts

- 1. Systematically test computational artifacts by considering all scenarios and using test cases.
- 2. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Computing Systems

Topic

Strand

Strand	Networks and the Internet	
Торіс	Networking	
NI.N.6.a Identify the role of hardware components to understand the infrastructure of networks and the internet (including cloud servers).		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a general knowledge of how information is broken down to be transmitted over a network. By the end of 6th grade, students understand the flow of information across the hardware of the internet. In future grades, students will identify specific hardware components in the infrastructure of the internet.
		 IMPORTANT CONCEPTS Devices must be connected to the internet to share information. Hardware devices are required to transfer information across the internet. Information travels from router to router across the internet. Servers retrieve (or store) information.
		 KEY SKILL/PROCEDURES Explain that the internet is made up of connected devices. Explain that data travels through devices to get from one location to another on the internet.
		Content Elaborations
		CLARIFICATIONS Students should understand a simple flow diagram of how information travels from a networked computer across the internet to retrieve information.
		CONTENT FOCUS Students will understand that data travels through devices to get from one location to another location on the internet.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks and the Internet	
Торіс	Networking	
NI.N.6.b Identify (i.e., rules) and e are used to trans networks and the	r protocols explain why they smit data across e internet.	 Expectations for Learning LEARNING PROGRESSION In previous grades, students developed general knowledge of how information is broken down to be transmitted over a network. By the end of 6th grade, students can identify that protocols are rules that define how data between devices is sent and received. In future grades, students will identify specific protocols. IMPORTANT CONCEPTS Devices connected to the internet use protocols. Protocols used for websites include http and https (usage not mechanics). KEY SKILL/PROCEDURES Identify the purpose of protocols. Identify the need for protocols. ELARIFICATIONS Students should understand that all devices connected to the internet use protocols work together to get data from one location to another location on the internet. COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate protocols are rules to the other to get data from one protocols.

Strand	Networks an	nd the Internet
Торіс	Cybersecur	ity
NI.C.6.a Identify cybersecurity concerns and measures needed to protect electronic information.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using and creating a password for a personal account. By the end of 6th grade, students understand the concern that electronic information needs to and can be protected. In future grades, students will learn about encryption to protect information.
		 IMPORTANT CONCEPTS Personal information is valuable information. Social media information is valuable information. Information can be protected from theft and manipulation.
		 KEY SKILL/PROCEDURES Identify personal digital habits that help to protect information. Demonstrate software settings to protect information.
		Content Elaborations
		CLARIFICATIONS Students will be able to define personal information, such as birthday, address and phone number to explain why it is important that this information is protected (i.e., identify theft). In addition, students will understand what constitutes social media information and explain which information should be shared and which information should remain private.
		CONTENT FOCUS Students will understand that there is personal information that should be kept private for security reasons. Students need to realize not all non-private information needs to be shared via social media.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing
		(Content Statement aligns to Core Practice rather than specific Practice Statements).

Strand	Networks and the Internet	
Торіс	Cybersecur	ity
NI.C.6.b Identify the different types of malware to understand threats to data security.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using and creating a password for a personal account. By the end of 6th grade, students can identify some of the different types of malware that exist that threaten data security. In future grades, students will learn about encryption to protect information.
		 IMPORTANT CONCEPTS Obtain a general understanding of "what is a computer virus?" Obtain a general understanding of "what is spyware?"
		 KEY SKILL/PROCEDURES Describe various computer threats, such as how malware is spread via email.
		Content Elaborations
		CLARIFICATIONS At this level, students will be able to define effective strategies used to safeguard their personal information, such as not clicking on links in an email.
		CONTENT FOCUS Students will be able to identify simple measures they can use to protect their personal information.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Networks an	nd the Internet
Торіс	Cybersecuri	ity
NI.C.6.c Identify private informati	ways to protect on.	 Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using and creating a password for a personal account. By the end of 6th grade, students need to understand private information can be protected by individuals and by software. In future grades, students will have a deeper understanding of how information is protected. IMPORTANT CONCEPTS Access rights include but are not limited to reading, writing, renaming and deleting files. Software is available to detect and protect information. Shared files and privacy filters are safety measures. Settings can be accessed to disable options to download and print files. KEY SKILL/PROCEDURES Access rights as a security measure. Identify the advantages and disadvantages of safety measures. Active students deepen their understanding of security measures to safeguard online information and documents in various file formats. For example, students should be able to share documents on a shared server, understanding specific security settings. CONTENT FOCUS Students will be able to identify how specific software settings (e.g., public vs. private settings) for files can safeguard their data. COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing (Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand

Topic

Networks and the Internet

Internet of Things

NI.IOT.6.a Define and explore aspects of embedded devices, smart devices and intelligent devices and the way they record, observe and mimic human habits.

NI.IOT.6.b Identify and define blockchains to recognize how every device made has unique identifiers and the weaknesses that allow programmers and hackers to see personally identifiable information.

Expectations for Learning

LEARNING PROGRESSION

In grade 5, students gained an understanding of how information is broken into pieces to be transferred over the internet and to use risk/benefit analysis in device utilization. In grade 6 students research and define how different smart/intelligent devices track human activities to record and mimic their habits. In grade 6, students define the term blockchain to recognize how every bit of information shared over networks is personally identifiable. They also explore the weaknesses in networks that allow programmers, both legitimate and illegitimate, to access that personal information. In grade 7, students will be able to explain the positive and negative uses of IoT as it applies to daily life.

IMPORTANT CONCEPTS

- Our devices use data collected from our daily habits to personalize our experience (i.e., advertisements, mapping, daily routines).
- Personally identifiable information is gathered and transmitted across networks.

KEY SKILLS/PROCEDURES

- Review the phrase Internet of Things and how it connects to the blockchain.
- Recognize that connections to the internet are key to IoT and these connections can mimic human behavior and respond to input.
- Recognize that devices have unique identifiers that allow programmers to access identifiable information.

Content Elaborations

CLARIFICATIONS

Humans interact with the world through our senses: touch, smell, sight, taste and hearing. Sense receptors in the body are constantly receiving information about the world, from the heat of a coffee cup to the smell of flowers, and transmitting it to the brain, where the information is processed. The Internet of Things (IoT) derives its power from technologies that mimic these functions: sensors embedded in devices and internet connections that allow networked devices to gather massive amounts of information and analyze it all for meaning.

All information that is sent and received over the internet is identifiable.

Blockchain is a system of recording information in a way that makes it difficult or impossible to change, hack or cheat the system. A blockchain is essentially a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain.

Strand	Networks and the Internet	
Торіс	Internet of Things	
		CONTENT FOCUS Devices track our habits both online and in the real world to adapt content to cater to our habits to provide a custom personal experience. All information on the network is identifiable and able to be tracked to the originator.
		 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.
		 Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Data and An	alysis
Торіс	Data Collect	ion and Storage
DA.DCS.6.a Identify and use an appropriate digital data collection tool to compile information.		Expectations for Learning LEARNING PROGRESSION In previous grades, students have explored data sets and can define types of data. In 6th grade, students experience collecting data with a specific tool. They develop an understanding that different tools are used to manage specific data. In future grades, students will be able to evaluate the tools that would provide the best solution.
		 IMPORTANT CONCEPTS Use different data capturing tools (e.g., electronic survey, digital thermometer, yard sticks, meter sticks).
		 KEY SKILL/PROCEDURES Identify and use different types of data collection tools that are available. Select and use the appropriate tool to collect different types of data.
		Content Elaborations
		CLARIFICATIONS Students need to experience the difference between the use of tools, such as rulers, yardsticks, meter sticks, thermometers, electronic surveys, phones, computers and tablets.
		CONTENT FOCUS Students can collect data from individual tools or systems.
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Ana	alysis
Торіс	Data Collecti	ion and Storage
DA.DCS.6.b Select and utilize appropriate file formats to organize collected data.		Expectations for Learning LEARNING PROGRESSION In previous grades, students explored files of different types and were able to differentiate the uses of the various types. By the end of 6th grade, students need to know the type of data and how it is stored and select the appropriate type of file. In future grades, students will be able to determine the limitation of various file types.
		 IMPORTANT CONCEPTS Identify picture and text file extensions and the characteristics of these file extensions.
		 KEY SKILL/PROCEDURES Explain that not all file extensions are the same. Explain the differences in the quality of the image.
		Content Elaborations
		CLARIFICATIONS Students select and utilize the correct file type for various sets of data and text.
		CONTENT FOCUS Students understand the difference between size and quality for various images. Students should have experience with various file formats (e.g., .docx, .GDOC, .xlsx, GSHEET .pdf, .txt, .dat, .gif, .jpg, .tiff, .png, .bmp, .bpg, and other formats).
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data And An	alysis
Торіс	Data Collecti	ion and Storage
DA.DCS.6.c Utilize a file structure to logically organize data to support individual and collaborative work.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience saving files to a school or portable device. By the end of 6th grade, students know how to organize data, save files and access files, including shared files, on different mediums. In future grades, students will provide a more logical structure for storing files.
		 IMPORTANT CONCEPTS Files can be shared. Documents can be organized in folders and subfolders on a hard drive or cloud.
		 KEY SKILL/PROCEDURES Utilize procedures for how to share file(s) with others. Explain the importance of files being separated into folders and subfolders based on content. Demonstrate how to follow directions to organize files into folders and subfolders.
		Content Elaborations
		CLARIFICATIONS Students need to be able to organize their files within logical structures. (e.g., A contextual example would be using a file cabinet to store folders, notebooks, and papers.) Put folders inside of folders that are labeled appropriately.
		CONTENT FOCUS Students can store files in a system where they can be located later. Students should be able to locate files on the hard drive or cloud.
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Ana	alysis
Торіс	Visualization	and Communication
DA.VC.6.a Identify and label patterns in models or representations to infer connections between data sets.		Expectations for Learning LEARNING PROGRESSION In previous grades, had experience with patterns and collection of information in math classes. By the end of 6th grade, students can find patterns in data sets and infer connections between them. Data visualization includes visual, auditory, tactile, oral and other sensory representations. In future grades, students will be able to analyze relationships and patterns between them.
		 IMPORTANT CONCEPTS Identify patterns within a given data set. Compare two or more models or representations (e.g., two graphs or box-and-whisker charts) to discover similarities or trends between them.
		 KEY SKILL/PROCEDURES Find patterns and infer connections.
		Content Elaborations
		 CLARIFICATIONS Given a pair of graphs, students will read the graphs and make comparisons between the two and ask the following questions: What is the same, What is different and What story is each telling?
		CONTENT FOCUS Students should be able to read a graph and make comparisons between two graphs.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.
		Career Connections
		CAREER EXPLORATION Students identify careers that use data to drive business decisions. Students research to find an instance where different data sets were used to make a specific business decision. Students examine the data sets to identify patterns to see why the specific business decision was made.

Strand	Data and An	alysis
Торіс	Visualization	and Communication
DA.VC.6.b Create a spreadsheet utilizing formulas, functions and graphs to represent and analyze data.		Expectations for Learning LEARNING PROGRESSION In previous grades, student analyzed graphs in classes. By the end of 6th grade, students recognize that a graph can be created from data using a spreadsheet. In future grades, students will be able to utilize formulas and functions.
		 IMPORTANT CONCEPTS Graphs are a representation of data. Formulas and functions are used to represent data.
		 KEY SKILL/PROCEDURES Explain that data can be used to draw conclusions.
		Content Elaborations
		CLARIFICATIONS Given a data set, students will construct a graphical representation.
		CONTENT FOCUS Students will be able to recognize pie charts, bar graphs, histograms and other data models. Students will find statistical results, such as mean, median, mode, percentage and degrees in a circle.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.
		Practice 5. Creating Computational Artifacts2. Create a computational artifact for practical intent, personal expression or to address a societal issue.

Strand	Data and Ana	alysis
Торіс	Inference and	d Modeling
DA.IM.6.a Identify and utilize data sets to support or refute a hypothesis.		Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had experience analyzing data models (e.g., charts, graphs). By the end of 6th grade, students can provide evidence to support or refute a prediction about a collection of data. In future grades, students will be able to hypothesize about self-generated data.
		 IMPORTANT CONCEPTS Develop a hypothesis (a prediction) for a problem and then determine if the data collected around the problem supports the hypothesis.
		 KEY SKILL/PROCEDURES Given a problem statement, students will be able to create a hypothesis (prediction), collect data (e.g., survey results), analyze a data set and compare the analysis to the hypothesis.
		Content Elaborations
		CLARIFICATIONS Students will be given a problem statement and asked to create a hypothesis, collect data, organize the results in an electronic tool, and support or disprove the hypothesis.
		CONTENT FOCUS Students will understand what type of data would be appropriate to help analyze a problem. They should then be able to complete the processes necessary to support or disclaim a hypothesis.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
ATP.A.6.a Compare and refine multiple algorithms for the same task to determine which is the most efficient.		Expectations for Learning LEARNING PROGRESSION In previous grades, students have had experience developing an algorithm for a simple process. At the end of 6th grade, students should be able to choose an algorithm for a multi-step process and evaluate multiple algorithms to determine the most efficient solution. In future grades, students will be able to create algorithms for the most efficient solution.
		 IMPORTANT CONCEPTS Understand the flow of a program. Compare different sets of pseudocode and determine the most efficient solution.
		 KEY SKILL/PROCEDURES Identify the inputs, outputs, processes and decisions.
		Content Elaborations
		CLARIFICATIONS An algorithm is a series of instructions to obtain the desired result. One example could be a set of directions to travel from the school to the pizza shop or the process of calculating a nine-week grade. Comparing algorithms can be comparing different sets of directions between two locations; all sets of directions end at the same location, but one set may be shorter, safer or have fewer turns. This would be analyzing the algorithms to determine which one is more efficient where efficiency is not necessarily the "fastest" path.
		CONTENT FOCUS An algorithm is a series of instructions to obtain the desired result. One example could be a set of directions to travel from the school to the pizza shop or the process of calculating a nine-week grade. Comparing algorithms can be comparing different sets of directions between two locations; all sets of directions end at the same location, but one set may be shorter, safer or have fewer turns. This would be analyzing the algorithms to determine which one is more efficient where efficiency is not necessarily the "fastest" path.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
		 Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena. 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Variables and	d Data Representation
ATP.VDR.6.a Identify unknown values that need to be represented by a variable within a multi-step process.		Expectations for Learning LEARNING PROGRESSION In previous grades, students created variables to store and modify data. By the end of 6th grade, students understand how to use variables in a multi-step process. In future grades, students will be able to understand that variables have different storage requirements and will use parameters. They will learn about scope.
		 IMPORTANT CONCEPTS Identify unknown values in an algorithm.
		 KEY SKILL/PROCEDURES Explain the concept of a variable.
		Content Elaborations
		CLARIFICATIONS Students will deepen their understanding of variables, including when and how to declare and name new variables. A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. The identifier makes keeping track of the data that is stored easier, especially if the data changes. Naming conventions for identifiers, and thoughtful choices of identifiers, improve program readability. (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students should be able to identify variables and be able to explain the advantages of using self-descriptive variable names. They will utilize and understand the importance of self-descriptive variables.
		 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	Algorithmic T	hinking and Programming
Торіс	Variables and	I Data Representation
ATP.VDR.6.b C use them within multi-step proce	reate variables and a ss.	Expectations for Learning LEARNING PROGRESSION In previous grades, students developed an understanding of what it means to vary (opposed to being constant) and that this abstract value is expressed with an alphanumeric representation. By the end of 6th grade, students understand how to create and use variables. In future grades, students will be able to understand that variables have different storage requirements and will use parameters. They will learn about scope.
		 IMPORTANT CONCEPTS Create a variable to represent an unknown value.
		 KEY SKILL/PROCEDURES Define and utilize a variable in an algorithm.
		Content Elaborations
		CLARIFICATIONS At this level, students deepen their understanding of variables, including when and how to declare and name new variables. A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. The identifier makes keeping track of the data that is stored easier, especially if the data changes. Naming conventions for identifiers, and thoughtful choices of identifiers, improve program readability. (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students should be able to identify and assign variables. Students should focus on using self-descriptive variable names. Students will utilize and understand the importance of self-descriptive variables. They will create new self-descriptive variables.
		 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	Algorithmic T	hinking and Programming
Торіс	Control Struc	ture
ATP.CS.6.a Identify and trace decisions and loops that exist in a multi-step process within a program.		Expectations for Learning LEARNING PROGRESSION In previous grades, students applied sequences, events, loops and conditionals in increasingly complex ways. By the end of 6th grade, students are able to identify decisions and loops in programs to solve problems. In future grades, students will understand and incorporate proper processes, loops and conditionals in programs to solve problems.
		 IMPORTANT CONCEPTS Identify the decision structures within an algorithm. Identify and apply the structures within an algorithm.
		 KEY SKILL/PROCEDURES Properly use if statements (if-then and if-then-else). Properly use Pre-test (do-while), post-test (while) and definite loop (for, for next).
		Content Elaborations
		CLARIFICATIONS An example of a nested conditional structure is deciding what to do based on the weather outside. If it is sunny outside, I will further decide if I want to ride my bike or go running, but if it is not sunny outside, I will decide whether to read a book or watch TV. (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students at this level will be able to work with single-decision statements, as opposed to nested, and single loops (i.e., iterative processes). Students should be able to identify the decision (if/then) statement(s) and the loop statements (for, while, do) and understand the conditions of when the body of the code (the choice to go running or ride the bike) will be executed and/or how often that code would be executed.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Algorithmic T	hinking and Programming
Торіс	Control Struc	ture
		 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, considering key features, time and resource constraints and user expectations.
		 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Modularity	
ATP.M.6.a Decompose problems into parts to facilitate the design, implementation and review of programs.		Expectations for Learning LEARNING PROGRESSION In previous grades, students began to use abstraction to further refine and design an algorithm. By the end of 6th grade, students can identify and utilize the procedures/modules within a set of instructions or code. In future grades, students will continue to identify and utilize the procedures/modules within a set of text-based instructions or code.
		 IMPORTANT CONCEPTS Identify smaller components of an algorithm. Identify a set of steps of an algorithm's component that produces a result.
		 KEY SKILL/PROCEDURES Group and organize steps that work together to produce a result. Identify the steps that were used when provided with the result.
		Content Elaborations
		CLARIFICATIONS A procedure is a module (a group of instructions within a program) that performs a particular task. Procedures are invoked to repeat groups of instructions. For example, a procedure, such as one to draw a circle, involves many instructions, but all of them can be invoked with one instruction, such as drawing a circle. Procedures that are defined with parameters are generalizable to many situations and will produce different outputs based on a wide range of inputs (arguments). (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students will utilize modules to increase the organization of code, the ability to hide details and the reusability.
		 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Algorithmic	Thinking and Programming
Торіс	Modularity	
		 Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Practice 6. Testing and Refining Computational Artifacts Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility

Program Development

Algorithmic Thinking and Programming

ATP.PD.6.a Write code that utilizes algorithms, variables and control structures to solve problems or as a creative expression.	Expectations for Learning LEARNING PROGRESSION In previous grades, students learned how to create a program through block-based programming. By the end of 6th grade, students can advance in designing and creating their block-based programs utilizing parameters. In future grades, students will begin text-based programming.
	 IMPORTANT CONCEPTS Write code to solve a problem using block-based coding software. Utilize block-based code that has parameters and understand the impact of using different parameter values.
	 KEY SKILL/PROCEDURES Use block-based programming. Use procedures (block-based code) with parameters effectively.
	Content Elaborations
	CLARIFICATIONS Block-based programming is an accessible entry point for writing code. It teaches fundamental programming skills and encourages experimentation and creativity. Students can "drag" and/or "link" blocks to produce a result, such as animation and picture drawing.
	CONTENT FOCUS Students are to be introduced to a programming language through block-based code. Students should be able to use proper commands to move an object, add to an object and change the color of an object.
	COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
	 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, considering 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.

Strand

Торіс
Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Program Dev	velopment
ATP.PD.6.b Te debug and refin	and trace to e code.	Expectations for Learning LEARNING PROGRESSION In previous grades, students became less dependent on guided questions and began to debug more complex programs. By the end of 6th grade, students can identify errors in code and modify and fix errors so that a program will run correctly and produce the expected result. In future grades, students will learn to test and refine programs using a range of text cases.
		 IMPORTANT CONCEPTS Test a variety of solutions within the programming solution. Identify errors within the program.
		 KEY SKILL/PROCEDURES Debug (fix) one's code.
		Content Elaborations
		CLARIFICATIONS Students need to understand that errors often occur when writing code. While using block-based coding, students will be able to find errors and make corrections.
		CONTENT FOCUS Students will be able to correct errors when the code will not execute correctly.
		Students will experience two types of errors: runtime (this happens when the program "crashes") and logical (this happens when the program is successfully executed but the results were incorrect).
		 COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts Systematically test computational artifacts by considering all scenarios and using test cases. Identify and fix errors using a systematic process.

Strand	Artificial Intellig	gence
Торіс	Natural Interact	tions
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 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 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. There are limitations to what a machine can learn because machine learning does not happen the same way as human learning and machines do not share the same experiences as humans.
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Artificial Intellig	gence
Торіс	Natural Interact	tions
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 bias can be introduced to a 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. Describe when to use training and when to use a reasoning 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 is the process of providing a machine learning algorithm with training data to learn from and create a machine learning model. The reasoning model, also known as machine reasoning, generates conclusions from available knowledge by using logical techniques like deduction and induction.
		CONTENT FOCUS Training is the process of creating a machine learning model by using a machine learning algorithm on a data set 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.

Artificial Intelligence

Department

of Education

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Strand

Topic Perception	
AI.P.6.a Give examples of	Expectations for Learning
different types of computer perception that can extract meaning from sensory	LEARNING PROGRESSION In grade 5, students learned about how sensor 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.
computers collect information from sensors.	 IMPORTANT CONCEPTS Compare the ways computers perceive the world around them. Categorize and describe sensors that work with computers. Explain the types of data that are 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.
	CONTENT FOCUS Students focus on 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 Inte	lligence
Торіс	Perception	
AI.P.6.b Give e how humans co	examples of ombine n multiple nderstand how sensors to	Expectations for Learning LEARNING PROGRESSION
modalities to ur computers use collect data.		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 data set.
		 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.
		CONTENT FOCUS How are computers and humans alike in how they perceive the world?
		 COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems Identify complex, interdisciplinary, real-world problems that can be solved computationally. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. Evaluate whether it is appropriate and feasible to solve a problem computationally.
AI.P.6.c Give e	xamples of	Expectations for Learning
perception that meaning from s to show the cor between senso	can extract sensory signals nection rs and	LEARNING PROGRESSION In grade 5, students learned about how sensor 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.
computer perce	ption.	 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.

Strand	Artificial Intelligence	
Торіс	Perception	
		 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 <i>Practice 4.</i> Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.
AI.P.6.d Classif	y a given	Expectations for Learning
image (e.g., "traffic scene", "nature scene", "social gathering", etc.) and then describe the kinds of		LEARNING PROGRESSION In grade 5, students learned about how sensor 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.
need in order to	understand	IMPORTANT CONCEPTS
scenes of this ty the image in an	/pe to utilize algorithm.	 Explain the kind of information a computer needs 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.

Strand	Artificial Intelligence	
Торіс	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.

Artificial Intelligence

Strand

	Topic Representation	on & Reasoning
AI.RR compu find a reasou knowl	AI.RR.6.a Illustrate how a	Expectations for Learning
	computer can solve a maze, find a route on a map or reason about concepts in a knowledge graph by drawing a	LEARNING PROGRESSION In grade 5, students described how Artificial Intelligence (AI) representations support reasoning to answer questions. In grade 7, students will compare several algorithms that could be used to solve a specific type of reasoning problem.
	search tree.	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 generate 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.
		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 uses 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.

Strand	Artificial Intelligence
Торіс	Machine Learning
AI.ML.6.a Contrast the unique characteristics of human learning with the ways machine learning systems operate to identify the	Expectations for Learning LEARNING PROGRESSION In grade 5, students described ways that Artificial Intelligence (AI) systems 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.
limitations of machine learning.	 IMPORTANT CONCEPTS Understand how a person learns how to do something. Understand how machines learn how to do something. Compare and contrast the differences between human learning and machine learning. Discuss whether there are things machines cannot learn that humans can and why.
	 KEY SKILLS/PROCEDURES Students will be able to analyze their learning processes (metacognition). 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 Human learning is complex and impacted by a variety of factors including socialization, environment, emotions, etc. There are limitations to what a machine can learn because machine learning does not happen the same way as human learning and machines do not share the same experiences as humans
	CONTENT FOCUS Understand the differences between human learning and machine learning.
	 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
Торіс	Machine Learning
AI.ML.6.b Illustrate the structure of a neural network to describe how its parts form a set of functions that compute an output.	Expectations for Learning LEARNING PROGRESSION In grade 5, students illustrated how a neural network is a function that computes an output. In grade 7, students will describe neural network architectures.
	 IMPORTANT CONCEPTS Understand what a neural network is. Understand how neural networks are organized. Understand how a neural network computes an output.
	 KEY SKILLS/PROCEDURES Students will be able to illustrate the structure of a neural network. Students will be able to describe how the neural network's parts form a set of functions. Students will be able to compute the output of a neural network.
	Content Elaborations
	CLARIFICATIONS Human Neural networks are organized as layers of units (input, hidden and output layers), with weighted connections between units in successive layers. Each unit computes the sum of its weighted inputs. It passes that sum through a transfer function to produce a numeric output.
	CONTENT FOCUS A neural network maps input patterns to output patterns in a complex way. Each neuron computes a function, and the network computes a complex function that can be considered a very wiggly mathematical function.
	 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	
Торіс	Societal Impa	icts
AI.SI.6.a Identify and explain how humans have control in curating training data sets 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 Artificial Intelligence (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 data set. 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 data sets can contain bias in machine learning by analyzing a data set for bias. Students will be able to explain how humans have agency in curating training data sets 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 data sets because 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 data sets, 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.

Strand	Artificial Intelligence
Торіс	Societal Impacts
AI.SI.6.b Identify and explain how algorithmic bias impacts artificial intelligence systems to prevent bias in future data sets.	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 Artificial Intelligence (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 data sets.
	 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 data sets 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.
	CONTENT FOCUS Strategies for overcoming algorithmic bias include narrowing data sets to be more specific to the problem, structuring data to represent different opinions, knowing where data is coming from and understanding it, considering the end-user while developing a program, and seeking feedback from a diverse pool of people to use in improving 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.

Strand	Impacts of C	omputing
Торіс	Culture	
IC.Cu.6.a Identif current technolo people's everyda understand the i a society.	fy the change that ogies have on ay activities to impact within	Expectations for Learning LEARNING PROGRESSION In previous grades, students should have become familiar with some of the ways in which we communicate in today's world. By the end of 6th grade, students begin to develop a better understanding of how we connect to people around the country and the world. Students study how these communication tools impact society. In future grades, students will study the history of computing to evaluate the impact on everyday activities.
		 IMPORTANT CONCEPTS Current technology provides efficiency and convenience for everyday activities. The use of technology increases personal communication and collaboration. Technology has an impact on culture.
		 KEY SKILL/PROCEDURES Communicate via school technology with one's parents, class and teacher. Provide feedback to one's peers using existing technologies.
		Content Elaborations
		CLARIFICATIONS Students need to understand how today's technology has impacted the amount and speed of information that can be accessed and shared. Students can safely experience this phenomenon through technology provided through their school and/or classroom.
		CONTENT FOCUS Students should list different types of technology they use at school and home, as well as technology that is used in the world around them. Students can identify what they can do with the technology to improve their quality of life.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Impacts of C	omputing
Торіс	Culture	
IC.Cu.6.b Identify issues of bias and accessibility in the design of existing technologies to address equality and equity in society.		Expectations for Learning LEARNING PROGRESSION In previous grades, students need to have developed an understanding that computing has become a global connection. At the end of 6th grade, students understand that even though computing has increased global connections, there are still areas of the world and individuals who do not have the same access. In future grades, students will evaluate technologies for issues of bias and accessibility.
		 IMPORTANT CONCEPTS Computing makes all aspects of our lives more efficient. It allows us to communicate on a global scale. Access for those in third-world countries is not equitable to those living in many other countries. Computing in the educational setting is not equitable globally or even within our own country. Social-economic status impacts the access for many in our country. Access may be an issue for persons with disabilities.
	 KEY SKILL/PROCEDURES Explain that access is important for everyone regardless of their social-economic status, disability or geographic location. Research the issue of accessibility and report our findings. 	
		Content Elaborations CLARIFICATIONS The educational system tries to level the computing access playing field for all students when in reality, not all students have the same opportunities or access once they leave the school setting. Helping students become aware of the world in which they live will help foster citizenship and problem solving (i.e., "thinking outside the box"). Students may experience accessibility limitations personally or observe the bias against a family member or friend. This bias may exist due to disabilities or economic status. Students also need to be exposed to the bias and accessibility issues that many people have globally. CONTENT FOCUS Students will be able to understand that computing on a global level is made easier through the efficiency of computing. There is also a disconnect in equity for all students having access to computing. This refers to accessibility based on socio-economic status, persons with disabilities and third-world countries. Students will learn to identify tools that allow equity of accessibility for all students.

Strand	Impacts of C	omputing
Торіс	Culture	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 3. Employ self- and peer-advocacy to address bias in interactions, product design and development methods.
IC.Cu.6.c Identify and explore careers related to the field of computer science.		Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had some experience using technology. At the end of 6th grade, students understand that there are many different people and jobs involved in creating the technologies that they utilize. There is a wide variety of computer science careers available and many new careers being developed daily that students should explore. In future grades, students will learn about how computing impacts other career fields.
		 IMPORTANT CONCEPTS It is necessary to stay up-to-date on future industry needs. Computer science is more than writing code or building a piece of hardware.
		 KEY SKILL/PROCEDURES Describe several different existing careers involving computer science and understand that there will be positions in the future that have not yet been defined.
		Content Elaborations
		CLARIFICATIONS There are many careers under the umbrella of computer science, many of which do not involve coding and building a piece of hardware. Students should be aware of the possibilities that exist today and realize that there will be new jobs for them when they graduate that does not even exist today.
		CONTENT FOCUS Students need to understand that a computer science career is not just writing code, but it is a current and new frontier for careers.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Impacts of Computing

Topic Social Interactions

IC.SI.6.a Analyze and present beneficial and harmful effects of electronic communications to understand their impacts on interpersonal, global, economic, political, business and cultural interactions.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students collaborated with others to share the workload, increase diverse perspectives and improve an artifact. By the end of 6th grade, students can differentiate between the beneficial and harmful effects of technology on a global aspect. In future grades, students will continue to practice safety and proper personal use of devices.

IMPORTANT CONCEPTS

- Identify positive and negative impacts of devices and computing on the health and well-being of businesses, economics, politics and cultural interactions.
- Provide examples of beneficial and harmful effects on persons through social media, phones and other devices.

KEY SKILL/PROCEDURES

- Differentiate between the harmful and beneficial effects of computing and devices globally and locally on economics, businesses, politics and cultural differences.
- Describe ways in which the internet globally impacts business, politics and economics.
- Communicate the pros and cons of personal interaction with email, phones and social media.
- Describe the advantages and disadvantages of electronic collaboration for interpersonal use.

Content Elaborations

CLARIFICATIONS

Computing and devices have a significant impact on connecting with other people, sharing information, and expressing ideas. Students need to understand the power of these devices and differentiate between their beneficial and harmful effects. The economic/business/political uses of these devices can be quantified. The interpersonal effects may be a good transition to an anti-bullying lesson/unit.

CONTENT FOCUS

Students should be able to evaluate how the use of computing devices can contribute or be a detriment to the economics, businesses, politics and cultural differences at the global and local levels. Students also should be able to determine how social media and technological devices can contribute to or have consequences in their daily lives.

Strand	Impacts of Computing	
Торіс	Social Interactions	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. Practice 7. Communicating About Computing
		2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Impacts of Computing

Topic Safety, Law and Ethics

IC.SLE.6.a Describe tradeoffs between allowing information to be public and keeping information private and secure to inform decision making.

IC.SLE.6.b Identify the social and economic implications of privacy in the context of safety, law or ethics to understand how privacy impacts these areas.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students should have had experience with devices at school. By the end of 6th grade, students understand the difference between public and personal information and the necessity of not sharing personal information. In future grades, students should be able to apply these concepts and continually investigate security concerns and legal rights.

IMPORTANT CONCEPTS

- Identify what is considered to be personal information (e.g., address, phone number, birthdate, social security number, financial information.)
- Have a familiarity with some of the "attacks" made by third parties trying to misuse private information

KEY SKILL/PROCEDURES

- Differentiate between personal and public information and make decisions about which items can be safely shared within social media.
- Communicate the contents of one's digital footprint.
- Recognize third party attempts of retrieving personal information (e.g., emails, phishing.)

Content Elaborations

CLARIFICATIONS

Social engineering is based on tricking people into breaking security procedures and can be thwarted by being aware of various kinds of attacks, such as emails with false information and phishing. Security attacks often start with personal information that is publicly available online. All users should be aware of the personal information, especially financial information, that is stored on the websites they use. Protecting personal online information requires authentication measures that can often make it harder for authorized users to access information. (K-12 Computer Science Framework, 2016)

CONTENT FOCUS

Students will be able to identify and understand what information is considered to be personal (e.g., address, phone number, birthdate, social security number, financial information). It is vital that students understand what information should be kept private and secure to protect themselves. Teachers need to reinforce that decisions made regarding their personal information will become a "digital footprint" and be at risk for "attacks" made by third parties trying to misuse private information.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
IC.SLE.6.c Evaluate the development of new technologies in communication, entertainment and business to understand the impact.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experiences with collaborative documents, school email, electronic grade books and electronic school communication. By the end of 6th grade, students are able to identify some of the positive and negative effects that technology in communication has in the business world, including the entertainment business. In future grades, students will be able to apply these concepts.
		 Technology has had a profound effect in the business world.
		 KEY SKILL/PROCEDURES Explain how communication in the business world has become faster and easier and has expanded opportunities. Describe the advantages (e.g., speed and efficiency, communication log, mobile workers.) Describe the disadvantages (e.g., lack of relationship building, informal communication, distractions.) Explain why communication must be more deliberate; reacting to electronic messages should be well thought out.
		Content Elaborations
		CLARIFICATIONS Technology has changed the business world in many ways and perhaps the biggest impact computing has had is in the way businesses communicate. It has expanded the market and business partnerships with companies and allowed for expansion. Overall, this has been a positive impact for businesses and the economy, but it can make communication more distracting and less clear.
		CONTENT FOCUS Students will be able to focus on the positive and negative impacts of computing on the business world.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture (Content Statement aligns to Core Practice rather than specific Practice Statements.) Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Create team norms, expectations, and equitable workloads to increase efficiency and effectiveness. Solicit and incorporate feedback from, and provide constructive feedback to, team members and other stakeholders.
IC.SLE.6.d Prov credit when usin artifacts that are	ride appropriate g resources or not our own.	 Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had some experience creating original work that may include code, text, video or graphics. There should have been discussions on citing/providing credit to any sources that are copied/inserted into their work. By the end of 6th grade, students should continue providing credit for all sources. In future grades, students should continue providing credit for all sources. IMPORTANT CONCEPTS Plagiarism/cheating is when an individual represents someone else's work as their own. In creating a computational artifact, students can create their original work, including video, music, text, images, graphs and program code. When using external work to integrate into a computational artifact, one must acknowledge, attribute and/or cite sources and include a bibliography with their submission. External work that should be acknowledged includes video, music, text, images, graphs and programmed code that are used in the creation of computational artifacts. Forvide proper credit for items inserted into one's work; the credit may be in MLA or APA formatted citations or some other accepted format. Give credit to not only textbooks, scientific reports and websites, but also appropriate persons in a collaboration effort.

Strand	Impacts of Computing	
Торіс	Safety, Law a	and Ethics
		 Content Elaborations CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet, such as video, photos and music, creates the opportunity for unauthorized use, such as online piracy, and disregard of copyrights, such as lack of attribution. (CSTA K-12 Computer Science Standards, 2017) Students need to learn the importance of providing proper credit for all the sources, not only the electronic sources but also those persons with whom they have worked. CONTENT FOCUS Students will be able to give appropriate credit for items, such as information, videos and pictures, that they use in their work. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing
		Students will be able to give appropriate credit for items, such as information, videos and pictures, that the use in their work. COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribute

Impacts of Computing

Торіс	Safety, Law a	and Ethics
IC.SLE.6.e Different the appropriate a content on the in identify unethical online behavior.	IC.SLE.6.e Differentiate between the appropriate and inappropriate content on the internet and identify unethical and illegal online behavior.	Expectations for Learning LEARNING PROGRESSION In previous grades, most students had some experience finding information on the internet and used the internet for communication. By the end of 6th grade, students should have experience differentiating between appropriate and inappropriate content and behavior on the internet. In the future, students will continue using the internet for communication and be able to identify unethical and illegal online behavior.
		 IMPORTANT CONCEPTS The internet contains sites and information that are for adults only. Some sites and programs have a minimum age requirement. Students should have permission from adults before using social media. The internet should not be used for bullying.
		 KEY SKILL/PROCEDURES Explain that one should not use sites that encourage vandalism, gambling, crime, terrorism, racism, eating disorders or suicide, nor should they use pictures or videos from the internet which show images of pornography, violence or cruelty to other people or animals.
		Content Elaborations
		CLARIFICATIONS Increased computing through numerous devices has increased access globally for all ages. At much younger ages, students have access to the internet through devices such as phones and tablets. Not all information on the internet is appropriate for students and they should be made aware of the dangers of access this information.
		CONTENT FOCUS Students will learn that they should have adult (parent) permission to use devices and that they should report inappropriate information that they may find to an adult.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand

GRADE 7

Strand	Computing S	Systems
Торіс	Devices	
CS.D.7.a Develop and implement a process to evaluate existing computing devices capabilities based on personal interaction with the device.		Expectations for Learning LEARNING PROGRESSION In previous grades, students learned about the internal components of a computer. By the end of 7th grade, students use prior knowledge to evaluate devices dependent upon personal needs. In future grades, students will be able to identify improvements to make for a computing device for better interactions with users.
		 IMPORTANT CONCEPTS Select and use appropriate hardware and software components. Create an evaluative process for existing devices.
		 KEY SKILL/PROCEDURES Compare similar applications to determine similarities and differences between the applications.
		Content Elaborations
		CLARIFICATIONS Students will develop and make comparisons between similar apps and be able to communicate the benefits and limitations of each.
		CONTENT FOCUS Students can determine computing devices that are better fit for completing a task than others.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computation products.

Strand	Computing S	systems
Торіс	Hardware/So	ftware
CS.HS.7.a Evaluate hardware and software combinations used to accomplish a task.		Expectations for Learning LEARNING PROGRESSION In previous grades, students looked at the ways hardware and software components come together to collect and exchange data. By the end of 7th grade, students use/simulate hardware and software components to accomplish a task. In future grades, students will make decisions on the use of hardware and software combinations to effectively complete a task.
		 IMPORTANT CONCEPTS Select and use/simulate appropriate hardware and software components to accomplish a task with guidance.
		 KEY SKILL/PROCEDURES Evaluate input devices and software to determine which combination(s) will produce a proper outcome based on a request.
		Content Elaborations
		CLARIFICATIONS Consider multiple components, such as functionality, cost, size, speed, accessibility and aesthetics to select the appropriate hardware or software for a given task.
		CONTENT FOCUS Students can summarize the possible computing device(s) and software to use to produce an outcome based on a requirement provided.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions. 2. Evaluate existing technological functionalities and incorporate them into new designs.

Strand

Computing Systems

Topic Troubleshooting

CS.T.7.a Use a systematic process to identify and evaluate the source of a routine computing problem. Select the best solution to solve the computing problem and communicate the solution to others.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students worked to diagnose problems, describe the problem and develop strategies to resolve technology issues. By the end of 8th grade, students can identify and evaluate problems, determine the best solution and also communicate with others to help them solve those problems. In future grades, students will understand the troubleshooting process to evaluate a pre-determined situation.

IMPORTANT CONCEPTS

- Use a basic troubleshooting process.
- Have a working knowledge of computing devices.
- Communicate to others via electronic and/or in-person communication.

KEY SKILL/PROCEDURES

- Utilize knowledge of computing devices, hardware and software to locate and solve a problem.
- Create a list of possible solutions to implement.
- Evaluate solutions to determine the best one.
- Communicate a solution to others.

Content Elaborations

CLARIFICATIONS

As students gain more experience listing possible solutions, they need to be able to test the solutions and determine the best solution. They also need to learn how to communicate these solutions to others via electronic or in-person communication to help guide others to a solution.

CONTENT FOCUS

Students can identify troubleshooting steps that are key to solving the software/hardware problem. This process involves collaboratively working through the troubleshooting steps.

COMPUTER SCIENCE PRACTICES

Practice 6. Testing and Refining Computational Artifacts

- 1. Systematically test computational artifacts by considering all scenarios and using test cases.
- 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.7.a Explain the role of hardware components and diagram the infrastructure of networks and the internet (including cloud servers).		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a very basic understanding of how devices are connected to the internet. By the end of 7th grade, students can diagram specific hardware components used to understand the flow of information across the hardware of the internet. In future grades, students will model specific hardware components in the infrastructure of the internet.
		 IMPORTANT CONCEPTS Multiple devices are required for data to flow on the internet. Devices connected to the internet must have an address. Each device has its role in the flow of data on the internet. Understanding the role of each device allows the student to diagram the flow of data from one location to another across the internet. Specific hardware used in networking includes routers and switches.
		 KEY SKILL/PROCEDURES Diagram how data travels through devices to get from one location on the internet to others. Explain the role of key hardware that makes up the internet. Use knowledge of key hardware to diagram how data might flow from one location to another across the internet.
		Content Elaborations
		CLARIFICATIONS Students will be able to identify and diagram basic components (e.g., computer, router, server); students can draw lines to make connections of how information travels across the internet.
		CONTENT FOCUS Students will identify specific components used to transfer data on the internet.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks and the Internet	
Торіс	Networking	
		 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.

Strand	Networks and	d the Internet
Торіс	Networking	
NI.N.7.b Explain the protocols (i.e., rules) and why they are used to transmit data across networks and the internet.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a very basic understanding of how devices are connected to the internet. By the end of 7th grade, students can understand that different protocols are used for different types of data being transmitted between devices. In future grades, students will identify a wider range of protocols used in networking.
		 IMPORTANT CONCEPTS Protocols are used for websites, including http and https (usage not mechanics). Protocols are used for email, including POP3 and IMAP (usage not mechanics).
		 KEY SKILL/PROCEDURES Identify the purpose of protocols. Identify the need for protocols. Identify how different protocols are used in different situations (http and https).
		Content Elaborations
		CLARIFICATIONS Protocols are rules that define how messages between computers are sent. They determine how quickly and securely information is transmitted across networks and the internet, as well as how to handle transmission errors.
		CONTENT FOCUS Students will understand the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks and the Internet	
Торіс	Cybersecurit	ty
NI.C.7.a Identify and apply introductory methods of encryption to model the secure transmission of information.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a general understanding that private information should be protected from malware threats. By the end of 7th grade, students understand that encryption can be used to protect information for the secure transmission of information. In future grades, students will understand physical measures to protect information.
		 IMPORTANT CONCEPTS Research the history of encryption. Introduce the concept of encryption and decryption of plaintext. Introduce the technique of Caesar shift (Each letter in the plaintext will be replaced by a letter with some fixed number of positions down the alphabet.)
		 KEY SKILL/PROCEDURES Create one's encryption method. Utilize the Caesar shift to decrypt information.
		Content Elaborations
		CLARIFICATIONS Students can explain how encryption can protect the confidentiality of data. Students examine the modifications of different Caesar shift encryptions. In addition, students will create a pattern of encryption based on a Caesar shift and decrypt other students' work.
		CONTENT FOCUS Students will understand encryption effectively protects the confidentiality of data for using secure transmissions.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)
		 Practice 2. Collaborating Around Computing 1. Cultivating working relationships with individuals possessing diverse perspectives, skills and personalities.
		 Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
Ohio Dep of Ed	artment ducation	

Strand
Торіс
NI.C.7.b Describ malware to show affects informatio

Strand	Networks and the Internet	
Торіс	Cybersecurit	Σ Υ
NI.C.7.c Identify concerns and me to protect electro	cybersecurity easures needed onic information.	Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a general understanding that private information should be protected from malware threats. By the end of 7th grade, students understand how information is protected and where it is needed. In future grades, students will learn about additional encryption algorithms.
		 IMPORTANT CONCEPTS Different protocols can be compared or contrasted (e.g., http versus https).
		 KEY SKILL/PROCEDURES Identify secure communication protocols across the internet.
		Content Elaborations
		CLARIFICATIONS In this grade, students should be able to connect how encryption can protect data with https and understand where encryption is needed, such as online banking, versus where it is not, as in a simple online search.
		CONTENT FOCUS Students will understand the connection between encryption and https across the internet.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks and	the Internet
Торіс	Internet of Thi	ings
NI.IOT.7.a Explain the positive and negative impacts of IoT as it applies to daily life and create ways to mitigate the negative impacts on society.		Expectations for Learning LEARNING PROGRESSION In grade 6, students researched and defined how smart and intelligent devices were able to track their activities to be able to personalize the experience of utilizing the device. In grade 7, students will recognize the positive and negative impacts technology has on their daily lives, as well as the impact of technology on society as a whole.
		 IMPORTANT CONCEPTS Devices track our daily movements as well as our online activities to quickly deliver information that is pertinent to us. Data collected and stored has positive and negative effects.
		 KEY SKILLS/PROCEDURES List the positive and negative uses of IoT and discuss how it applies to our daily lives. Explain the benefits of the IoT, such as convenience, safety and health, and the risks, including data theft and other forms of criminality.
		Content Elaborations
		CLARIFICATIONS On a personal level, IoT can provide great benefits such as home security, financial management, medical monitoring and treatment, home resource management and other valuable functions. At the same time, students should recognize that the data collected by our connected devices can be improperly or maliciously used.
		CONTENT FOCUS The same devices and information that can help us can also make us vulnerable.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		<i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Analysis	
Торіс	Data Collect	ion and Storage
DA.DCS.7.a Cor contrast digital d tools to make the and reliable.	npare and ata collection em more useful	Expectations for Learning LEARNING PROGRESSION In previous grades, students had the experience of identifying various data collection tools. By the end of 7th grade, students can determine the most appropriate tool(s) to use for data collection. In future grades, students will consistently choose appropriate file types.
		 Identify the strengths and weaknesses of various data collection tools. KEY SKILL/PROCEDURES Select the appropriate tool for a particular data collection.
		Content Elaborations
		CLARIFICATIONS Students will need to know the difference between data collection tools.
		CONTENT FOCUS Students can identify the method of data collection (for example, surveys versus sensor data). The method of data collection can affect the accuracy and precision of the data. (K-12 Computer Science Framework, 2016)
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Analysis	
Торіс	Data Collecti	ion and Storage
DA.DCS.7.b Evaluate various file		Expectations for Learning
storage capabili	ties.	LEARNING PROGRESSION In previous grades, students had limited experience in selecting and utilizing appropriate file types for various collections of text and data. By the end of 7th grade, students should be able to explain and utilize different types of file formats and explain the capacity limits of each file. In future grades, students will learn how data is stored on different computer systems.
		 IMPORTANT CONCEPTS The type of data file corresponds to the type of file format. Identify image and video file extensions and characteristics of file extensions including color, size and visual capabilities. When given an image or video, the student can identify the file format.
		 KEY SKILL/PROCEDURES Explain the differences in text and data files. Explain the differences in the quality of the image or video. Explain the type of file extension for various software.
		Content Elaborations
		CLARIFICATIONS In addition to the Content Elaborations for DA.DCS.6.b, students need to be able to choose the correct image or video editing software tool for images and videos.
		CONTENT FOCUS Students can create videos of different file types such as wav, webm and mp4. Students should have experience with various file formats (e.g., .docx, .GDOC, .xlsx, GSHEET .pdf, .txt, .dat, .gif, .jpg, .tiff, .png, .bmp, .bpg, .avi, .mov, .mpeg, .mp4, and .wmv and other formats).
		COMPUTER SCIENCE PRACTICES <i>Practice 2.</i> Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Analysis	
Торіс	Data Collection and Storage	
DA.DCS.7.c Crestructure to orga support individua collaborative wo	ate a logical file nize data to l and k.	Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience organizing, saving, accessing, and sharing files. By the end of 7th grade, students can understand a logical process for organizing data in folders and subfolders on the hard drive or the cloud. In future grades, students will be knowledgeable about the organization of files and how to properly share them with others.
		 IMPORTANT CONCEPTS Files should be placed in a given organizational system.
		 KEY SKILL/PROCEDURES Explain that files should be separated based on content into folders and subfolders.
		Content Elaborations
		CLARIFICATIONS Students need to be able to create their logical file structure.
		CONTENT FOCUS Students understand the importance of organizing their files. Create and utilize shortcuts to their file system (on the desktop, create a shortcut to a file system).
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Analysis	
Торіс	Visualization a	and Communication
DA.VC.7.a Com between data se interpret results.	municate relations ets to	Expectations for Learning LEARNING PROGRESSION In previous grades, students made connections between data sets. By the end of 7th grade, students can explain relationships in data models and suggest patterns. Data visualization includes visual, auditory, tactile, oral and other sensory representations. In future grades, students will be able to utilize raw data and develop models.
		 IMPORTANT CONCEPTS Data models are used to explain and make predictions.
		 KEY SKILL/PROCEDURES Suggest patterns by comparing data in the models. Explain the suggested patterns in verbal or written form.
		Content Elaborations
		CLARIFICATIONS Given a pair of data models (e.g., graphs, charts), students will identify relationships between the two and suggest patterns that are evident in both models to tell the story about what the models are saying.
		CONTENT FOCUS Students will read two or more data models to find relationships and list patterns they see that make sense of the data. Students should be able to do this using a variety of types of models.
		COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.
Strand	Data and Ana	alysis
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Торіс	Visualization	and Communication
DA.VC.7.b Create a spreadsheet utilizing formulas, functions and graphs to represent and analyze data.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience observing graphs created from spreadsheets. By the end of 7th grade, students can use formulas and functions in a spreadsheet to answer questions and draw conclusions. In future grades, students will use formulas and functions that help represent collections of data.
		 IMPORTANT CONCEPTS Formulas and functions are used to create meaning from a set of data.
		 KEY SKILL/PROCEDURES Utilize the formulas and basic functions of a spreadsheet.
		Content Elaborations
		CLARIFICATIONS Given a data set, students will use functions and formulas to make conclusions. (e.g. Given raw data about the number and type of pets that their peers own, students will find the average number of pets per family, etc.)
		CONTENT FOCUS Students will be able to use sum, average, min, max and count formulas and functions in a spreadsheet.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
		 Practice 5. Creating Computational Artifacts 2. Create a computational artifact for practical intent, personal expression or to address a societal issue.

Strand	Data and An	alysis
Торіс	Inference an	d Modeling
DA.IM.7.a Create and analyze models and simulations to accurately hypothesize a real-world situation.		Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had experience analyzing data models (e.g., charts, graphs). By the end of 7th grade, students are able to provide evidence to support or refute a hypothesis (prediction) about a collection of data. In future grades, students will be able to hypothesize about self-generated data.
		 IMPORTANT CONCEPTS Develop a hypothesis for a problem and then determine if the data trend supports the hypothesis.
		 KEY SKILL/PROCEDURES Given a problem statement, create a hypothesis (prediction), collect data (e.g., survey results), interpret data trends and compare these interpretations to the hypothesis. Research data trends.
		Content Elaborations
		CLARIFICATIONS Students will select a problem statement and be asked to create a hypothesis, collect data, organize the results using an electronic tool and support or disprove the hypothesis.
		CONTENT FOCUS Students will research and find information that exemplifies data trends.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Algorithmic Thinking and Programming	
Торіс	Algorithms	
ATP.A.7.a Select and modify pseudocode for a multi-step process to solve a problem.		Expectations for Learning LEARNING PROGRESSION In previous grades, students should have developed a basic understanding of what goes into an algorithm and learned how to write pseudocode. As students create an algorithm, they should be able to evaluate the solution and make modifications in their pseudocode to solve the problem. At the end of 7th grade, students should be able to identify the parts of a program's pseudocode (input, output, decisions). In future grades, students will write their own pseudocode and be able to justify the most efficient solution for a multi-step process.
		 IMPORTANT CONCEPTS Understand the flow of a program. Compare different sets of pseudocode and determine the most efficient solution.
		 KEY SKILL/PROCEDURES Identify the inputs, outputs, processes and decisions. Use proper symbols to create flow charts to represent pseudocode.
		Content Elaborations
		CLARIFICATIONS Students should be able to write pseudocode to model an algorithm. This could be writing a recipe for making a sandwich, writing directions between two locations, or writing the steps necessary to compute a semester grade. At this level, the expectation is that looping is done utilizing iteration, not recursion.
		CONTENT FOCUS Students should be able to identify the inputs, outputs, and decision steps within the algorithms they create in pseudocode. Students should be able to create a flow chart representation of their pseudocode, using proper symbols for inputs, outputs and decisions.
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.
		 Practice 3. Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.

Strand	Algorithmic Thinking and Programming	
Торіс	Algorithms	
		 Practice 4. Developing and Using Abstractions Model phenomena and processes and simulate systems to understand and evaluate potential outcomes. Practice 5. Creating Computational Artifacts Modify an existing artifact to improve or customize it.

Strand	Algorithmic Thinking and Programming	
Торіс	Variables an	d Data Representation
ATP.VDR.7.a Use test cases to trace variable values to determine		Expectations for Learning
the result.		LEARNING PROGRESSION In previous grades, students developed an understanding of what it means to vary (as opposed to being constant) and that this abstract value is expressed with an alphanumeric representation. By the end of 7th grade, students understand how to use variables in a test case. In future grades, students will be able to understand that variables have different storage requirements and will use parameters. They will learn about scope.
		 IMPORTANT CONCEPTS Identify the top and low range of values that will successfully run a solution. Identify out of bound values.
		 KEY SKILL/PROCEDURES Use Input /output charts.
		Content Elaborations
		CLARIFICATIONS Students will deepen their understanding of variables, including when and how to declare and name new variables. A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. The identifier makes keeping track of the data that is stored easier, especially if the data changes. Naming conventions for identifiers, and thoughtful choices of identifiers, improve program readability. (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students will be able to identify variables and choose appropriate test values for each variable. Students will be able to identify "good" vs. "bad" input values for variables by tracking results on an input/output chart while running test cases.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.</i> Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.
		 Practice 4. Developing and Using Abstractions 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Control Strue	ctures
ATP.CS.7.a Use decisions and lo to solve a proble	Control Strue	Expectations for Learning LEARNING PROGRESSION In previous grades, students need to have learned how to create and utilize self-descriptive variables. Students also need to have learned to identify simple conditionals and loops and to trace the processes. At the end of 7th grade, students understand and incorporate proper processes, loops and conditionals in programs to solve problems. In future grades, students will understand that variables have different storage requirements and restrictions, and can choose the correct one to use for a task. Students will use parameters to pass variable information into methods and return values to get information out of a method. Students will be introduced to the scope and how a program can access or change a variable. IMPORTANT CONCEPTS • Utilize and apply the decision structures properly in an algorithm. • Utilize and apply the loop structures properly in an algorithm. KEY SKILL/PROCEDURES • Properly use If-then, if-then-else, and if-then-else if statements. • Properly use Pre-test (do-while), post-test (while) and definite loop (for, for next). Conditional statements can have varying levels of complexity, including compound and nested conditionals. Compound conditionals combine two or more conditions in a logical relationship, and nesting conditionals. Compound conditional structure is deciding what to do based on the weather outside. If it is sunny outside, I will further decide if I want to ride my bike or go runnin
		example, functional programming languages implement repetition using recursive function calls instead of loops. At this level, understanding implementation in multiple languages is not essential. (K-12 Computer Science Framework, 2016)

Strand	Algorithmic Thinking and Programming	
Торіс	Control Structures	
		CONTENT FOCUS Students will identify and create compound conditional statements, such as the one described by first choosing the weather: if sunny, then will you go running or biking; else if rainy, will you read or watch TV. Then, the student should include nesting conditions and looping (e.g., Input an integer and if it is even, print a row of "E"s; if it is odd, print a column of "O"s.)
		 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	Algorithmic	Thinking and Programming
Торіс	Modularity	
ATP.M.7.a Decompose problems into parts to facilitate the design, implementation and review of increasingly complex programs.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience decomposing an event, experience or problem. For example, to create a mural or draw a scene, several "parts" must be chosen first (the background, the characters placed, the action programmed). By the end of 7th grade, students can identify and utilize the procedures/modules within a set of instructions or code. Students should also be able to reuse the modules in new problem sets or coding. In future grades, students will be able to utilize the procedures/modules within a set of complex instructions or code.
		 IMPORTANT CONCEPTS Identify smaller components of an algorithm. Identify a set of steps of an algorithm's component that produces a result. Reuse the smaller components of the program (modules) in new problem situations.
		 KEY SKILL/PROCEDURES Group and organize steps that work together to produce a result. When provided with a result, identify the steps that were used. Reuse the identified module/procedure (organized set of steps) in a new problem situation.
		Content Elaborations
		CLARIFICATIONS A procedure is a module (a group of instructions within a program) that performs a particular task. Procedures are invoked to repeat groups of instructions. For example, a procedure, such as one to draw a circle, involves many instructions, but all of them can be invoked with one instruction, such as drawing circle. Procedures that are defined with parameters are generalizable to many situations and will produce different outputs based on a wide range of inputs (arguments). (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students will be able to utilize modules to increase the organization of code, the ability to hide details and the reusability.

Strand	Algorithmic	Thinking and Programming
Торіс	Modularity	
		 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally. Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Practice 6. Testing and Refining Computational Artifacts Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand	Algorithmic Thinking and Programming	
Торіс	Program Deve	elopment
ATP.PD.7.a Write code that utilizes algorithms, variables and control structures to solve problems or as a creative expression.		Expectations for Learning LEARNING PROGRESSION In previous grades, students learned how to use parameters in a block-based programming. By the end of 7th grade, students begin the transition to text-based coding in order to design and create their own project or to solve a problem. They should use procedures that require parameters. In future grades, students will design and create their own text-based programs.
		 IMPORTANT CONCEPTS Write code to solve a problem using programming software that will transition them from block- based to text-based programming.
		 KEY SKILL/PROCEDURES Explore programming with software that is intended to transition students from block-based to text-based code. Use procedures containing parameters.
		Content Elaborations
		CLARIFICATIONS A transitional programming language will help the student convert to text-based coding. This transitional software will still hide some of the details of coding, automatically fix a few typographical errors, but will allow students to define variables and create control structures.
		CONTENT FOCUS Students should be able to define variables, implement control structures (loops, if/then/else) and use procedures containing variables.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		 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.

Strand	Algorithmic Thinking and Programming	
Торіс	Program Development	
		Career Connections CAREER EXPLORATION Students explore careers in coding like computer programming, as well as those careers that support creative professions such as filmmaker, podcaster, digital imaging specialist and other creative professions. Students present or create an artifact showing their learning.

Strand	Algorithmic Thinking and Programming	
Торіс	Program Dev	velopment
ATP.PD.7.b Test, trace and debug to refine code.		Expectations for Learning LEARNING PROGRESSION In previous grades, students identified and corrected errors in block-based code to make the program run correctly and produce the expected result. By the end of 7th grade, students can identify and correct two types of errors (run-time and logical) when using a transitional programming language. In future grades, students will continue to refine their programs using a range of text cases.
		 IMPORTANT CONCEPTS Test a variety of solutions within the programming solution. Identify and fix errors within the program.
		 KEY SKILL/PROCEDURES Use troubleshooting techniques to debug the code. Debug one's code.
		Content Elaborations
		CLARIFICATIONS Students need to understand that errors often occur when writing code and some of those errors can only be found by verifying that the output is correct. Many transitional programming languages have built-in features to help students identify and correct errors.
		CONTENT FOCUS Students will be able to differentiate between run-time (when a program crashes) and logical (when the results are incorrect) errors and then correct those errors.
		 COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Program Dev	velopment
ATP.PD.7.c Identify procedures that utilize parameters.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using procedures with parameters in block-based coding. For example, there might be a procedure called "move _steps" where the amount of steps is a parameter. By the end of 7th grade, students continue this experience and extend it in a transitional programming language. They are also comfortable with procedures and parameters. In future grades, students will expand their experience with parameters.
		 IMPORTANT CONCEPTS Identify and utilize a procedure and its parameters needed to solve a solution in a transitional text-based programming language.
		 KEY SKILL/PROCEDURES Implement a given procedure and use appropriate values for the parameters in a transitional text-based programming language.
		Content Elaborations
		CLARIFICATIONS At this level, it is appropriate to have students implement canned procedures with parameters in both block- based and text-based programming languages. Examples of procedures for block-based programming languages are: switch costume to, go to x: y:, say _ for _ secs. Examples of procedures for text-based languages are: pam.turnLeft(), pam.waddle(), pam.isFish(here), pam.isWater(right). These procedures are canned methods which students implement. Students are not expected to write procedures with return types (methods, functions) from scratch; they are expected to be able to implement them with correct values for the required parameters.
		CONTENT FOCUS Students will understand how to implement canned procedures (methods) with proper parameter values in a text-based programming language.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Artificial Inte	elligence
Торіс	Natural Inter	actions
AI.NI.7.a Curate a data set 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 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 data sets 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 data set to train a language processing program. Students will be able to train a language processing algorithm to recognize a data set of voice commands to complete a task or problem.
		Content Elaborations CLARIFICATIONS Voice command is a conversational Artificial Intelligence (AI) tool that uses voice commands to receive and interpret directives.
		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. Data sets 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 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.

Artificial Intelligence

Natural Interactions

Strand

Торіс

AI.NI.7.b Identify the	Expectations for Learning
components of a chatbot and explain how each component contributes to the chatbot's human-like responses.	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.
	Content Elaborations
	CLARIFICATIONS Chatbot components include (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, e.g., 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.

Strand	Artificial Intelli	gence
Торіс	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, how computer perception 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 An intelligent agent is 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 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 Intelli	gence
Торіс	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 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 Intelli	igence
Торіс	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.

Strand Artificia	i intelligence
Topic Represe	entation & Reasoning
AI.RR.7.a Compare severa algorithms that could be us to solve a specific type of reasoning problem.	Bal Expectations for Learning Sed 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 model the process of solving
01	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, describe what each one does and give an 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.

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Strand	Artificial Intelligence	
Торіс	Representation & Reasoning	
	 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts 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. Create a computational artifact for practical intent, personal expression, or to address a societal issue. Modify an existing artifact to improve or customize it. 	

Strand Artificial	ntelligence
Topic Machine	_earning
AI.ML.7.a Model how unsupervised learning finds patterns in unlabeled data to identify how machine learning takes place.	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 data set to evaluate the quality of the data set.
	 IMPORTANT CONCEPTS A classification model is the 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 based on the future assumptions. In prediction, the output is a continuous value; tabular data set: a collection of rows and columns.
	 KEY SKILLS/PROCEDURES Explain the difference between a classification and a prediction model. Discuss how the same tabular data set can create different results when run through a classification model vs. a prediction model. Be able to judge the quality of a data set once a model has been run, including and discussing strategies for improving your data set.
	Content Elaborations
	CLARIFICATIONS Machine learning models have specific applications based on the desired outcome of a given data set. Classification models sort a data set into groups of similar data (e.g., grouping students by interest in specific sports) vs. Prediction models create a prediction based on previous data to take a new data set and predict where it will go or do (e.g., predicting a student's lunch order based on their previous orders.)
	CONTENT FOCUS Different t ypes of machine learning can produce different outcomes.

Strand	Artificial Intelligence	
Торіс	Machine Learr	ning
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions. Abstractions are formed by identifying patterns and extracting common features from specific examples to create generalizations. Using generalized solutions and parts of solutions designed for broad reuse simplifies the development process by managing complexity. By the end of Grade 12, students should be able to: Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
AI.ML.7.b Create a data set for training a decision tree classifier or predictor to explore the impact that different feature encodings have on the decision tree.		Expectations for Learning LEARNING PROGRESSION In grade 6, students created a labeled data set with explicit features of several types. In grade 8, students will compare the features of two real-world data sets. IMPORTANT CONCEPTS • Classifier • Feature Types • Decision Tree classifiers • Nodes
		 KEY SKILLS/PROCEDURES Students will create a data set. Students will choose different features to include. Students will explore the impact of different feature encodings.
		Content Elaborations CLARIFICATIONS The choice of features to include, and the best encoding to use for these features, depends on the reasoning problem being solved.

Strand	Artificial Intelligence	
Торіс	Machine Learn	ning
		CONTENT FOCUS At each node of the decision tree, the learning algorithm tries to pick a feature that will be most helpful in separating the remaining instances into different classes. Features that do not correlate strongly with any class will not be chosen.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions. Abstractions are formed by identifying patterns and extracting common features from specific examples to create generalizations. Using generalized solutions and parts of solutions designed for broad reuse simplifies the development process by managing complexity. By the end of Grade 12, students should be able to: Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. 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 Intelli	gence
Торіс	Societal Impac	ets
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 data sets 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 data sets.
		 IMPORTANT CONCEPTS Describe the effects of training data on the accuracy of an Artificial Intelligence (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 data set.
		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 data sets because 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. Strategies for avoiding bias in data sets include knowing your users, having a diverse development team, pulling data from multiple sources and testing for bias.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Topic Societal Impac	ets and the second s
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 data sets. In grade 8, students will identify bias potential in the design of artificial intelligence systems and describe how to utilize inclusive Artificial Intelligence (AI) design to prevent algorithmic bias.
	 IMPORTANT CONCEPTS Explain how classification in a data set can create problems in supervised AI systems. Explain how data sets 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 data set and how it is used in a supervised AI system. Students will be able to develop strategies for creating inclusive and accurate data sets using classification.
	Content Elaborations
	CLARIFICATIONS Classification means identifying shared characteristics of certain classes in a data set.
	CONTENT FOCUS Classification of data sets can create an algorithmic bias if the data are not complete, balanced, selected or labeled appropriately. Ensuring classes represent as many possible data points as possible is one means of creating a more inclusive and accurate data set 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.

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Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.7.a Compare current technologies from the present to the past to evaluate the effect on people's everyday activities.	are current m the present to the the effect on ay activities.	Expectations for Learning LEARNING PROGRESSION In previous grades, students should have become familiar with how we communicate via technology in today's world. At the end of grade 7, students study the history of computing and technology, including cultural differences, and develop a better understanding of the advancement of computing and its global impact. In future grades, students will study how current technologies affect the economy.
		 IMPORTANT CONCEPTS Examine the change in communication and collaboration styles. Review the history of computing and technology to understand diversity. Examine the change in technology skills and tools that are required for the workforce.
		 KEY SKILL/PROCEDURES Communicate via school technology with one's family, class and teacher. Trace the advancement of computing and indicate where globally the advancement has occurred.
		Content Elaborations
		CLARIFICATIONS Students need to understand how today's technology has increased the amount and speed of information that can be accessed and shared. Students can safely experience this phenomenon through technology provided by their school and/or in their classroom. Students should be able to demonstrate/illustrate the basic timeline of the advancement of computing.
		CONTENT FOCUS Students can compare how a task was accomplished in the past and compare it to how the task is accomplished now, emphasizing how technology has impacted the change.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.7.b Evalu- technologies to i bias and access	ate various dentify issues of ibility.	Expectations for Learning LEARNING PROGRESSION In previous grades, students need to have developed an understanding that computing has become a global connection. At the end of 7th grade, students can identify technologies that have bias and accessibility issues for many areas of the world. There are still areas of the world and individuals who do not have the same access. In future grades, students will propose guidelines to positively impact bias and accessibility.
		 IMPORTANT CONCEPTS Computing makes all aspects of our lives more efficient. It gives us the opportunity to communicate on a global scale. Bias and accessibility within technology include third world countries, equity, socio-economic status, and persons with disabilities.
		 KEY SKILL/PROCEDURES Explain that access is important for everyone regardless of their socioeconomic status, disability or geographic location. Research the issue of accessibility, identify some of the technologies with this issue and report their findings.
		Content Elaborations
		CLARIFICATIONS The educational system tries to level the computing access playing field for all students, when in reality, not all students have the same opportunities or access once they leave the school setting. Helping students become aware of the world in which they live will help foster citizenship and problem solving (i.e., "thinking outside the box"). Students may experience and identify access limitations personally or observe the bias against a family member or friend. This bias may exist due to disabilities or economic status. Students also need to identify the technology bias and accessibility issues that many people have globally.
		CONTENT FOCUS Students will determine appropriate technologies for making computing accessible to all. Through research, students will identify a particular need and then determine the appropriate technology or adaptation.

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Strand	Impacts of Computing	
Торіс	Culture	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 3. Employ self- and peer-advocacy to address bias in interactions, product design and development methods.
IC.Cu.7.c Identify and explore careers related to the field of computer science.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using technology on personal and/or school devices. They had classroom conversations about a few computer science employment opportunities. At the end of 7th grade, students understand that there are many different people and jobs involved in creating the technology that they utilize and this fact equates to numerous jobs in the computer science fields. In future grades, students will evaluate how new technologies and professions will solve real-world problems.
		 IMPORTANT CONCEPTS It is necessary to stay up-to-date on future industry needs. Computer science is more than writing code or building a piece of hardware. The ever-evolving area of computing will create jobs that do not exist today.
		 KEY SKILL/PROCEDURES Describe several different existing careers involving computer science and understand that there will be positions in the future that have not yet been defined.
		Content Elaborations
		CLARIFICATIONS There are many careers under the umbrella of computer science, many of which do not involve coding and building a piece of hardware. Students should be aware of the possibilities that exist today and realize that there will be new jobs for them when they graduate that does not even exist today.
		CONTENT FOCUS Students need to understand that a computer science career is not just writing code, but is an integral part of all industries and world culture.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)
	artment	

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.7.d Expla impacts innovat	in how computing on in other fields.	 Expectations for Learning LEARNING PROGRESSION In previous grades, students had experiences utilizing several different mediums of technology, such as email, shared school documents, electronic grade books and research on the internet. By the end of 7th grade, students should be able to identify both the positive and negative impact that computing has had in other fields (e.g., robotics in manufacturing, virtual meetings, medical advances). In future grades, students will evaluate how new technologies and professions will solve real-world problems. IMPORTANT CONCEPTS The communication, computation, and connection opportunities provided by computing technologies
		 have provided a wave of innovation in other fields. Due to the current data processing, networking and computational abilities of computers, we are now able to accomplish things that we had never dreamed possible. KEY SKILL/PROCEDURES Identify areas where the benefits of computing technology could be applied to other fields to make them more efficient and/or successful.
		Content Elaborations
		CLARIFICATIONS The big idea here is that computing applies to a wide variety of fields. Students should be allowed to make connections between computing technologies and how they could impact and continue to improve people's lives.
		CONTENT FOCUS Students should have the ability to identify current computing innovations and explore the relationship of how those innovations both positively and negatively affect various careers and other fields of study. Students should study how computing can relate to a variety of careers and explain the advantages and disadvantages of current technologies.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.

Impacts of Computing

Topic Social Interactions

IC.SI.7.a Analyze and present beneficial and harmful effects of electronic communications to understand their impacts on interpersonal, global, economic, political, business and cultural interactions.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students had continual conversations with teachers about the proper use of electronic devices whenever there was a lesson that involved use of a computing device. In 7th grade, students explore the global, economic, political, business and cultural effects a little more deeply. In future grades, interpersonal use of devices should be a continual conversation and not contained to this single strand.

IMPORTANT CONCEPTS

- Identify positive and negative impacts of devices and computing on the health and well-being of businesses, economics, politics and cultural interactions.
- Provide examples of beneficial and harmful effects of persons through social media, phones and other devices.

KEY SKILL/PROCEDURES

- Differentiate between the harmful and beneficial effects of computing and devices globally and locally on economics, businesses, politics and cultural differences.
- Describe ways in which the internet globally impacts business, politics and economics.
- Communicate the pros and cons of personal interaction with email, phones and social media.
- Describe the advantages and disadvantages of electronic collaboration for interpersonal use.

Content Elaborations

CLARIFICATIONS

Computing and devices have a significant impact on connecting with other people, sharing information and expressing ideas. Students need to understand the power of these devices and differentiate between their beneficial and harmful effects. The economic/business/political uses of these devices can be quantified. The interpersonal effects may be a good transition to an anti-bullying lesson/unit.

CONTENT FOCUS

Students should be able to evaluate how the use of computing devices can contribute or be a detriment to the economics, businesses, politics and cultural differences at the global and local levels. Students also should be able to determine how social media and technological devices can contribute to or have consequences in their daily lives.

Strand	Impacts of Computing	
Торіс	Social Interactions	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. Practice 7. Communicating About Computing Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Impacts of Computing

Topic Safety, Law and Ethics

IC.SLE.7.a Describe tradeoffs between allowing information to be public and keeping information private and secure to inform decision-making.

IC.SLE.7.b Identify the social and economic implications of privacy in the context of safety, law or ethics to understand how privacy impacts these areas.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students should have had experience with devices at school and had lessons/teacher conversations about information sharing. By the end of 7th grade, students understand and can explain the difference between public and personal information and the necessity of not sharing personal information. In future grades, students should be able to apply these concepts and continually investigate security concerns and legal rights.

IMPORTANT CONCEPTS

- Identify what is considered to be personal information (e.g., address, phone number, birth date, social security number, financial information).
- Be familiar with some of the "attacks" made by third parties trying to misuse private information.
- Identify the consequences of providing misinformation.

KEY SKILL/PROCEDURES

- Differentiate between personal and public information and make decisions about which items can be safely shared within social media.
- Recognize third-party attempts of retrieving personal information (e.g., emails, phishing).
- Communicate the contents of one's digital footprint.
- Communicate the implications of providing false or misinformation with devices.

Content Elaborations

CLARIFICATIONS

Social engineering is based on tricking people into breaking security procedures and can be thwarted by being aware of various kinds of attacks, such as emails with false information and phishing. Security attacks often start with personal information that is publicly available online. All users should be aware of the personal information, especially financial information, that is stored on the websites they use. Protecting personal online information requires authentication measures that can often make it harder for authorized users to access information. (K-12 Computer Science Framework, 2016)

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		CONTENT FOCUS Students will be able to identify and understand what information is considered to be personal (e.g., address, phone number, birth date, social security number, financial information) vs. public. It is vital that students understand what information should be kept private and secure to protect themselves. Teachers need to reinforce that decisions made regarding their personal information will become a "digital footprint" and be at risk for "attacks" made by third parties trying to misuse private information. Students will additionally be able to understand how the release or sharing of personal information can publicly harm their livelihood or others.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Impacts of Computing

Topic Safety, Law	and Ethics
IC.SLE.7.c Evaluate the development of new technologies in communication, entertainment and business to understand the impact.	Expectations for Learning LEARNING PROGRESSION In previous grades, students had experiences with collaborative documents, school email, electronic grade books and electronic school communication. By the end of 7th grade, students can identify some of the positive and negative effects that technology in communication has in the business world, including the entertainment business. In future grades, students will be able to apply these concepts.
	 IMPORTANT CONCEPTS Technology has had a profound effect in the business world.
	 KEY SKILL/PROCEDURES Explain how communication in the business world has become faster and easier and has expanded opportunities. Describe the advantages (e.g., speed and efficiency, communication log, mobile workers). Describe the disadvantages (e.g., lack of relationship building, informal communication, distractions). Explain why communication must be more deliberate; reacting to electronic messages should be well thought out.
	Content Elaborations
	CLARIFICATIONS Technology has changed the business world in many ways and perhaps the biggest impact computing has had is in the way businesses communicate. It has expanded the market and business partnerships with companies and allowed for expansion. Overall, this has been a positive impact on businesses and the economy, but it can make communication more distracting and less clear.
	CONTENT FOCUS Students will be able to focus on the positive and negative impacts of computing on the business world.
	COMPUTER SCIENCE PRACTICES <i>Practice 1.</i> Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.

Strand

Strand	Impacts of Computing	
Торіс	Safety, Law	and Ethics
		 Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Create team norms, expectations and equitable workloads to increase efficiency and effectiveness. Solicit and incorporate feedback from, and provide constructive feedback to, team members and other stakeholders.
IC.SLE.7.d Provide appropriate credit when using resources or artifacts that are not our own.		 Expectations for Learning LEARNING PROGRESSION In previous grades, students had some experience creating original work that may include code, text, video or graphics and had discussions on citing/providing credit to any sources that were copied/inserted into their work. By the end of 7th grade, students should continue providing credit for all sources. In future grades, students should continue providing credit for all sources. In future grades, students should continue providing credit for all sources. IMPORTANT CONCEPTS Plagiarism/cheating is when you represent someone else's work as your own. In creating a computational artifact, students can create their original work, including video, music, text, images, graphs and program code. When using external work to integrate into a computational artifact, one must acknowledge, attribute and/or cite sources and include a bibliography with their submission. External work that should be acknowledged includes video, music, text, images, graphs and program code that are used in the creation of computational artifacts. KEY SKILL/PROCEDURES Provide proper credit for items inserted into their work; the credit may be in MLA or APA formatted citations or some other accepted format. Give credit to not only textbooks, scientific reports and websites but also appropriate persons in a collaboration effort.

Strand	Impacts of Computing	
Торіс	Safety, Law a	and Ethics
		 Content Elaborations CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet, such as video, photos and music, creates the opportunity for unauthorized use, such as online piracy, and disregard of copyrights, such as lack of attribution. (CSTA K-12 Computer Science Standards, 2017). Students need to learn the importance of providing proper credit for all sources, not only the electronic sources but also those persons with whom they have worked. CONTENT FOCUS Students will be able to give appropriate credit for items, such as information, videos and pictures, that they use in their work. COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.
IC.SLE.7.e Expl between the long the internet, pers identity and pers	ain the connection gevity of data on sonal online sonal privacy.	 Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had experience using the internet, school email, school electronic communication and an electronic grade book. Students should have also learned to differentiate between appropriate and inappropriate websites and behavior on the internet and social media. By the end of 7th grade, students understand the tracking that is done while they are electronically communicating and the fact that they leave a "digital footprint." In future grades, students will be able to apply these concepts. IMPORTANT CONCEPTS Identify the type of information contained in a "digital footprint." KEY SKILL/PROCEDURES Identify the data points accessed by apps on a phone (e.g., email, location, phone number, call logs, calendar events). Identify online tracking with websites, cookies, cross-device tracking, passwords and hotspots.
Strand	Impacts of Computing	
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Торіс	Safety, Law and Ethics	
		 Content Elaborations CLARIFICATIONS As students access the internet and search online, whether it is via apps on their phones or a web browser on a computing device, they are providing information about themselves. These pieces of information can be equated to puzzle pieces where more pieces are needed to complete the picture. Computing devices (e.g., through web browsers and phone apps) collect these puzzle pieces to form this complete picture. Students need to be aware of this "digital footprint" that is being collected about them, and they need to investigate strategies to reduce this footprint. CONTENT FOCUS Students should focus on the contents of their digital footprint and what information they leave behind about themselves on the internet. COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.

GRADE 8

Strand	Computing S	ystems
Торіс	Devices	
CS.D.8.a Evaluate the advantages and limitations of existing computing devices to recommend design improvements based on analysis of how users interact with the device.		Expectations for Learning LEARNING PROGRESSION In previous grades, students learned how to evaluate devices dependent upon personal needs. By the end of 8th grade, students can identify improvements to possibly make a computing device for better interaction with users. In future grades, students will be able to extract technological information about computing systems to determine the best practice for situations.
		 IMPORTANT CONCEPTS Identify a problem and make appropriate revisions. Brainstorm ideas to improve a computing device. Hardware defines how the user can interact with the device.
		 KEY SKILL/PROCEDURES Evaluate and communicate the advantages and disadvantages of a computing device.
		Content Elaborations
		CLARIFICATIONS Students will work collaboratively and communicate the advantages and disadvantages of computing devices, such as memory limitations.
		CONTENT FOCUS Students can make recommendations to improve a computing device.
		 COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand	Computing Systems	
Торіс	Hardware/So	oftware
CS.HS.8.a Design projects that combine hardware and software components that could complete a task.		Expectations for Learning LEARNING PROGRESSION In previous grades, students used/simulated hardware and software components to accomplish a task. By the end of 8th grade, students make decisions on the use of hardware and software combinations to effectively complete a task. In future grades, students will make decisions on the use of hardware and software combinations to effectively complete a task.
		 IMPORTANT CONCEPTS Research, select and use/simulate appropriate hardware and software components to accomplish a task. Experience the project management process.
		 KEY SKILL/PROCEDURES Evaluate hardware and software to determine which combination(s) will produce a proper outcome based on a request. Determine the best hardware and software to use to produce a result.
		Content Elaborations
		CLARIFICATIONS Consider multiple components, such as functionality, cost, size, speed, accessibility and aesthetics to select the appropriate hardware or software for a given task.
		CONTENT FOCUS Students can summarize and recommend the best combination of computing device(s) and software(s) to use to produce an outcome based on a requirement provided. Students will use project management skills as a key tool to effectively complete a task.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions. 2. Evaluate existing technological functionalities and incorporate them into new designs.

Computing Systems

Troubleshooting

process to identify and evaluate the source of a routine computing problem. Select the best solution to solve the computing problem and communicate the solution to others	LEARNING PROGRESSION In previous grades, students worked to diagnose problems, describe the problem and develop strategies to resolve technology issues. By the end of 8th grade, students can identify and evaluate problems, determine the best solution and communicate with others to help them solve those problems. In future grades, students will understand the troubleshooting process to evaluate a pre-determined situation.
	 IMPORTANT CONCEPTS Use a basic troubleshooting process. Have a working knowledge of computing devices. Communicate to others via electronic and/or in-person communication.
	 KEY SKILL/PROCEDURES Utilize knowledge of computing devices, hardware and software to locate and solve a problem. Create a list of possible solutions to implement. Evaluate solutions to determine the best one. Communicate a solution to others.
	Content Elaborations
	CLARIFICATIONS As students gain more experience listing possible solutions, they need to be able to test the solutions and determine the best solution. They also need to learn how to communicate these solutions to others via electronic or in-person communication to help guide others to a solution.
	CONTENT FOCUS

Expectations for Learning

Students can identify troubleshooting steps that are key to solving the software/hardware problem. This process involves collaboratively working through the troubleshooting steps.

COMPUTER SCIENCE PRACTICES

Practice 6. Testing and Refining Computational Artifacts

- 1. Systematically test computational artifacts by considering all scenarios and using test cases.
- 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand

Topic

CS.T.8.a Use a systematic

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.8.a Model the role of hardware components to diagram the infrastructure of networks and the internet (including cloud servers).		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a basic understanding of how devices and protocols are used in networking. By the end of 8th grade, students can develop a model representing networking hardware to understand the flow of information across the internet. In future grades, students should be able to apply these concepts.
		 IMPORTANT CONCEPTS Multiple devices are required for data to flow using protocols on the internet. Each device has a role in the flow of data on the internet. Understanding the role of each device allows the student to diagram the flow of data from one location to another across the internet. Students should be able to explain concepts, including routers, switches, packets and protocols
		 KEY SKILL/PROCEDURES Collaboratively create a working model of how data travels through a network, incorporating key hardware components.
		Content Elaborations
		CLARIFICATIONS Students will identify basic components (e.g., computer, router, server) where they can create a model to make connections of how information travels across the internet.
		CONTENT FOCUS Students will understand the purpose of hardware and how it enables communication on the internet.
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 1. Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities.
		 Practice 4. Developing and Using Abstractions 3. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks and the Internet	
Торіс	Networking	
		 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.
NI.N.8.b Model rules) and expla used to transmit networks and th	protocols (i.e., in why they are data across e internet.	Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a basic understanding of how devices and protocols are used in networking. By the end of 8th grade, students can identify a wide range of protocols and how they are utilized to transfer data across the internet. In future grades, students will understand a wider range of networking methodologies. IMPORTANT CONCEPTS • Protocols are used for websites, including http and https (usage not mechanics). • Protocols are used for email, including POP3 and IMAP (usage not mechanics). • Introduce additional protocols, such as TCP/IP (usage not mechanics). • Introduce additional protocols, such as TCP/IP (usage not mechanics). • Demonstrate how data is transmitted across networks. • Illustrate how data is transmitted. Content Elaborations CLARIFICATIONS At this level, students need to know protocols are used for internet communication on many levels. There are layers of protocols in place to transmit information across the internet. COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions A Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.

Strand	Networks an	d the Internet
Торіс	Networking	
NI.N.8.c Explain how a system responds when information is lost to understand the effect it has on the transferred information.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a basic understanding of how devices and protocols are used in networking. By the end of 8th grade, students understand that information that is lost via transmission will be re-transmitted. In future grades, students will learn about retransmission algorithms.
		 IMPORTANT CONCEPTS Understand how information is broken into packets. Lost packets will be re-transmitted. The result of missing packets can mean a loss of quality or missing information.
		 KEY SKILL/PROCEDURES Utilize a working model to simulate missing packets.
		Content Elaborations
		CLARIFICATIONS Students will utilize a working model of basic components (e.g., computer, router, server) to model how protocols are used to transmit information across the internet.
		CONTENT FOCUS Students will understand that hardware combined with specific software protocols work together to get data from one location to another location on the internet.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		Practice 5. Creating Computational Artifacts3. Modify an existing artifact to improve or customize it.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	:y
NI.C.8.a Explain digital security m to protect electro	how physical and easures are used nic information.	Expectations for Learning LEARNING PROGRESSION In previous grades, students developed an understanding that encryption is one way to secure information. By the end of 8th grade, students understand physical measures to protect devices and software measures to protect electronic information. In future grades, students will learn different security measures to protect information.
		 IMPORTANT CONCEPTS Be able to safeguard physical devices from theft. Differentiate between physical and digital locks. Password protect all devices.
		 KEY SKILL/PROCEDURES Define physical locks (e.g., a locked room or car). Define software digital locks (e.g., Encryption is a software digital lock).
		Content Elaborations CLARIFICATIONS
		In this grade, students will understand that physical locks, such as a locked car, can protect electronic information in combination with digital locks like encryption.
		CONTENT FOCUS Students will understand physical locks and digital locks can be used to protect devices and electronic information.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ty
NI.C.8.b Compare and contrast the effects of different types of malware to determine strategies for how to protect devices.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed an understanding that encryption is one way used to secure information. By the end of 8th grade, students understand general practices used to identify malware infections. Students can describe how malware can affect information. In future grades, students will learn about removal strategies for malware.
		 IMPORTANT CONCEPTS Follow best practices to password protect all devices. It is best to use biometrics, when available. Recognize the symptoms of a malware infection.
		 KEY SKILL/PROCEDURES Identify behaviors of malware to determine a possible infection. Develop strategies for how to protect devices.
		Content Elaborations
		CLARIFICATIONS Students can identify that malware behaviors, such as reduced speed and pages that will not load, are evidence of infection. Students will understand protection strategies including anti-malware software, regular software updates and common sense (i.e., practice skeptical computing).
		CONTENT FOCUS Students will be able to recognize common behaviors of malware to determine a possible infection on their computers. Students will develop strategies for how to protect devices.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ty
NI.C.8.c Compare and contrast examples of various threat actors, such as nation-states, cyberterrorist groups, organized crime or hacktivists.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a general understanding that private information should be protected from malware threats, online services and unauthorized access. By the end of grade 8, students should recognize different threat actors and threat vectors that are commonly employed.
		In future grades, students will be able to infer, articulate and employ best practices for threat mitigation.
		 IMPORTANT CONCEPTS There are different types of threat actors that operate differently with different motivations. There are different threat vectors commonly employed to access information or disrupt services.
		 KEY SKILLS/PROCEDURES Identify the types of threat actors and their objectives. Identify common threat vectors. Discuss cyber hygiene and threat mitigation.
		Content Elaborations
		CLARIFICATIONS Students will begin to work more independently. Previously, they will and have been working with computing, data systems, and devices like Raspberry Pi's, Arduinos and other devices. Now students should become more aware of online threats and threat actors.
		CONTENT FOCUS Understand and discuss different threat vectors that are used by the different threat actors and their motives.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ty
NI.C.8.d Explore and differentiate examples of complex encryption methods, e.g., Vigenère, Bacon's cipher and Enigma.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed a general understanding of basic encryption. By the end of grade 8, students should recognize different encryption methods. In future grades, students will be able to utilize various encryption techniques to protect data.
		 IMPORTANT CONCEPTS Encryption is a key concept in password and personal data security. Encryption is needed to protect data in transit and at rest. Understanding encryption could lead students to more advanced cyber security topics.
		 KEY SKILLS/PROCEDURES Identify the goals of encryption. Identify types and explain the uses of encryption. Discuss the uses of encryption. Use encryption methods to solve problems.
		Content Elaborations
		CLARIFICATIONS There are many classic examples of encryption that can be engaging and interesting to both teachers and students. Discuss how encryption can solve problems in computing and protect assets.
		CONTENT FOCUS As students leave grade 8, they should know and understand what personal data is, why it is important to them and why it is important to protect personally identifiable information.
		Students should also understand that information and data can be protected using encryption methods and other processes. This includes the idea of the CIA triad, a concept that focuses on the balance between the confidentiality, integrity and availability of data under the protection of your information security program.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Expectations for Learning

LEARNING PROGRESSION

Networks and the Internet

Internet of Things

identify careers associated with the computer science field. NI.IOT.8.b Model the lifecycle of information in the IoT: data gathering, transmission.	In grade 7, students will recognize the positive and negative impacts that technology has on their daily lives, as well as the impact of technology on society as a whole. In grade 8, students will explore their career interests through embedded activities. Career exploration strategies are opportunities for students to discover and understand the various aspects of IoT importance. In grades 9-12, students can gather information so they can design simple smart applications and an accompanying life cycle.
reception, and analysis to recreate a real-world scenario.	 IMPORTANT CONCEPTS Various careers are associated with IoT. IoT information has a lifecycle.
	 KEY SKILLS/PROCEDURES List the various career pathways associated with the IoT field. Explain the lifecycle of the information in the IoT.
	Content Elaborations
	CLARIFICATIONS Students will explore IoT careers and investigate the necessary pathways to engage in future academic and industry professions.
	The lifecycle of information in the IoT is data gathering, transmission, reception and analysis. To understand IoT, analysis involves recreating a real-world scenario such as using IoT-enabled lighting settings to make lights bright or dim, warm or cool.
	CONTENT FOCUS The Internet of Things (IoT) is revolutionizing every industry, from home appliances to agriculture to space exploration.
	The IoT is the worldwide network of internet-connected, automated devices that sense and collect interconnected data to enable users to monitor and control an environment.
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COMPUTER SCIENCE PRACTICES *Practice 4.* Developing and Using Abstractions

Strand

Topic

NI.IOT.8.a Explore career pathways related to IoT to

Strand	Networks and the Internet	
Торіс	Internet of Things	
		Evaluate existing technological functionalities and incorporate them into new designs.
		 Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Strand	Data and Analysis	
Торіс	Data Collecti	on and Storage
DA.DCS.8.a Interpret digital d collection tools to manage information effectively.		Expectations for Learning LEARNING PROGRESSION In previous grades, students worked with data tools and differentiated the appropriate uses of the tools. By the end of 8th grade, students are consistently able to choose and use an appropriate data tool for any given set of data. In future grades, students will be able to understand the benefits of different data collection tools and pick the appropriate one to use for a problem.
		 Choose data collection tools for various activities. KEY SKILL/PROCEDURES Justify the choice of data collection tool when given a data set.
		Content Elaborations
		CLARIFICATIONS Students need to be able to choose the correct data collection tool given certain parameters. Students can experience the collection of data either individually or collaboratively with at least two types of data sets (e.g., an opinion survey, age survey or height survey).
		CONTENT FOCUS Students can identify types of data that are more difficult to collect than others. For example, emotions must be subjectively evaluated on an individual basis and are thus difficult to measure across a population. Access to tools may be limited by factors including cost, training, and availability. (K-12 Computer Science Framework, 2016)
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.
		Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Ana	alysis
Торіс	Data Collecti	on and Storage
DA.DCS.8.b Ide systems to defin stored and acce	tify data storage how data is sed.	Expectations for Learning LEARNING PROGRESSION In previous grades, students learned to identify different file types, including video and image. By the end of grade 8, students can choose and use an appropriate data tool for any given set of data. Students should be able to explain and utilize different types of file formats. Students understand that files are stored in a root directory on the hard drive or a network server (in the cloud) with folders and subfolders and be able to appropriately share files. In future grades, students will use data analysis tools.
		 IMPORTANT CONCEPTS Data collection tools can be used to find accurate data to be analyzed. Data analysis tools are used to interpret and investigate the data. There are different ways to represent data in a computer system that have varying costs and benefits.
		 KEY SKILL/PROCEDURES Use data analysis tools to organize data and identify trends, patterns and outliers. Select an appropriate data collection tool. Explain how data is stored on different computer systems.
		Content Elaborations
		CLARIFICATIONS Students can collect data using • spreadsheets, • qualitative surveys, • quantitative surveys and • experimental data.
		CONTENT FOCUS Students should be able to extract, sort and filter data into a data storage tool like a spreadsheet, database or XML file and use tools to find useful information from the data.

Strand	Data and Analysis	
Торіс	Data Collecti	on and Storage
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Analysis	
Торіс	Data Collecti	ion and Storage
DA.DCS.8.c Create a logical file structure to organize data in different storage systems to support individual and collaborative work.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience with organizing files in folders and subfolders. By the end of 8th grade, students understand that files are stored in a root directory on the hard drive or in the cloud with folders and subfolders and be able to appropriately share files. In future grades, students will be able to apply these concepts.
		 IMPORTANT CONCEPTS Organize data in a format that is logical to the student's needs.
		 KEY SKILL/PROCEDURES Create folders and subfolders on the hard drive or the cloud.
		Content Elaborations
		CLARIFICATIONS Students are to create a file system of at least two levels.
		CONTENT FOCUS Students should be able to recognize the structure of directories and the pathname of the file.
		COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Data and Analysis	
Торіс	Visualization	and Communication
DA.VC.8.a Evaluto construct a m or representation	uate data odel n.	Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience reading and identifying relationships between two models. By the end of 8th grade, students can take raw data and make a model from that data. Students are then able to analyze the data in their model to determine patterns. Data visualization includes visual, auditory, tactile, oral and other sensory representations. In future grades, students will create data visualization artifacts using multiple data sources to analyze and answer real-world questions.
		 IMPORTANT CONCEPTS Models are created from a collection of raw data (e.g., survey results that have not been previously organized into any type of chart or graph). Analyze a model and determine patterns from raw data.
		 KEY SKILL/PROCEDURES Create a variety of types of graphs and find patterns.
		Content Elaborations
		CLARIFICATIONS Given a set of data, students will select an appropriate type of data model, model the data, read and analyze the model and describe patterns noticed.
		CONTENT FOCUS Students will be able to make data models from different types of graphs. Data models may include line/bar/circle/pictographs, box-and-whisker plots, maps and hierarchical or relational models.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.
		Practice 5. Creating Computational Artifacts.2. Create a computational artifact for practical intent, personal expression or to address a societal issue.

Strand	Data and Ana	alysis
Торіс	Visualization	and Communication
DA.VC.8.b Crea utilizing formulas graphs to repres analyze data.	te a spreadsheet s, functions and ent and	Expectations for Learning LEARNING PROGRESSION In previous grades, students used formulas and functions (canned formulas) in a spreadsheet. By the end of 8th grade, students can use functions and formulas and/to create graphs from a spreadsheet that represents collections of data. In future grades, students will evaluate the ability of data visualization artifacts to identify key features and relations by using scientific inquiry, practice and applications.
		 IMPORTANT CONCEPTS Formulas and functions are necessary to create a visual representation of a collection of data.
		 KEY SKILL/PROCEDURES Create a representation (charts, graphs) of a collection of data to conclude.
		Content Elaborations
		CLARIFICATIONS Students will use formulas and functions in a spreadsheet with self-collected data to analyze and present results and conclusions.
		CONTENT FOCUS Students will be able to explore (research and collect) data and utilize formulas and functions to visualize results and draw conclusions.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
		 <i>Practice 5.</i> Creating Computational Artifacts. 2. Create a computational artifact for practical intent, personal expression or to address a societal issue.

Strand	Data and Analysis	
Торіс	Inference and	d Modeling
DA.IM.8.a Create and analyze models and simulations to accurately hypothesize a real-world situation.		Expectations for Learning LEARNING PROGRESSION In previous grades, students should have had experience analyzing data models (e.g., charts, graphs). By the end of 8th grade, students can provide evidence to support or refute a hypothesis (prediction) about a self-generated collection of data. In future grades, students will construct a model using collected data, create a hypothesis, test it and refine it to discover connections and trends.
		 IMPORTANT CONCEPTS Develop a hypothesis for a problem and then determine if the data collected around the problem supports the hypothesis.
		 KEY SKILL/PROCEDURES Given a problem statement, create a hypothesis (prediction), collect data (e.g., survey results), interpret data trends, compare trends to the hypothesis and analyze data trends. Compare related data sets.
		Content Elaborations
		CLARIFICATIONS Students will create a problem statement and hypothesis, collect data, organize and analyze the results using an electronic tool and identify the trends to support or disprove the hypothesis.
		CONTENT FOCUS Students will construct a problem statement and understand what type of data would be appropriate to help analyze their problem. They should then be able to complete the processes necessary to support or disclaim a hypothesis.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating about Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
ATP.A.8.a Crea pseudocode to s process and just efficient solution	te multiple solve a multi-step tify the most	Expectations for Learning LEARNING PROGRESSION In previous grades, students should have developed a basic understanding of what goes into an algorithm and know how to write pseudocode. As students create multiple solutions to a problem, they must be able to analyze various solutions and determine the most efficient. At the end of 8th grade, students should be able to identify the parts of a program's pseudocode (input, output, decisions). In future grades, students will learn how to break a problem into steps, and then in addition to just pseudocode be able to represent the algorithm using process and data flow diagrams. Students will be able to explain the steps of the problem and be able to communicate why they broke the problem down the way they did. Finally, they will be able to implement their created algorithm in an appropriate programming language and optimize it using best practices.
		 IMPORTANT CONCEPTS Understand the flow of a program. Compare different sets of pseudocode and determine the most efficient solution. Recognize and define iteration. KEY SKILL/PROCEDURES
		 Identify the inputs, outputs, processes and decisions. Use proper symbols to create flow charts to represent pseudocode.
		Content Elaborations
		CLARIFICATIONS Students should be able to write more than one pseudocode solution for the same problem (e.g., two different sets of directions between two locations). Then, they should be able to analyze each proposed solution and list the pros and cons of each. At this level, the expectation is that looping is done utilizing iteration, not recursion.
		CONTENT FOCUS Students should be able to identify the inputs, outputs, and decision steps within the algorithms they create in pseudocode. Students should be able to create a flow chart representation for each of their pseudocode solutions, using proper symbols for inputs, outputs and decisions.

Strand	Algorithmic	Thinking and Programming
Торіс	Algorithms	
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.
		 Practice 3. Recognizing and Defining Computational Problems 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
		 Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		<i>Practice 5.</i> Creating Computational Artifacts 3. Modify an existing artifact to improve or customize it.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Variables an	d Data Representation
ATP.VDR.8.a A and determine to valid solutions.	nalyze test cases the range of	Expectations for Learning LEARNING PROGRESSION In previous grades, students developed an understanding of what it means to vary (as opposed to being constant) and that this abstract value is expressed with an alphanumeric representation. By the end of 8th grade, students understand how to use variables and analyze test cases. In future grades, students will be able to understand that variables have different storage requirements and restrictions and be able to choose the correct one to use for a task. Students will also use parameters to pass variable information into methods and return values to get information out of a method. Students will also learn about the scope or when the program can access or change a variable.
		 IMPORTANT CONCEPTS Identify the top/low range of values that will successfully run a solution. Identify out of bound values. KEY SKILL/PROCEDURES Test values in and out of the range of data. Test value upper, middle and lower range of the data. Test invalid input (e.g., negative numbers, zero, etc.).
		Content Elaborations CLARIFICATIONS Students will deepen their understanding of variables, including when and how to declare and name new variables. A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. The identifier makes keeping track of the data that is stored easier, especially if the data changes. Naming conventions for identifiers, and thoughtful choices of identifiers, improve program readability. (K-12 Computer Science Framework, 2016)
		CONTENT FOCUS Students will be able to identify variables and choose appropriate test values for each variable. Students will be able to identify "good" vs. "bad" input values for variables by tracking results on an input/output chart while running test cases. Students will learn to test for cases of invalid input (e.g., values that result in division by zero, square root of a negative value, a blank variable vs. zero, etc.)

Strand	Algorithmic	Thinking and Programming
Торіс	Variables an	d Data Representation
		COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. Practice 4. Developing and Using Abstractions
		 Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
ATP.VDR.8.b U	se a data structure	Expectations for Learning
to represent a collection.		LEARNING PROGRESSION In previous grades, students created, used and traced variables. By the end of 8th grade, students can identify a collection of information that can be represented by a single identifier (data structure). In future grades, students will understand that variables have different storage requirements and restrictions and can choose the correct one to use for a task. Students will use parameters to pass variable information into methods and return values to get information out of a method. Students will understand the scope, or when the program can access or change a variable.
		 IMPORTANT CONCEPTS Create a variable that holds a collection of related values.
		 KEY SKILL/PROCEDURES Identify a list of related values that can be categorized and assigned to a variable.
		Content Elaborations
		CLARIFICATIONS Using a single variable name, students will be able to create a list of colors where each color has its defining value(s).
		CONTENT FOCUS Students will understand that one identifier can "contain" a list of information. Students will have experience with using a built-in data structure provided by the software.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand	Algorithmic ⁻	Thinking and Programming		
Торіс	Control Strue	ctures		
ATP.CS.8.a Use and apply decisions and loops in a program to solve a problem.		Expectations for Learning LEARNING PROGRESSION In previous grades, students developed an understanding of variables and how to use a simple conditional and loop (not compound or nested). By the end of 8th grade, students understand and incorporate proper processes, loops and conditionals in programs to solve problems. In future grades, students will understand that variables have different storage requirements and restrictions and can choose the correct one to use for a task. Students will use parameters to pass variable information into methods and return values to get information out of a method. Students will be introduced to the scope and how a program can access or change a variable.		
		 IMPORTANT CONCEPTS Utilize and apply the decision structures properly in an algorithm. Utilize and apply the loop structures properly in an algorithm. Utilize and apply nested structures within an algorithm. KEY SKILL/PROCEDURES 		
		 Properly use If-then, if-then-else, and if-then-else if statements. Properly use Pre-test (do-while), post-test (while) and definite loop (for, for next). 		
		Content Elaborations CLARIFICATIONS Conditional statements can have varying levels of complexity, including compound and nested conditionals. Compound conditionals combine two or more conditions in a logical relationship, and nesting conditionals within one another allow the result of one conditional to lead to another being evaluated. An example of a nested conditional structure is deciding what to do based on the weather outside. If it is sunny outside, I will further decide if I want to ride my bike or go running, but if it is not sunny outside, I will decide whether to read a book or watch TV. Different types of control structures can be combined, such as loops and conditionals. Different types of programming languages implement control structures in different ways. For example, functional programming languages implement repetition using recursive function calls instead of loops. At this level, understanding implementation in multiple languages is not essential.		

Strand	Algorithmic Thinking and Programming		
Торіс	Control Strue	ctures	
		CONTENT FOCUS Students will be able to create compound conditional statements such as the one described by first choosing the weather: if sunny then will you go running or biking, else if rainy will you read or watch TV. Then, the student should include nesting conditions and loop (e.g., Input an integer and if it is even, prints a row of "E"s; if it is odd, print a column of "O"s.)	
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations. 	
		<i>Practice 3</i> . Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.	

Strand	Algorithmic	orithmic Thinking and Programming		
Торіс	Modularity			
ATP.M.8.a Decompose problems and subproblems into parts to facilitate the design, implementation and review of complex programs.		 Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience decomposing an event, experience or problem. For example, to create a mural or draw a scene, several "parts" must be chosen first (the background, the characters placed, the action programmed). By the end of 8th grade, students can identify and utilize the procedures/modules within a set of instructions or code. Students should also be able to reuse the modules in new problem sets or coding and pull out the modules for testing. In future grades, a student will continue to apply this concept. 		
		 IMPORTANT CONCEPTS Identify smaller components of an algorithm. Identify a set of steps of an algorithm's component that produces a result. Smaller components of a program (modules) can be reused in new problem situations. Isolate procedures (modules) for testing. 		
		 KEY SKILL/PROCEDURES Group and organize steps that work together to produce a result. When provided with a result, identify the steps that were used. Reuse the identified module/procedure (organized set of steps) in a new problem situation. Identify a module and test it. 		
		Content Elaborations CLARIFICATIONS A procedure is a module (a group of instructions within a program) that performs a particular task. Procedures are invoked to repeat groups of instructions. For example, a procedure, such as one to draw a circle, involves many instructions, but all of them can be invoked with one instruction, such as drawing a circle. Procedures that are defined with parameters are generalizable to many situations and will produce different outputs based on a wide range of inputs (arguments). (K-12 Computer Science Framework, 2016)		
		CONTENT FOCUS Students will be able to organize code, hide details and increase reusability. Additionally, procedures increase efficiency and accuracy when testing and debugging.		

Strand	Algorithmic Thinking and Programming		
Торіс	Modularity		
		 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. 3. Evaluate whether it is appropriate and feasible to solve a problem computationally. Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Practice 6. Testing and Refining Computational Artifacts Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. 	

Algorithmic Thinking and Programming

Topic Program Dev	elopment
ATP.PD.8.a Write code that utilizes algorithms, variables and control structures to solve problems or as a creative expression.	Expectations for Learning LEARNING PROGRESSION In previous grades, students learned how to create a program through block-based and transitional programming. By the end of 8th grade, students can design and create their transitional languages. In future grades, students will learn how software development progresses through a life cycle.
	 IMPORTANT CONCEPTS Write code to solve a problem using a text-based programming language.
	 KEY SKILL/PROCEDURES Use text-based code that includes operations, variable definitions and control structures to solve problems.
	Content Elaborations
	CLARIFICATIONS Students will write code using a transitional (for students coming from block-based coding or no experience in any language) text-based programming language. Students will be using operators (add, subtract, multiply, divide), variable definitions, and control structures (for, while, do, if/then/else) in their code to solve a problem or create a graphic.
	CONTENT FOCUS Students should be able to define variables, implement control structures (loops, if/then/else) and use procedures containing variables.
	COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
	 Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations. Create a computational artifact for practical intent, personal expression, or to address a societal issue.

Strand

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Strand	Algorithmic T	Thinking and Programming		
Торіс	Program Deve	elopment		
ATP.PD.8.b Systematically test and refine programs using a range of test cases.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience programming in a transitional programming language. They also had some exposure to finding and correcting errors in a transitional programming language. By the end of 8th grade, students continue to use a transitional programming language and increase the complexity of the code (e.g., nesting conditionals) which will increase the complexity of debugging. Students should be able to identify errors (run-time and logical), modify and test code to make the program robust. In future grades, students will use the software development life cycle to refine their programs.		
		 IMPORTANT CONCEPTS Compile code to successfully run programming code and produce the expected result. Test a variety of solutions within the programming solution. Identify and fix errors within the program. Understand the meaning of a robust program. 		
		 KEY SKILL/PROCEDURES Use troubleshooting techniques to debug the code. Debug code. Differentiate between logical and run-time errors. Write robust code. 		
		Content Elaborations		
		CLARIFICATIONS Students need to understand that errors often occur when writing code. Introduce the concept of a robust program. Students need to understand that just because their code did not "crash" and output was produced, there still may be errors in the code, especially if the output is incorrect. Many transitional programming languages have built-in features to help students identify (troubleshoot) and correct run-time errors (debug) but finding the logical errors will take more investigation.		

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Program Dev	velopment
		CONTENT FOCUS Students will produce robust code by differentiating between run-time (when a program crashes) and logical (when the results are incorrect) errors and then, independently, correcting those errors. Students will create robust code by experiencing and differentiating between two types of errors: runtime (this happens when the program "crashes") and logical (the happens when the program is successfully executed, but the results were incorrect).
		 COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts Systematically test computational artifacts by considering all scenarios and using test cases. Identify and fix errors using a systematic process.
ATP.PD.8.c Use procedures that utilize parameters to pass values.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had some experience using procedures with parameters in either block- based or transitional programming languages. By the end of 8th grade, students are experienced using multiple procedures that have one or more parameters in a transitional language. In future grades, students will continue their investigation of procedures by passing multiple parameters and returning values.
		 IMPORTANT CONCEPTS Identify and utilize multiple procedures and their parameters needed to solve a solution in a transitional text-based programming language.
		 KEY SKILL/PROCEDURES Implement multiple procedures and use appropriate values for the parameters.
		Content Elaborations
		CLARIFICATIONS Students will implement predefined procedures with parameters in text-based programming languages. Students are not expected to write procedures with return types (methods, functions) from scratch; they are expected to be able to implement them with various data types for the parameters.
		CONTENT FOCUS Students will understand how to implement predefined procedures (methods) with proper parameter values in a text-based programming language.

Strand	Algorithmic Thinking and Programming		
Торіс	Program Development		
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.	

Strand	Artificial Inte	lligence		
Торіс	Machine Lea	arning		
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 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 data set creates different results when run through a classification model vs. a prediction model. Interpret the quality of the data set once the model has been run and explain what qualities should be present. Describe strategies for improving data sets. 		
		 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 data set based on the outcome of running their chosen model. Students will be able to train a classification model or prediction model using a tabular data set. 		
		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 data set is a collection of rows and columns.		
		CONTENT FOCUS Machine learning models have specific applications based on the desired outcome of a given data set. Classification models sort a data set into groups of similar data (e.g., grouping students by interest in specific sports) vs. prediction models which create a prediction based on previous data to take a new data set and predict where it will go or do (ex. predicting a student's lunch order based on their previous orders.)		

Strand	Artificial Intelligence	
Торіс	Machine Lear	ning
		 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.

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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/Artificial Intelligence (AI).

KEY SKILLS/PROCEDURES

- Students will be able to analyze natural vs. machine intelligence and explain the differences and commonalities between the two.
- Students will be able to identify and describe elements of intelligence in humans, animals and machines to better understand how machines learn.

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. They 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.

Strand	Artificial Intell	igence		
Торіс	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.		
Artificial Intelligence

Perception

A sy bi o c c d	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 detectors can be composed to form more complex feature detectors In high school, students will learn what Artificial Intelligence (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 data set 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.

Strand

Topic

Strand

Topic

Artificial Intelligence 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 Artificial Intelligence (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.

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.8.a Mod of solving a gra	del the process aph-search breadth-first	Expectations for Learning LEARNING PROGRESSION
search to draw	a search tree.	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 (e.g., 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 In computer science, a graph is a non-linear data structure that consists of nodes and edges, visualizes relationships between objects; it is a 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.

Strand	Artificial Intelligence	
Торіс	Representation & Reasoning	
		Career Connections
		CAREER EXPLORATION Using OhioMeansJobs K12, students take the Career Cluster Inventory and ask themselves "Am I interested in a career in Computer Science?" Students use the Dynamic Career Pathways tool to explore occupations in this industry while using the Employment Projections tool to research further and determine whether a career in Computer Science may be of interest to them.

Expectations for Learning

Artificial Intelligence

Machine Learning

Strand

Topic

AI.ML.8.a Explain the

and using a reasoning

model to identify how a

difference between training

machine learns.	machine learning system and explain how that bias impacts people.
 AI.ML.8.b Illustrate how objects in an image can be segmented and labeled to construct a training set for object recognition. AI.ML.8.c Explain how the choice of training data shapes the behavior of the classifier to identify how bias can be introduced if the training set is not properly balanced. 	 IMPORTANT CONCEPTS Describe training in machine learning. Describe using a reason model in machine learning. Compare and contrast machine learning using a training versus a reasoning model. Select the proper model (training or reasoning model) for machine learning. Construct training sets for object recognition. Balance the training set so that bias is not introduced. KEY SKILLS/PROCEDURES Students will be able to define a training model in terms of machine learning. Students will be able to define a reasoning model. Students will be able to explain the difference between training and using a reasoning model. Students will be able to label data. Students will be able to identify bias in training data.
	Content Elaborations
	CLARIFICATIONS Training is the process of providing a machine learning algorithm with data to learn from to create a machine learning model. A reasoning model, also known as machine reasoning, generates conclusions from available knowledge by using logical techniques like deduction and induction.
	Students can be given a set of images and asked to draw a bounding box around every person, dog or traffic sign in the image, and label the object appropriately. As a follow-up, students could be asked to estimate the time it would take to construct a labeled data set with several thousand examples. Machine learning requires large amounts of data to be effective. Human expertise is usually required to label the data, which could be labor-intensive.
	A classifier trained on a loan application data set where most of the rejected applicants lived in Pleasantville might decide to never make a loan to anyone who lives in Pleasantville.
	CONTENT FOCUS Students should be given a set of images and label the objects appropriately.

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

Strand	Artificial Intelligence	
Торіс	Machine Lear	ning
		Students should know the differences and specific uses of training models versus a reasoning model.
		Bias can result if the model is asked to classify inputs that don't resemble the training data or if the training data contains irrelevant correlations the classifier should not rely on
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Abstractions are formed by identifying patterns and extracting common features from specific examples to create generalizations. Using generalized solutions and parts of solutions designed for broad reuse simplifies the development process by managing complexity. By the end of Grade 12, students should be able to: Extract common features from a set of interrelated processes or complex phenomena. Evaluate existing technological functionalities and incorporate them into new designs. 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.

Strand	Artificial Inte	lligence
Торіс	Societal Impa	acts
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 Artificial Intelligence (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 is trained on a set of data that will give the desired result when run. Data sets with bias will cause the AI system to be biased, as the training data impacts how it responds to data sets given to it in the future. There are strategies for overcoming bias in data sets.
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Department

Strand	Artificial Intelligence	
Торіс	Societal Impa	ncts
AI.SI.8.b Iden in the design of intelligence sy describe how inclusive AI de algorithmic bia	tify bias potential of artificial rstems and to utilize esign to prevent as.	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 Artificial Intelligence (AI) system. Describe what strategies are used 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.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.8.a Cor technologies a the current ec	pare current nd how they affect nomy.	Expectations for Learning LEARNING PROGRESSION In previous grades, students should have become familiar with the history of computing and the ways in which we currently communicate via technology. By the end of 8th grade, students develop an understanding of the impact of computing on our country and the global economies. In the future, students will analyze new technologies to predict realistic impacts on society.
		 IMPORTANT CONCEPTS Identify how technology increases efficiency in the workforce. Identify how technology contributes to automation/job loss. Technology can result in the need for refitting the educational requirements for jobs. Technology improves communication and collaboration in the workforce. Advancements in technology contribute to new and unknown careers.
		 KEY SKILL/PROCEDURES Communicate via school technology with one's parents, class and teacher. Explain the economic impact of the advancement of computing.
		Content Elaborations CLARIFICATIONS Globalization, coupled with the automation of the production of goods, allows access to labor that is less expensive and creates jobs that can easily move across national boundaries. (K-12 Computer Science Framework, 2016)
		Students should explore the many pros and cons of this automation and globalization as it pertains to the economy and job market. Students need to learn about the additional learning needed when a worker changes jobs and the challenge of training young students for jobs that do not exist today.
		CONTENT FOCUS Students should consider a specific technology and its impact on the world. Students should discuss the economic impacts of this piece of technology on families, communities and the world.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Impacts of C	omputing
Торіс	Culture	
IC.Cu.8.b Propo guidelines/stand positively impac accessibility in t future technolog	ose potential lards/criteria to t bias and he design of jies.	Expectations for Learning LEARNING PROGRESSION In previous grades, students need to have developed an understanding that computing has become a global connection. By the end of 8th grade, students can identify technologies that have bias and accessibility issues for many areas of the world and then propose potential guidelines/modifications that would eliminate the bias and increase accessibility for all. In future grades, students will evaluate an alternative solution where a current tool does not exist due to limited resources.
		 IMPORTANT CONCEPTS Computing makes all aspects of our lives more efficient. It gives us the opportunity to communicate on a global scale. Bias and accessibility within technology include third world countries, equity, socio-economic status, and persons with disabilities.
		 KEY SKILL/PROCEDURES Explain that access is important for everyone regardless of their socioeconomic status, disability or geographic location. Research the issue of bias and accessibility of computing, identify some of the technologies with this issue and propose guidelines/modifications for improvements.
		Content Elaborations CLARIFICATIONS The educational system tries to level the computing access playing field for all students when not all students have the same opportunities or access once they leave the school setting. Helping students become aware of the world in which they live will help foster citizenship and problem solving (i.e., "thinking outside the box"). Students may experience and identify access limitations personally or observe the bias against a family member or friend. This bias may exist due to disabilities or economic status. This life experience may give them ideas for ways to improve accessibility. Students also need to identify the technology bias and accessibility issues that many people have globally. CONTENT FOCUS Students will determine technologies with bias in computing. Through research, students will identify the bias, determine the appropriate technology or adaptation and propose guidelines/modifications for improvements to positively impact bias and accessibility.

Strand	Impacts of Computing	
Торіс	Culture	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 3. Employ self- and peer advocacy to address bias in interactions, product design and development methods

Strand	nd Impacts of Computing	
Торіс	Culture	
IC.Cu.8.c Identi careers related computer science	fy and explore to the field of ce.	Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience using technology on personal and/or school devices and had several classroom conversations about computer science employment opportunities. At the end of 8th grade, students understand that there are many different people and jobs involved in creating the technology that they utilize, and this fact equates to numerous jobs in the computer science fields. In future grades, students will evaluate how new technologies and professions will solve real-world problems.
		 IMPORTANT CONCEPTS It is necessary to stay up to date on future industry needs. Computer science is more than writing code or building a piece of hardware. The ever-evolving area of computing will create jobs that do not exist today. KEY SKILL/PROCEDURES Describe several different existing careers involving computer science and understand that there will be positions in the future that have not yet been defined.
		Content Elaborations CLARIFICATIONS There are many careers under the umbrella of computer science, many of which do not involve coding and building a piece of hardware. Students should be aware of the possibilities that exist today and realize that there will be new jobs for them when they graduate that do not even exist today.
		CONTENT FOCUS The priority is that students need to understand that a computer science career is not just writing code but is an integral part of all industries and world culture.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture (Content Statement aligns to Core Practice rather than specific Practice Statements.)

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.8.d Explain how computing impacts innovation in other fields.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had experience utilizing several different mediums of technology, such as email, shared school documents, electronic grade books and research on the internet. By the end of 8th grade, students should be able to identify both the positive and negative impact that computing has had in other fields (e.g., robotics in manufacturing, virtual meetings, medical advances). In future grades, students will evaluate how new technologies and professions will solve real-world problems.
		 IMPORTANT CONCEPTS The communication, computation, and connection opportunities provided by computing technologies have provided a wave of innovation in other fields. Due to the current data processing, networking, and computational abilities of computers, we are now able to accomplish things that we had never dreamed possible. KEY SKILL/PROCEDURES Identify areas where the benefits of computing technology could be applied to other fields to make one more efficient and/or successful.
		Content Elaborations
		CLARIFICATIONS The big idea here is that computing applies to a wide variety of fields. Students should be given the opportunity to make connections between computing technologies and how they could impact and continue to improve people's lives.
		CONTENT FOCUS Students should have the ability to identify current computing innovations and explore the relationship of how those innovations both positively and negatively affect various careers and other fields of study. Students should study how computing can relate to a variety of careers and explain the advantages and disadvantages of current technologies.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.

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Expectations for Learning
LEARNING PROGRESSION In previous grades, students had continual conversations with teachers about the proper use of electronic devices whenever there was a lesson that involved the use of a computing device. By the end of 8th grade, students evaluate the pros and cons of face-to-face interactions versus electronic interactions (e.g., emails, phones, social media). In future grades, students will have a continual conversation on interpersonal use of devices and this conversation will not be contained to this single strand.
 IMPORTANT CONCEPTS Identify positive and negative impacts of devices and computing on the health and well-being of businesses, economics, politics and cultural interactions. Explain the advantages and disadvantages when comparing electronic meetings with face-to-face meetings. Provide examples of beneficial and harmful effects on persons through social media, phones and other devices.

KEY SKILL/PROCEDURES Differentiate between the harmful and beneficial effects of computing and devices globally and locally •

- on economics, businesses, politics and cultural differences.
- Describe ways in which the internet globally impacts business, politics and economics.
- Communicate the pros and cons of personal interaction with email, phones and social media. ٠
- Describe the advantages and disadvantages of electronic collaboration for interpersonal use.

Content Elaborations

CLARIFICATIONS

Computing and devices have a significant impact on connecting with other people, sharing information and expressing ideas. Students should discuss and investigate the pros and cons of electronic communication (i.e., email, phone, social media) versus face-to-face meetings. This is not only something that can be discussed at an interpersonal level but also on the business side where companies must weigh the expense of travel for meetings against the impersonal electronic meetings. The interpersonal effects may be a good transition to an anti-bullying lesson/unit.

Impacts of Computing

Social Interactions Topic

IC.SI.8.a Evaluate the impacts of electronic communication on personal relationships to be able to evaluate differences between face-to-face and electronic communication.

Strand

Strand	Impacts of Computing		
Торіс	Social Intera	Social Interactions	
		CONTENT FOCUS Students should be able to evaluate how the use of computing devices can contribute or be a detriment to the economics, businesses, politics and cultural differences at the global and local levels.	
		Students also should be able to determine how social media and technological devices can contribute to or have consequences in their daily lives.	
		Students should be able to distinguish the benefits and ramifications of face-to-face meetings and electronic meetings.	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 	
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. 	

Impacts of Computing

Topic Safety, Law and Ethics

IC.SLE.8.a Explain user privacy concerns related to the collection and generation of data that may not be evident through automated processes.

IC.SLE.8.b Describe the social and economic implications of privacy in the context of safety, law or ethics to be global digital citizens.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students should have had experience with devices at school and had lessons/teacher conversations about information sharing. By the end of 8th grade, students understand and can explain the difference between public and personal information, the necessity of not sharing personal information and the implications of misinformation. In future grades, students should be able to apply these concepts and continually investigate security concerns and legal rights.

IMPORTANT CONCEPTS

- Identify what is personal information (e.g., address, phone number, birth date, social security number, financial information).
- Be familiar with some of the "attacks" made by third parties trying to misuse the private information
- Identify the consequences of providing misinformation.
- Review cases where auto-generated information-gathering programs put the public users at risk and misused their data.

KEY SKILL/PROCEDURES

- Differentiate between personal and public information and make decisions about which items can be safely shared within social media.
- Recognize third-party attempts of retrieving personal information (e.g., emails, phishing).
- Communicate the contents of one's digital footprint.
- Recognize unsafe auto-generated data collection tools.
- Communicate the implications of providing false or misinformation with devices.

Content Elaborations

CLARIFICATIONS

Social engineering is based on tricking people into breaking security procedures and can be thwarted by being aware of various kinds of attacks, such as emails with false information and phishing. Security attacks often start with personal information that is publicly available online. All users should be aware of the personal information, especially financial information, that is stored on the websites they use. Protecting personal online information requires authentication measures that can often make it harder for authorized users to access information. (K-12 Computer Science Framework, 2016)

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		CONTENT FOCUS Students will be able to identify and understand what information is personal (e.g., address, phone number, birth date, social security number, financial information) vs. public. It is vital that students understand what information should be kept private and secure to protect themselves. Teachers need to reinforce that those decisions made regarding their personal information will become a "digital footprint" and be at risk for "attacks" made by third parties trying to misuse private information. Students will also be able to understand how the release or sharing of personal information publicly can harm their livelihood or others. Additionally, students will learn of the long-term impact social media and auto-generated data collection tools will have on their lives because they gather and store personal information.
		COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture
		(Content Statement aligns to Core Practice rather than specific Practice Statements.)
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.8.c Identify ethical and legal security measures used to protect electronic information.		Expectations for Learning LEARNING PROGRESSION In previous grades, students explored and identified some of the positive and negative effects technological communication has had in the business world, including the entertainment business. By the end of 8th grade, students can identify ways in which computing has made the demand for increased security and information protection necessary in the business world. In future grades, students will investigate security concerns, such as data breaches, privacy policies and intellectual property laws.
		 IMPORTANT CONCEPTS Be able to identify the moral and basic legal issues facing business, such as the storage of patient information by hospitals, universities and medical offices.
		 KEY SKILL/PROCEDURES Explain that businesses must protect patient/client privacy and confidential information. Explain that businesses must assure the security of patient/client information.
		Content Elaborations
		CLARIFICATIONS Confidential information is at risk more today than ever. Students need to have a basic understanding that they should give out their personal information to only those businesses approved by their parents. They should understand that businesses are under moral and ethical obligations to keep their sensitive data secure.
		CONTENT FOCUS Students should focus on issues that have occurred dealing with data breaches exposing personal information and the responsibilities businesses must protect data.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's perspectives when designing and developing computational products.

Strand	Impacts of C	omputing
Торіс	Safety, Law a	and Ethics
IC.SLE.8.d Provide appropriate credit when using resources or artifacts that are not our own.		Expectations for Learning LEARNING PROGRESSION In previous grades, students had some experience creating original work that may include code, text, video or graphics and had discussions on citing/providing credit to any sources that are copied/inserted into their work. By the end of 8th grade, students should continue providing credit for all sources. In future grades, students should continue providing credit for all sources.
		 IMPORTANT CONCEPTS Plagiarism/cheating is when you represent someone else's work as your own. In creating a computational artifact, students can create their original work, including video, music, text, images, graphs and program code. When using external work to integrate into a computational artifact, one must acknowledge, attribute and/or cite sources and include a bibliography with their submission. External work that should be acknowledged includes video, music, text, images, graphs and programmed code that are used in the creation of computational artifacts.
		 KEY SKILL/PROCEDURES Provide proper credit for items inserted into their work; the credit may be MLA, APA citations or some other accepted format. Provide credit to not only textbooks, scientific reports and websites but also appropriate persons in a collaboration effort.
		Content Elaborations
		CLARIFICATIONS Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media on the internet, such as video, photos and music, creates the opportunity for unauthorized use, such as online piracy, and disregard of copyrights, such as lack of attribution. (CSTA K-12 Computer Science Standards, 2017)
		Students need to learn the importance of providing proper credit for all the sources, not only the electronic sources but also those persons with whom they have worked.

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		CONTENT FOCUS Students will be able to give appropriate credit for items, such as information, videos and pictures, that they use in their work.
		COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

Grades 9-12

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Strand	Computing Systems	
Торіс	Devices	
CS.D.9-12.F.a Identify different multifunctional computing devices and connection technologies, both virtual and physical, to describe their purpose. CS.D.9-12.F.b Develop and apply criteria to evaluate computing systems for a given purpose and existing limitations		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will be able to identify improvements to possibly make a computing device for better interaction with users.
		In the 9-12 Foundational Level: Students will extract technological information about computing systems and their limitations to determine effective solutions for given situations.
CS.D.9-12.F.c Create an artifact to demonstrate the roles and interactions of computing systems		In the 9-12 Advanced Level: Students will extract technological information about computing systems to determine and integrate the best practices for complex situations.
embedded in everyday objects. CS.D.9-12.F.d Evaluate alternative computing architectures for emerging technologies including cluster and guantum computing.		 IMPORTANT CONCEPTS Different devices interact with each other. Everyday devices have computers in them Criteria can be used to evaluate computing systems. There are multiple methods to evaluate computing systems. Computing systems can consist of both virtual and physical components.
· ·	-	 KEY SKILL/PROCEDURES Communicate/explain how different devices interact to determine the proper device for usage. Identify the different devices and their purpose to evaluate the proper device for usage. Create criteria to effectively evaluate a computing system. Apply a method of evaluation to verify functionality.

Strand	Computing S	Systems
Торіс	Devices	
		Content Elaborations CLARIFICATIONS Examples of simple devices could be: • a garage door opened, • a toaster and • a microwave.
		 Examples of complex devices could be: tablet on a refrigerator, an alarm system and a multi-functional printer.
		 Examples of virtual devices could be: a cloud server, a remote server, a software driver emulating hardware and a virtual hard drive.
		 Examples of connecting technologies could be: wired networks and components, routers and switches, wireless network technologies and Bluetooth.
		CONTENT FOCUS Understand that everyday devices have computers
		Understand how different devices communicate with each other
		Understand the difference between virtual and physical
		COMPUTER SCIENCE PRACTICES <i>Practice 4</i> . Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena

Strand	Computing Systems	
Торіс	Hardware an	d Software
CS.HS.9-12.F.a Compare and contrast interactions between application software, system software and hardware.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will make decisions on the use of hardware and software combinations to effectively complete a task.
		In the 9-12 Foundational Level: Students dictate the appropriate software to install onto specific hardware to work as specified.
		In the 9-12 Advanced Level: Students will construct a working system based on hardware and software criteria.
		 IMPORTANT CONCEPTS Hardware must have software to function. Software consists of operating systems, firmware and applications.
		 KEY SKILL/PROCEDURES Evaluate the purpose of operating systems, firmware and applications to enable the hardware to operate as designed.
		Content Elaborations
		 CLARIFICATIONS Operating systems are software that controls the computer basic functions. Examples of operating system types are: server (web, e-mail, file, application, print), desktop/client, mobile, loT and simple/complex (garage door opener/multi-function printer).
		Firmware controls specific hardware (graphics card).
		Applications provide a service for the end-user.
		CONTENT FOCUS Focus on understanding what operating systems are and how they work.

Strand	Computing Systems	
Торіс	Hardware an	d Software
		 COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 3. Solicit and incorporate feedback from and provide constructive feedback to, team members and other stakeholders. 4. Evaluate and select technological tools that can be used to collaborate on a project.

Strand	Computing S	Systems
Торіс	Troubleshoo	oting
CS.T.9-12.F.a Apply a systemic process to identify problems and take steps to correct them within an integrated computing system. CS.T.9-12.F.b Analyze an IT		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will be able to identify a problem, make a list of possible solutions to a problem, determine the best solution and also communicate with others to help them solve the problem.
repairs are need build it.	ed or how to	In the 9-12 Foundational Level: Students will understand the troubleshooting process to evaluate a predetermined situation.
		In the 9-12 Advanced Level: Students will use the troubleshooting process to resolve a real-world problem.
		 IMPORTANT CONCEPTS Systematic processes can be used to solve problems. Not all computer parts are compatible.
		 KEY SKILL/PROCEDURES Apply an existing systematic process to correct problems. Identify common problems with devices. Explain the compatibility of different components.
		 Content Elaborations CLARIFICATIONS The troubleshooting process includes the following: Identify a problem/gather information. Theorize possible solutions. Test possible solutions. If no solutions result, return to step 2. Implement the solution. Do a full system test, the user tests system. Create documentation. CONTENT FOCUS Focus on using systematic processes to solve problems. Understand how to analyze computer parts to identify problems.

Strand	Computing Systems	
Торіс	Troubleshooting	
		 COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems Identify complex, interdisciplinary, real-world problems that can be solved computationally. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. Evaluate whether it is appropriate and feasible to solve a problem computationally. Practice 6. Testing and Refining Computational Artifacts Systematically test computational artifacts by considering all scenarios and using test cases. Identify and fix errors using a systematic process. Practice 7. Communicating About Computing Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Networks and	d the Internet
Торіс	Networking	
 NI.N.9-12.F.a Evaluate and select networking devices to establish scalable communications. NI.N.9-12.F.b Evaluate and select networking protocols for classical, clustered and quantum computing to establish network 		Expectations for Learning LEARNING PROGRESSION By the and of grade 8:
		Students will be able to develop a model representing networking hardware to understand the flow of information. Students will be able to generally identify a wide range of protocols and how they are utilized to transfer data across the internet. Students will understand that information that is lost via transmission will be retransmitted.
communication. NI.N.9-12.F.c Understand scalability and reliability of networks to describe the relationships and effects of how the different types of networks work together.		In the 9-12 Foundational Level: Students will be able to gather information to be able to create simple LANs and WANs with the understanding of how devices connect.
		In the 9-12 Advanced Level: Students will be able to develop and connect a working network model from given criteria.
		 IMPORTANT CONCEPTS Network devices have connectivity. Protocols are used for network communications. Network topologies have limitations. Different network topologies can be interconnected. Devices have both a physical and logical address.
		 KEY SKILL/PROCEDURES Demonstrate how to connect to a network device. Identify the tools to trace data through a network. Explain how to trace data through a network. Compare and contrast network topologies. Compare and contrast network devices. Identify the network a device is connected to. Define the common network protocols.

Strand	Networks and the Internet	
Торіс	Networking	
		Content Elaborations CLARIFICATIONS Examples of network devices could be: • hubs • switches • routers • firewalls • virtual servers This should include the network differences between classical, clustered and quantum computing. This should include all versions of network addressing. The scalability and reliability of networks can be evaluated by describing the relationship between routers, switches, servers, topology and addressing. CONTENT FOCUS IP addresses and how they relate to devices and the network. COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process.

Strand	Networks and the Internet	
Торіс	Cybersecurit	у
NI.C.9-12.F.a Ex employ principles NI.C.9-12.F.b Ide social and digital address possible both existing and technologies, inc	amine and s of cybersecurity. entify physical, security risks to attacks from d emergent cluding cluster	Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students understand physical measures to protect devices and software measures to protect electronic information. Students understand general practices used to identify malware infections. Students can describe how malware can affect information.
computing and c key distribution.	quantum	In the 9-12 Foundational Level: Students will be able to understand the cybersecurity impact on business and economy. Students will be able to employ principles of cybersecurity and emergent technologies including cluster computing and quantum key distribution.
		In the 9-12 Advanced Level: Students will be able to find the cybersecurity threat and provide a plan of action to remove the threat.
		 IMPORTANT CONCEPTS All endpoints must be protected. Physical security is the protection from physical actions and events that could cause loss or damage. Humans are the weakest point in cybersecurity. As emerging technologies evolve, so do the threats of cybersecurity attacks.
		 KEY SKILL/PROCEDURES Identify the goals, objectives and purposes of cybersecurity. Identify common risks, alerts and warning signs. Describe the concepts of malware attacks. Identify types of controls to eliminate malware from occurring. Demonstrate understanding of authentication, authorization and verification.
		Content Elaborations
		CLARIFICATIONS Know a response plan to understand why it is needed.
		Know the cybersecurity cycle to be able to create a response plan.
		Apply authentication, authorization and verification to be able to control network usage.
		Know common types of cybersecurity attacks to recognize and implement countermeasures.

Strand	Networks and the Internet		
Торіс	Cybersecuri	ty	
		Physical security is necessary to limit access to important hardware, making it more difficult to add malicious code to computers and network devices. Examples of physical security could include how and when to limit computer access to certain individuals, how to secure computers, and where to store backups and external hard drives.	
		Quantum Key Distribution (QKD) is a quantum cryptography protocol for the secure sharing of information. It produces a shared secure key for encryption and decryption of messages.	
		 CONTENT FOCUS Understand the cybersecurity cycle. Create Response plans (i.e., plan & prepare, identify, containment, investigation, remediation, follow-up). Understand and discuss common types of cybersecurity attacks. 	
		 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. 	
		 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, considering key features, time and resource constraints and user expectations. 	
		 Practice 6. Testing and Refining Computational Artifacts 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. 	

Networks and the Internet

Cybersecurity

NI.C.9-12.F.d Explore and utilize able to utilize various encryption techniques to protect data. examples of encryption methods, **IMPORTANT CONCEPTS** e.g., Vigenère, Bacon's cipher, • Threat actors are those parties who plan and execute threats. and Enigma. Threat vectors are ways threat actors enter a network or system. • Encryption is a concept that allows information to help protect files, networks and systems. ٠ **KEY SKILLS/PROCEDURES** Discuss threat vectors and the threat actors behind attacks. • Discuss how encryption helps to secure files, networks and systems. • **Content Elaborations CLARIFICATIONS** Threat actors could be nation-states, cyber terrorists, hacktivists or organized crime. **CONTENT FOCUS** By the end of grade 12, students should understand what data they should share and when it should be shared. They should exhibit good digital citizenry as it applies to cyber security hygiene, awareness and safe browsing. They also should know how to connect safely to online services using a Virtual Private Networking (VPN). Students also should understand that information and data can be protected using encryption methods and other processes. This includes the idea of the CIA triad, a concept that focuses on the balance between the confidentiality, integrity and availability of data under the protection of your information security program. **COMPUTER SCIENCE PRACTICES** Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.

Expectations for Learning

LEARNING PROGRESSION

In previous grades, students began to employ best practices for threat mitigation. By the end of the foundational level in grades 9-12, students will compare threat actors and threat vectors that are used. In previous grades, students should recognize different encryption methods. In future grades, students will be able to utilize various encryption techniques to protect data.

Strand

Topic

NI.C.9-12.F.c Compare and

contrast examples of various

threat actors, such as nation-

states, cyber terrorist groups,

organized crime or hacktivists.

Strand	Networks and	the Internet
Торіс	Internet of Th	ings
NI.IOT.9-12.F.a Design an IoT life cycle scenario that encompasses data gathering, transmission, reception and data analysis to demonstrate		Expectations for Learning LEARNING PROGRESSION In grade 8: Students modeled the lifecycle of information in the IoT, data gathering, transmission, reception and analysis, to recreate a real-world scenario.
how the IoT op apply these sk products that r the process.	perates and ills to design nodel	By the end of the 9-12 Foundational Level: Students can gather information to be able to design simple smart applications and an accompanying lifecycle.
NI.IOT.9-12.F.b Explore and plan career pathways related to IoT to identify careers		In the 9-12 Advanced Level: Students will be able to design and implement a working smart device and its life cycle or application for a smart device life cycle.
associated with the compute science field.	h the computer	 IMPORTANT CONCEPTS Smart devices with sensors are a part of the IoT life cycle. A smart device may receive as well as send information. Students will identify and analyze the data they gather and what they transmit across the internet, and determine what entity receives the data and what is done with the data after it is received.
		 KEY SKILLS/PROCEDURES Demonstrate understanding of smart devices. Demonstrate the life cycle of smart device implementations. Design a smart device life cycle. Implement a smart device life cycle (advanced).
		Content Elaborations
		CLARIFICATIONS Smart devices, while an essential part of an IoT life cycle, must be paired with other devices to transmit and receive data. That data must then be analyzed to provide meaning from that data.
		CONTENT FOCUS Smart device life cycles.

Strand	Networks and the Internet	
Торіс	Internet of Th	ings
		 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.
		<i>Practice 4.</i> Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.
		 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	Data and Ana	alysis
Торіс	Data Collecti	on and Storage
DA.DCS.9-12.F. patterns in a rea through hypothe use of data tools and knowledge. DA.DCS.9-12.F. storage systems	a Analyze I-world data store sis, testing and to gain insight b Investigate data to compare and	Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will consistently be able to choose and use an appropriate data tool for any given set of data. Students should be able to explain and utilize different types of file formats and explain the capacity limits of each file. Students will understand that files are stored in a root directory on the hard drive or in the cloud with folders and subfolders and be able to appropriately share files.
and accessed.	ia is stored	In the 9-12 Foundational Level: Students will use scientific practices to select data analysis tools to organize data and identify trends, patterns and outliers. Students will be able to understand the benefits of different data collection tools and pick the appropriate one to use for a problem. Students will learn how data is stored on different computer systems. In the 9-12 Advanced Level: Students will apply basic techniques for locating, collecting, manipulating and interpreting small-scale multidimensional data sets (e.g., creating and distributing user surveys, accessing real-world data sets). Students will use various data collection techniques for different types of computational problems (e.g., mobile device, Global Positioning System (GPS), user surveys, embedded system sensors, open data sets,
		 social media data sets). IMPORTANT CONCEPTS Scientific practices are used for data analysis. Data collection tools can be used to find accurate data. Data analysis tools are used to interpret and investigate the data. There are different ways to represent data in a computer system that have varying costs and benefits. Data can be stored locally or on the network. KEY SKILL/PROCEDURES Use data analysis tools to organize data and identify trends, patterns and outliers. Use scientific practices to answer questions about real-world challenges; gather, analyze and interpret data to develop models and explanations. Identify an appropriate data collection tool for a given situation. Demonstrate understanding of how data is stored on different computer systems.

Strand	Data and Analysis
Торіс	Data Collection and Storage
	Content Elaborations CLARIFICATIONS Scientific practices are a methodology that focuses on investigation, evaluation and developing explanations of the natural world. Data collection could include data found from: • spreadsheets, • qualitative surveys, • quantitative surveys, and • experimental data.
	Data analysis tools could include: filters, pivot tables, similarity matching, regression, and classifications.
	 Ways of representing data could include: ASCII, UTF, decimal, binary, and hexadecimal.
	 Ways of encoding data could include: XML, databases, spreadsheets, and flat files.
	CONTENT FOCUS Focus on extracting data into a data storage tool like a spreadsheet, database or XML file and using tools to find useful information from the data
	Focus as well on how data and data structures can be stored on different systems.
Ohio Dep of Ed	artment ducation

Strand	Data and Analysis	
Торіс	Data Collection and Storage	
		COMPUTER SCIENCE PRACTICES Practice 3. Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		<i>Practice 4.</i> Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.
		<i>Practice</i> 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.
Strand	Data and Ana	alysis
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Торіс	Visualization	and Communications
DA.VC.9-12.F.a Analyze the benefits and limitations of data visualization or multisensory artifacts and tools to communicate which is most appropriate to solve a real-world problem.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will be able to take raw data and make a model from that data. Students then will be able to analyze the data in their model to determine patterns. Students will be able to utilize functions and formulas and will be able to create graphs from a spreadsheet that represent collections of data.
		In the 9-12 Foundational Level: Students will evaluate the ability of multisensory data artifacts to identify key features and relations by using scientific practices.
		In the 9-12 Advanced Level: Students will create data visualization artifacts using multiple data sources in order to analyze and answer real-world questions.
		 IMPORTANT CONCEPTS Multisensory artifacts, such as visualizations, are used to analyze data. Different multisensory artifacts have varied benefits and limitations. Multisensory artifacts can be used to look at real-world data and suggest solutions from the data. Different data analysis tools, including virtual tools, have varied advantages and disadvantages.
		 KEY SKILL/PROCEDURES Explain data analyzation artifacts. Analyze multisensory data artifacts to interpret their information. Communicate complex information gathered from analysis.
		Content Elaborations CLARIFICATIONS A multisensory artifact could be: • data visualizations, • audio analysis, • tactile analysis, and • olfactory analysis.

Strand	Data and Analysis	
Торіс	Visualization and Communications	
		A data visualization artifact could be: • a web page, • a chart, or • a graph.
		A web page would utilize HTML and CSS to create a data visualization.
		CONTENT FOCUS Focus on creating graphs or charts to analyze a data set that is appropriate for the target audience. Present the created graphs or charts to relay the relevant information to the target audience.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 2. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		 Practice 4. Developing and Using Abstractions 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Ana	alysis
Торіс	Inference and	d Modeling
DA.IM.9-12.F.a Evaluate a mod by creating a hypothesis, testing and refining it to discover connections and trends in the data.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will be able to evaluate a model associated with a concept to extract meaning. In the 9-12 Foundational Level: Students will construct a model using collected data, and create a hypothesis, test it and refine it to discover
		connections and trends. In the 9-12 Advanced Level: Students will collect, analyze and reorganize multiple sets of data to construct a model, create a hypothesis, test it and refine it to discover connections and trends between the multiple sets of data.
		 IMPORTANT CONCEPTS Scientific practices should be used to analyze data in a model. Data can be both valid and invalid. There are many different types of data models that can be utilized. There is a proper notation to use in a simple model.
		 KEY SKILL/PROCEDURES Create a simple model from given data. Evaluate data for validity. Demonstrate an understanding of fundamental data design techniques. Identify common model notations. Evaluate the appropriateness of common data model types.
		Content Elaborations
		CLARIFICATIONS Below, are steps to model data: Identify entity types. Identify attributes. Apply naming conventions. Identify relationships. Assign keys.

Strand	Data and Analysis	
Торіс	Inference an	d Modeling
		 Examples of data model types include hierarchical and relational. Analyzation is to deconstruct an argument; examine it critically to bring out essential elements. Below, are Common Model notations: Multiplicities (e.g., zero to one, one only, zero or more, one or more, specific range) Attributes (e.g., names, primary keys/unique identifier, foreign key) Associations (e.g., labels) CONTENT FOCUS The focus should be on creating a model from a set of data.
		 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, considering 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.

Strand	Algorithmic	Thinking and Programming
Торіс	Algorithms	
ATP.A.9-12.F.a appropriate prob strategies and vi create and refine real-world proble ATP.A.9-12.F.b	Define and use blem-solving isual artifacts to a solution to a em. Define and	Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students have a basic understanding of what goes into an algorithm and know how to write pseudocode. Students are able to analyze various solutions to determine the most efficient. Students are able to identify the parts of a program's pseudocode (input, output, decisions).
implement an alg decomposing pro- requirements fro statement to solv ATP.A.9-12.F.c	gorithm by oblem om a problem ve a problem. Define and	In the 9-12 Foundational Level: Students will learn how to break a problem into steps, and then, in addition to pseudocode, be able to represent the algorithm using process and data flow diagrams. Students will explain the steps of the problem and be able to communicate why they broke the problem down the way they did. Finally, they will be able to implement their created algorithm in an appropriate programming language and refine it using
explain iterative understand how apply them. ATP.A.9-12.F.d	e algorithms to v and when to d Define and ve algorithms to v and when to	best practices. In the 9-12 Advanced Level: Students will progress to learn about complex list algorithms such as sorting and searching. They will also understand and explain the concept of recursion, where a method calls itself until an exit condition is met."
explain recursive understand how apply them.		 IMPORTANT CONCEPTS Algorithms are the steps to solve a problem. There are strategies that simplify problem-solving. Problems can be broken down into smaller parts, such as inputs, outputs, decisions, loops and calculations. The flow of information through a program can be represented visually. Steps of a computer program can be represented by a diagram.
		 KEY SKILL/PROCEDURES Demonstrate how to break a problem into steps. Create a process flow diagram, data flow diagram and pseudocode for an algorithm. Explain the steps of a problem. Implement an algorithm in an appropriate programming language. Optimize an algorithm by removing redundant or repeated code and using alternative control structures. Use control structures to create an iterative algorithm. Use control structures to create a recursive algorithm.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
		Content Elaborations CLARIFICATIONS Algorithms are the steps to solve a problem.
		A complex problem is one in which the solution requires multiple (i.e., three or more) methods, objects and/or data structures.
		Problems can be broken down into smaller parts.
		The flow of information through a program can be represented visually.
		Steps of a computer program can be represented by a diagram.
		Present programming languages to students without extra functionality added by libraries, modules, etc. For example, using JavaScript without additional libraries like jQuery or React.
		 A problem-solving strategy has the following steps: Identify the problem. Analyze the problem. Identify decision criteria. Develop multiple solutions. Choose the optimal solution.
		CONTENT FOCUS The most important concept is the breaking down of problems into smaller pieces. You should also focus on at least one way of visualizing the algorithm.
		You should also focus on one programming language to implement the algorithm.
		 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.

Strand	Algorithmic Thinking and Programming	
Торіс	Algorithms	
		 Practice 5. Creating Computational Artifacts 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.
		 Practice 6. Testing and Refining Computational Artifacts 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

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Strand	Algorithmic	Thinking and Programming
Торіс	Variables and	d Data Representation
ATP.VDR.9-12.F of variables and them to create a program that sto appropriate ways	F.a Identify types data and utilize computer ores data in s.	Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will understand what it means to vary (opposed to being constant) and that this abstract value is expressed with an alphanumeric representation. Students will be able to determine the range of input values for variables. Students will be able to create, use and trace variables. Students will be able to identify a collection of information that can be represented by a single identifier.
		In the 9-12 Foundational Level: Students will understand that variables have different storage requirements and restrictions and will be able to choose the best variable type to use for a task. Students will also use parameters to pass variable information into methods and return values to get information out of a method. Students will also learn about scope, or when the program is able to access or change a variable.
		In the 9-12 Advanced Level: Student will move on to learn how data can be organized using different structures. This allows more complex pieces of information to be passed into and out of methods. Additionally, they will learn what the benefits and costs are for these advanced data structures. They will also see how these data structures can be used as templates to create multiple instances of the structure.
		 IMPORTANT CONCEPTS Variables are used to store data in programs. Different types of variables store different types of data. There are memory and performance implications for different types of variables. Variables exist within a scope that is the block of code in which they are defined. Variables can be used to pass data and return data to and from methods. When primitive variables are passed to and from methods, the data is copied from one variable into another.
		 KEY SKILL/PROCEDURES Explain the different sizes and restrictions of different data types. Use correct data types for the storage of information. Use parameters and return types to pass information into and out of methods.

Strand	Algorithmic	Thinking and Programming
Торіс	Variables an	d Data Representation
		Content Elaborations CLARIFICATIONS A constant literal is not a variable as it cannot be changed.
		Identify primitive data types (i.e., integer, Boolean, floating-point).
		Information should be stored in the smallest possible data type. It should also be stored in the correct data type (e.g., characters should be stored in a character data type).
		Programmers create variables to store data values of selected types. A meaningful identifier is assigned to each variable to access and perform operations on the value by name. Variables enable the flexibility to represent different situations, process different sets of data, and produce varying outputs.
		CONTENT FOCUS Integer data includes integer, long integer, unsigned integer, character and byte.
		Floating-point includes float and double.
		A string is not primitive as it is a collection of characters.
		Using the correct data type allows efficiency in memory management by using just enough memory storage without overflow or underflow.
		COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 1. Extract common features from a set of interrelated processes or complex phenomena.

Strand Algorith	mic Thinking and Programming
Topic Control	Structures
ATP.CS.9-12.F.a Define con structures and Boolean logic and use them to solve real-world scenarios. ATP.CS.9-12.F.b Use appro	rol Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will understand variables and how to use a simple conditional and loop. Students will understand and incorporate proper processes, loops and conditionals in programs to solve problems.
syntax to create and use a method. ATP.CS.9-12.F.c Use data scoping to isolate data.	In the 9-12 Foundational Level: Students will look at Boolean statements to test a condition. They will then use this to create if/then/else statements in code. They will also code the definition of a method and then use it to solve a problem. Students will then expand their understanding to include methods that have parameters and return values. Students will also see how control structures can be nested to form more readable complex control structures.
	In the 9-12 Advanced Level: Students will move on to learn how to put together methods, control structures and data structures to form a well-written program. They will use methods to organize the code into readable parts, data structures to organize data for easier processing, and control structures to direct the flow of the program. They will also learn to identify and remove redundant and inefficient code from a program.
	 IMPORTANT CONCEPTS An IF Statement conditionally executes a section of code based on the outcome of a Boolean statement. A Boolean statement compares one or more items using comparison and logical operators and returns true or false. Code can be executed repeatedly using loops. Methods can be used to organize and allow the reuse of code. Scope determines when and where a variable can be accessed. Variables can be used to pass data and return data through methods. Decimal data could be too precise to be used in Boolean statements and cannot be used in switch selection. KEY SKILL/PROCEDURES Write an IF statement to compare one or more items and execute code depending on whether it is true or false.
	 Apply iteration (loops) to solve a programming problem. Use logical operators in compound conditional statements.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Control Strue	ctures
		 Code the definition of a method. Call a method to solve a problem. Use parameters and return types to pass information into and out of methods. Nest same and different control structures.
		Content Elaborations
		CLARIFICATIONS Examples of control structures could be: • if-else, • switch, • loops, • method definitions, or • calling methods.
		A switch selects a section of code to execute based upon the value of a variable.
		Coding a definition of a method involves writing out the all the code necessary to use it in a program.
		Comparison operators evaluate the relation between two objects and return TRUE or FALSE.
		Logical operators evaluate the relation between multiple statements and return TRUE or FALSE.
		NOT reverses the Boolean outcome. For example, if a Boolean outcome results in TRUE, a NOT would result in comparing it to FALSE. If a Boolean outcome is FALSE, a NOT would result in comparing it to TRUE.
		Programmers consider tradeoffs related to implementation, readability and program performance when selecting and combining control structures.
		Programs use procedures to organize code, hide implementation details and make code easier to reuse. Procedures can be repurposed in new programs. Defining parameters for procedures can generalize behavior and increase reusability.

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Control Strue	ctures
		 CONTENT FOCUS Below, are key control structures that should be addressed (syntax and practice): If-else For and while loops Method declaration Calling methods Comparison and logical operators Understanding program flow (defining and calling methods) is very difficult for new learners. Spend a lot of time on simple method declarations and method calls. COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity. Practice 5. Creating Computational Artifacts Create a computational artifact for practical intent, personal expression or to address a societal issue.

Department

Strand	Algorithmic [•]	Thinking and Programming
Торіс	Modularity	
ATP.M.9-12.F.a Break down a solution into procedures using systematic analysis and design.		(See ATP.A.9-12.F.b for model curriculum information)
Equivalent to: ATP.A.9-12.F.b Define and implement an algorithm by decomposing problem requirements from a problem statement to solve a problem.		
ATP.M.9-12.F.b Create computational artifacts by systematically organizing, manipulating and/or processing data. (Oklahoma L1.AP.M.02)		
Addressed in:		
ATP.VDR.9-12. different data store store larger and data than variab	A.a Utilize prage structures to more complex les can contain.	
ATP.VDR.9-12./ appropriate data variables to use solution to a con	A.b Identify the structures or to design a nplex problem.	

Strand

Algorithmic Thinking and Programming

Topic **Program Development**

ATP.PD.9-12.F.a Investigate software development methodologies to select the appropriate one for a project to complete as a team.

ATP.PD.9-12.F.b Compare test methodologies to evaluate why each is used and to determine their benefits and costs.

ATP.PD.9-12.F.c Correctly use consistent naming conventions, version control and comments to demonstrate why these are important for future use, maintenance and reuse of code.

Expectations for Learning

LEARNING PROGRESSION

By the end of grade 8:

Students will be able to design and create their own code-based program using transitional programming languages. Students will be able to identify run-time and logical errors and modify and test code to make the program robust. Students will be experienced using pre-built procedures that have one or more parameters.

In the 9-12 Foundational Level:

Students will define different software development lifecycle methodologies, including phases, roles and workflows. Students will also see how unit, system and integration tests differ, and what they are used for. They will also see how common conventions, such as naming and commenting conventions, will improve code fixes and readability. Students will also see how source control can make finding errors easier by illustrating the changes that were made to the code.

In the 9-12 Advanced Level:

Students will then learn how to implement a solution to a problem using a software methodology from inception through support. This will require them to learn how to communicate as a team and work within their assigned role. Additionally, they will see how the practices they have learned so far make the project implementation simpler."

IMPORTANT CONCEPTS

- A software methodology is a series of phases to manage the design, development, testing and support of a software project.
- Different software methodologies have different roles and organization of team members to complete a project.
- Testing methodologies specify when and how coding is tested.
- Consistent naming conventions, version control and comments allow for easier maintenance and reuse of code.

KEY SKILL/PROCEDURES

- Define different software methodologies, including phases, roles and workflows.
- Utilize unit test, system test and integration test to validate an application.
- Utilize print statements, logging statements and debuggers to identify and correct issues.
- Define and follow a naming and commenting convention.
- Use source control to maintain versions of code.

Strand	Algorithmic [·]	Thinking and Programming
Торіс	Program Dev	velopment
		Use appropriate standard industry language when talking about project management.
		Content Elaborations
		CLARIFICATIONS Software methodologies include Waterfall, Agile, top-down, bottom-up and RAD.
		Version control software is software that maintains revisions and changes to code. Examples would include GIT, TFS and SVN.
		People design meaningful solutions for others by defining problems, criteria and constraints, carefully considering the diverse needs and wants of the community and testing whether criteria and constraints were met.
		CONTENT FOCUS Key software methodologies are the Waterfall Model and the Agile Development Model. The steps in both differences in approach should be discussed in this phase.
		GIT is the most common version control structure used by colleges and students should know how to use it to save, see and merge changes to files.
		 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, considering key features, time and resource constraints and user expectations.
		 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process.

Strand	Artificial Intelligence	
Торіс	Machine Learr	ning
AI.ML.9-12.F.a I llustrate what happens during each of the steps required when using machine learning to construct a classifier or predictor.		Expectations for Learning
		LEARNING PROGRESSION By the end of grade 8: Students explain the difference between training and using a reasoning model to identify how a machine learns.
		In the 9-12 Foundational Level: Students will illustrate what happens during each of the steps required when using machine learning to construct a classifier or predictor.
		In the 9-12 Advanced Level: Students will evaluate a data set used to train a real Artificial Intelligence (AI) system by considering the size of the data set, the way that the data were acquired and labeled, the storage required and the estimated time to produce the data set. Artificial Intelligence (AI), is the science and engineering of making intelligent machines and computer programs.
		 IMPORTANT CONCEPTS Decide on a problem to solve. Discover where to obtain the training data. Choose a feature set. Discover how to label the data. Run the learning algorithm. Use cross-validation set to decide when training should stop. Use a test set to measure performance.
		 KEY SKILLS/PROCEDURES Outline the steps of machine learning and elaborate on what is happening. How the machine learns the information. How the information is being stored. How the machine changes or modifies its existing algorithm.

Strand	Artificial Intelligence	
Торіс	Machine Learr	ning
		Content Elaborations
		CLARIFICATIONS The cross-validation set is used to avoid overfitting. The test set consists of examples that were not used during training or for cross-validation, so it provides an unbiased prediction of the reasoner's performance on new inputs.
		 CONTENT FOCUS The origins of the data set. How the data is being used. How the machine will make decisions or modify the existing algorithm as it learns more information.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.
AI.ML.9-12.F.k	Use either a	Expectations for Learning
supervised or unsupervised learning algorithm to train a model on real-world data, then evaluate the results.		LEARNING PROGRESSION By the end of grade 8, students will train a classification or prediction model using machine learning on a tabular data set to evaluate the quality of the data set.
		In the grades 9-12 Foundational Level, students will use either a supervised or unsupervised learning algorithm to train a model on real-world data, then evaluate the results.
		In the grades 9-12 Advanced Level, students will investigate imbalances in training data in terms of gender, age, ethnicity or other demographic variables that could result in a biased model by using a data visualization tool.
		 IMPORTANT CONCEPTS The supervised learning model is trained on a training set to produce the correct labels for labeled data. Students should evaluate the results by measuring the percent of items in a test set that are labeled correctly. The unsupervised learning model is trained to assign each input to a cluster of similar inputs. The clusters are determined by the learning algorithm because there are no labels attached to the training data. Students should evaluate the results by examining the clusters to see if they capture useful distinctions in the data set.

Strand	Artificial Intelli	igence
Торіс	Machine Learn	ning
		KEY SKILLS/PROCEDURES Supervised Learning Algorithm <i>Example:</i> Sort animal images into categories and teach a machine how to sort the images. Then, expose the machine to new images and quantify the results based on how many correct labels were applied to the new images.
		Unsupervised Learning Algorithm <i>Example:</i> Teach the machine to sort images into clusters based on useful distinctions, such as two legs, long tails, etc. Do not assign the images to distinct categories. Quantify the results by evaluating the contents of each cluster.
		Content Elaborations
		CLARIFICATIONS Supervised and unsupervised learning algorithms find patterns in data. In supervised learning, the "pattern" is the relationship between feature values and class labels. In unsupervised learning, the pattern is the way data is grouped into clusters. Real-world data sets are now widely available on the web. In earlier grade bands, students might test their trained models on a few new data points, but in this grade band, students are asked to quantitatively measure the performance of a trained model on a nontrivial test set.
		CONTENT FOCUS Using a search engine, conduct a search for "machine learning tools." Choose one that is free and compatible with the 1:1 devices used in the classroom. Model how the tool is used and have the students try to train the tool in various manners.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.
		Career Connections
		CAREER PLANNING Students research Artificial Intelligence career pathways using the Dynamic Career Pathways tool in OhioMeansJobs K-12 and identify qualifications (education, certification and experience) and career progression (entry, intermediate, advanced and expert level progression). Students examine how training data with models and discovering trends and relationships in a data set are used in these careers.

Strand	Artificial Intell	igence
Торіс	Natural Intera	ction
AI.NI.9-12.F.a Construct context- free grammar to parse simple languages and use language- processing tools to construct a chatbot. Use sentiment analysis		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will create a program, individually and collaboratively, that implements a language processing algorithm to create a functional chatbot.
tools to extra from text.	ct emotional tone	In the 9-12 Foundational Level: Students will construct context-free grammar to parse simple languages, use language processing tools to construct a chatbot and use sentiment analysis tools to extract emotional tone from text.
		In the 9-12 Advanced Level: Students will identify and debate the issues of Artificial Intelligence (AI) and consciousness.
		 IMPORTANT CONCEPTS Context-free grammars (CFGs) are a set of recursive rules used to generate patterns of strings and to describe context-free languages. CFGs can describe all regular languages and more, but they cannot describe all possible languages. Sentiment analysis (or opinion mining) is a natural language processing (NLP) technique used to determine whether data is positive, negative or neutral.
	 KEY SKILLS/PROCEDURES Describe Context-Free Grammar (CFG) and how the weighted and probabilistic extensions handle the ambiguity of natural language. Write an algorithm to create a chatbot. Incorporate a sentiment analysis tool into an algorithm to allow the machine to determine whether the data is positive, negative or neutral to generate its response. 	
		Content Elaborations
		CLARIFICATIONS Context-free grammars (CFGs) are a set of recursive rules used to generate patterns of strings and to describe context-free languages. CFGs can describe all regular languages and more, but they cannot describe all possible languages. Sentiment analysis (or opinion mining) is a natural language processing (NLP) technique used to determine whether data is positive, negative or neutral.

Strand	Artificial Intelligence	
Торіс	Natural Interac	tion
		CONTENT FOCUS Create a Chatbot that will respond to inputs based on the sentiment of inputed data. After students have gained experience testing (P6.2), debugging and revising (P6.1), they should begin to evaluate and refine their computational artifacts.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.
AI.NI.9-12.F.b	Demonstrate	Expectations for Learning
how sentence parsers handle ambiguity.		LEARNING PROGRESSION By the end of grade 8: Students will create a program, individually and collaboratively, that implements a language processing algorithm to create a functional chatbot.
		In the 9-12 Foundational Level: Students will demonstrate how sentence parsers handle ambiguity.
		 IMPORTANT CONCEPTS Parsing is an NLP task to assign syntactic structures to sentences according to grammar.
		 KEY SKILLS/PROCEDURES Differentiate between how humans and Artificial Intelligence (AI) learn language ambiguities.
		Content Elaborations
		CLARIFICATIONS This was mentioned under AI Perceptions with the differences between written and spoken language. Students should begin to evaluate and refine their computational artifacts after they have gained experience testing, debugging and revising.
		CONTENT FOCUS Machine learning can overcome language ambiguities.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand	Artificial Intell	ligence
Торіс	Natural Intera	ction
AI.NI.9-12.F.c Describe how artificial intelligence drives many software and physical systems.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students 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.
		In the 9-12 Foundational Level: Students describe how artificial intelligence drives many software and physical systems.
		 IMPORTANT CONCEPTS Artificial Intelligence (AI) is a component of smart homes, smartwatches and smartphones. KEX SKILLS/PROCEDURES
		 Brainstorm areas where AI exists in students' everyday encounters. Students will choose one area and present to the class how AI is used in that area.
		Content Elaborations
		CLARIFICATIONS Examples include digital ad delivery, self-driving cars and credit card fraud detection.
		CONTENT FOCUS Al is everywhere.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. After students have gained experience testing (P6.2), debugging and revising (P6.1), they should begin to evaluate and refine their computational artifacts.

Strand	Artificial Intelligence	
Торіс	Perception	
AI.P.9-12.F.a Explain how radar, lidar, GPS and accelerometer data are represented.		Expectations for Learning
		LEARNING PROGRESSION By the end of grade 8: Students explain how sounds and images are represented digitally in a computer to explain how sensor data is stored in a computer.
		In the 9-12 Foundational Level: Students will explain how radar, lidar, GPS and accelerometer data are represented.
		In the 9-12 Advanced Level: Students will describe some of the technical difficulties in making computer perception systems function well for diverse groups.
		 IMPORTANT CONCEPTS Radar and lidar do depth imaging; each pixel is a depth value. GPS triangulates position using satellite signals and gives a location as longitude and latitude. Accelerometers measure acceleration in three-orthogonal dimensions.
		 KEY SKILLS/PROCEDURES Define radar, lidar, GPS and accelerometers. Determine if this data is a string, numeric as integer or decimal or boolean. Choose one sensor device to research how the data is stored on the computer. Students should report findings to the whole class. Students should know how to explain the complex concepts in simple language and should add to their report based on questions from the class.
		Content Elaborations
		CLARIFICATIONS Radar and lidar measure distance as the time for a reflected signal to return to the transceiver. GPS determines position by triangulating precisely timed signals from three or more satellites. Accelerometers use orthogonally oriented strain gauges to measure acceleration in three dimensions.

Strand	Artificial Intelligence	
Торіс	Perception	
		CONTENT FOCUS Teachers should focus on deconstruction activities that help students analyze and interpret how sensors operate and how the computer stores data. The Artificial Intelligence (AI) components of the sensors will make decisions based on the information.
		COMPUTER SCIENCE PRACTICES <i>Practice 5.3</i> Modify an existing artifact to improve or customize it. At all grade levels, students should be able to examine existing artifacts to understand what they do.
AI.P.9-12.F.b	Describe the	Expectations for Learning
limitations and adva various types of computer sensors.	advantages of If ors.	LEARNING PROGRESSION By the end of grade 8: Students will 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.
		In the 9-12 Foundational Level: Students will describe the limitations and advantages of various types of computer sensors.
		In the 9-12 Advanced Level: Students will illustrate the abstraction hierarchy for speech understanding, from waveforms to sentences, showing how knowledge at each level is used to resolve ambiguities in the levels below.
		 IMPORTANT CONCEPTS Sensors are devices that measure physical phenomena such as light, sound, temperature or pressure.
		 KEY SKILLS/PROCEDURES Brainstorm types of computer sensors and the type of data they collect. Create a table, Venn diagram or another graphic organizer to illustrate the advantages and disadvantages of each type of sensor. Troubleshoot one sensor to provide a possible solution to a disadvantage.
		Content Elaborations
		CLARIFICATIONS Cameras have limited resolution, dynamic range and spectral sensitivity. Microphones have limited sensitivity and frequency response. Signals may be degraded by noise, such as a microphone in a noisy environment. Some sensors can detect things that people cannot like infrared or ultraviolet imagery or ultrasonic sounds.
Ohio of	epartment Education	

Strand	Artificial Intelligence	
Торіс	Perception	
		CONTENT FOCUS The focus is on cultural bias of programmers, ethics and limited data sets.
		COMPUTER SCIENCE PRACTICES <i>Practice 5.3</i> Modify an existing artifact to improve or customize it. At all grade levels, students should be able to examine existing artifacts to understand what they do.

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Strand Artificial Intelligence

Topic Representation & Reasoning

AI.RR.9-12.F.a Categorize realworld problems as classification, prediction, sequential decision problems, combination search, heuristic search, adversarial search, logical deduction or statistical inference.

AI.RR.9-12.F.b For each of these types of reasoning problems (classification, prediction, sequential decision-making, combinatorial search, heuristic search, adversarial search, logical deduction and statistical inference), list an algorithm that could be used to solve that problem.

Expectations for Learning

LEARNING PROGRESSION

By the end of grade 8:

Students will categorize problems like classification, prediction, combinatorial search or sequential decision problems.

In the 9-12 Foundational Level:

Students will categorize real-world problems like classification, prediction, sequential decision problems, combination search heuristic search, adversarial search, logical deduction or statistical inference.

IMPORTANT CONCEPTS

- Reasoning problems can be categorized based on:
 - Types of inputs supplied,
 - o Types of outputs to be produced, and
 - o Characteristics of the search space, if applicable.

KEY SKILLS/PROCEDURES

- Define combination search, heuristic search, adversarial search, logical deduction and statistical inference as it relates to computer science.
- Give students examples of different real-world problems to categorize.
- Students will justify their reasoning based on their knowledge of the categories.

Content Elaborations

CLARIFICATIONS

A heuristic search is needed when the state space is too large to examine all possible states. It uses a rule of thumb to limit the search by focusing on the most promising states. In an adversarial search used in a game-playing scenario, the algorithm alternates between finding the best move for the player, the best response for the opponent and which would be the worst move from the player's perspective. An adversarial search may require heuristics if the game is complex, such as chess or go.

The reasoner can apply inference rules to reach a logical deduction by starting with a set of facts to derive new facts. The logical deduction can be done using formal logic such as propositional or predicate logic, or ad hoc inference rules used with semantic networks or the IF-THEN rules found in expert systems. Statistical inference involves reasoning with probabilities.

Strand	Artificial Intel	Artificial Intelligence	
Торіс	Representatio	on & Reasoning	
		CONTENT FOCUS Reasoning problems can be categorized based on the types of inputs supplied, the types of outputs to be produced and the characteristics of the search space, if applicable.	
		COMPUTER SCIENCE PRACTICES <i>Practice 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.	
AI.RR.9-12.F.c	Describe the	Expectations for Learning	
differences between t search algorithms.	ween types of ms.	LEARNING PROGRESSION By the end of grade 8: Students will model the process of solving a graph search problem using breadth-first search to draw a search tree.	
		In the 9-12 Foundational Level: Students will describe the differences between types of search algorithms.	
		In the 9-12 Advanced Level: Students will illustrate breadth-first, depth-first and best-first search algorithms to grow a search tree.	
		 IMPORTANT CONCEPTS There are multiple algorithms for generating a search tree, each with its own advantages. 	
		 KEY SKILLS/PROCEDURES Categorize problems. Predict outcomes. Define and use the various algorithms. 	
		Content Elaborations	
		CLARIFICATIONS Some algorithms may be easier to implement in a particular programming language, work faster, require less memory to store data and be applicable in a wider variety of situations than other algorithms. Algorithms used to search and sort data are common in a variety of software applications. Encryption algorithms are used to secure data, and compression algorithms make data storage more efficient. At this level, the analysis may involve simple calculations of steps. Analysis using sophisticated mathematical notation to classify algorithm performance like Big-O notation is not expected.	

Strand	Artificial Intelligence		
Торіс	Representation & Reasoning		
		CONTENT FOCUS There are multiple algorithms for generating a search tree, each with its own advantages. Students should begin to evaluate and refine their computational artifacts after they have gained experience testing, debugging and revising.	
		COMPUTER SCIENCE PRACTICES <i>Practices 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.	

Strand	Artificial Intel	Artificial Intelligence		
Торіс	Societal Impa	cts		
AI.SI.9-12.F.a Critically explore the positive and negative impacts of an AI system.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will identify and explain how the composition of training data affects the outcome of a supervised artificial intelligence system.		
		In the 9-12 Foundational Level: Students will critically explore the positive and negative impacts of an Artificial Intelligence (AI) system.		
		In the 9-12 Advanced Level: Students will design an AI system to address social issues or explain how AI could be used to address a social issue.		
		 IMPORTANT CONCEPTS Weak AI vs strong AI. Robots replacing humans in the workforce. Overcoming the innate bias of creating AI. Ethics debates based on "just because we can, should we?" 		
		 KEY SKILLS/PROCEDURES Investigate and propose solutions to ethical and societal AI issues in a variety of settings like public safety, finance, social media marketing or government use. Discuss issues of bias and accessibility in the design of existing technologies. Using a web tool that trains a machine learning model without coding, investigate examples of bias and identify solutions. Identify and analyze examples of legal policies related to AI, including why and how they were or are being developed. Analyze real-world AI scenarios to determine the ethical and legal implications. 		

Strand	Artificial Intelligence		
Торіс	Societal Impacts		
		Content Elaborations CLARIFICATIONS Understand the positives aspects of Al including: • Less time and • Solves problems that humans cannot.	
		 Understand the negative aspects of AI including: Ethics of using biased data sets, Loss of jobs and Price of the technology. 	
		CONTENT FOCUS Students can have an ethical debate about AI. It is important to discuss the impacts that AI is having on society and develop criteria for the ethical design and deployment of AI-based systems	
		COMPUTER SCIENCE PRACTICES <i>Practices 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.	

Strand	Impacts of C	pacts of Computing		
Торіс	Culture			
IC.Cu.9-12.F.a technology to primpacts on soci IC.Cu.9-12.F.b existing and emarchitecture has other profession and negatively.	Analyze new redict realistic ety. Identify how erging computing and will impact is, both positively	Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will understand the impact of computing on our country and the global economies. Students have identified technologies that have bias and accessibility issues for many areas of the world; persons with disabilities and those of a lower social economic status. In the 9-12 Foundational Level: Students will analyze new technologies to be able to predict and recognize their impact on society, economy and culture. In the 9-12 Advanced Level: Students will be able to evaluate, analyze, adapt and make predictions about new technologies and professions to solve real-world situations. These real-world situations will include a wide variety of economic, scarcity, social and geopolitical factors. Students will focus on individual, local and global interactions to solve these higher-level real-world situations. IMPORTANT CONCEPTS • Technology can have positive and negative effects on society. • Technology can have bast and a major impact on many professions, not only computer programming jobs. • Computer shave had a major impact on many professions, not only computer programming jobs. • Computer science skills are important to many different professions. • Describe the different impacts technology can have on society. • Describe the different inpacts technology can have on society. • Computer science skills are included in computer science skills. Computer science skills are include		

Strand	Impacts of Computing		
Торіс	Culture		
		Changes that computer have brought to professions would be effects such as fewer machinists and more robotics in manufacturing.	
		CONTENT FOCUS Focus on how technology has changed society. Focus especially on the unintentional and unexpected consequences of technological innovation.	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture 1. Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computational products. 	
		 Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project. 	

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he pros and cons of face-to-face interactions versus electronic interactions nedia). I: letailed criteria to evaluate the appropriateness of different computer a given problem. Students will also begin to recognize and investigate the ted by a computer's automated processes and the resulting privacy concerns. I Level: stigate digital social interactions at the collegiate level. communication much cheaper and easier. and used to determine the best solution to a problem. nat can be used to increase communication, and each has different costs derstand when and how their information is collected and used. cormation can make it easier for your identity to be stolen.
Level: stigate di commun and use nat can b derstand ormation uld be us outer cor different

Strand	Impacts of Computing		
Торіс	Social Intera	ctions	
		Content Elaborations	
		CLARIFICATIONS Examples of computer communication tools include email, social networking sites, IM, RF and Bluetooth.	
		Personally, identifiable information is any information that can tie a piece of data back to the person who originally owned it. Examples would include SSN, last name, first name, favorite food, birth city and state, ID number and credit card information.	
		Criteria for evaluating communication tools could include reliability, access to software/hardware, cost and bandwidth requirements.	
		CONTENT FOCUS Focus on how technology has affected communication and the difficulty in using communication tools without giving up some privacy information. Do not worry too much about the mechanisms of automated collection. Focus on the impact of automated collection.	
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability. 	
		 Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project. 	
		 Practice 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution. 	

Impacts of Computing

Topic Safety, Law and Ethics

IC.SLE.9-12.F.a Interpret and analyze breaches in privacy and security to investigate the legal and ethical impact in classical and emerging technologies.

IC.SLE.9-12.F.b Analyze the concepts of usability and security to explain typical tradeoffs between them.

IC.SLE.9-12.F.c Analyze the collection and generation of data through automated processes to explain the legal concerns that are not always evident to users.

IC.SLE.9-12.F.d Explain the beneficial and harmful effects of intellectual property laws to determine the impacts on innovation.

Expectations for Learning

LEARNING PROGRESSION

By the end of grade 8:

Students understand and can explain the difference between public and personal information, the necessity of not sharing personal information and the implications of misinformation.

In the 9-12 Foundational Level:

Students will investigate security concerns, data breaches, privacy policies, intellectual property laws, the inverse relationship of usability versus security, a user's legal rights and the Creative Commons license. All these investigations will focus on both the legal and ethical impacts on our complex society.

In the 9-12 Advanced Level:

Students will further investigate the inverse relationship of usability versus security as well as all aspects of copyright law. This will also include creating, solving and implementing solutions to a variety of real-world situations.

IMPORTANT CONCEPTS

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- There are legal ramifications when individuals or groups break security or privacy laws.
- There are many practices involving privacy and security that, while technically legal, are not ethical.
- It is difficult to increase security in a system without decreasing usability.
- It is difficult to increase usability in a system without decreasing security.
- Automated collection of data can have legal implications depending on how it is done.
- Users have legal rights that they often are not aware of.
- Intellectual property laws impact how data can be used and what attribution is required.
- There are multiple types of licenses that can be applied to information and processes.
- Intellectual property laws can both protect creators and stifle innovation.
- Software "Terms of Use" and privacy policies can affect your legal rights.
- Existing law and legislation may not be current due to emerging technologies' rapid advancement.
- Challenges identified with classical technologies can guide how we prepare for future technologies.

KEY SKILL/PROCEDURES

- Describe what constitutes a breach of security or a breach of privacy.
- Analyze security and privacy breaches.
- Summarize the legal and ethical impact of security breaches.

Strand	Impacts of Computing		
Торіс	Safety, Law and Ethics		
		 Explain the difference between law and ethics. Analyze the tradeoffs between security and usability. Describe the legal protections people have under current laws. Compare how different companies use automatic processes of data collection. Define intellectual property. Explain the beneficial and harmful effects of intellectual property laws. Describe the different types of licenses that exist to protect content creators. Explain what a Creative Commons license is and how it is used. 	
		Content Elaborations	
		CLARIFICATIONS Analyzing security and privacy breaches could include looking at how they happened and why. Additionally, you could examine what the company could have done to minimize or avoid the breach.	
		Students should understand software "Terms of Use" and privacy policies.	
		Your legal rights include the rights to your personal data and your intellectual property rights.	
		CONTENT FOCUS Focus on tradeoffs, both security versus usability and free software versus commercial software. You do not need to go deeply into legal understanding. A basic understanding should be sufficient to discuss the impact of the laws.	
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution. 	

ADVANCED LEVEL

Strand	Computing Systems		
Торіс	Devices		
CS.D.9-12.A.a E function of variou formulate a huma interaction solution CS.D.9-12.A.b In	valuate the us devices to an on. htegrate	Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will be able to extract technological information about computing systems to determine the best practice for situations.	
multifunctional ca to solve a proble CS.D.9-12.A.c lo functionality of va of hardware com communication b and use that info system virtually o specific task.	omputing devices em. dentify the arious categories ponents and the between them, ormation to build a or physically for a	In the 9-12 Advanced Level: Students will extract technological information about computing systems to determine and integrate the best practices for complex situations.	
		Beyond High School: Students will gain a deeper understanding of how all devices interact in computing systems at the collegiate level.	
		 IMPORTANT CONCEPTS Devices are used to solve problems. Different devices interact with multiple devices. Different devices can be connected into a computing system. There are multiple methods to evaluate a computing system. 	
		 KEY SKILL/PROCEDURES Differentiate between a simple and complex device to understand how each is used both independently and as a resource in a system. Utilize multifunctional computing devices to solve a problem. Build a computing system to solve a need. 	
		Content Elaborations	
		CLARIFICATIONS Examples of simple devices could be: • a garage door opener, • a toaster and • a microwave.	
Strand	Computing Systems		
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Торіс	Devices		
		 Examples of complex devices could be: a tablet on a refrigerator, alarm system and multi-functional printer. CONTENT FOCUS Understand how multiple devices communicate with each other. Utilize multiple devices to solve a problem 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. 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes. 	

Strand	Computing Systems	
Торіс	Hardware/So	ftware
CS.HS.9-12.A.a of operating sys they will be used	Categorize types tems and how d.	Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students can dictate the appropriate software to install onto specific hardware to work as specified.
		In the 9-12 Advanced Level: Students will construct a working system based on hardware and software criteria.
		Beyond High School: Students will continue to further explore and evaluate the interactions and relationships between systems software and hardware at the collegiate level.
		 IMPORTANT CONCEPTS Different operating systems are used for different purposes.
		 KEY SKILL/PROCEDURES Describe the hardware requirements and the purpose of the hardware to determine which operating system will be used for installation.
		Content Elaborations
		CLARIFICATIONS Operating systems are software that controls the computer basic functions. Examples of operating system types are: server (web, e-mail, file, application, print), desktop/client, mobile and loT simple/complex (garage door opener/multi-function printer).
		CONTENT FOCUS Focus on constructing a system for a given purpose to enhance its performance, reliability, usability and accessibility.

Strand	Computing Systems	
Торіс	Hardware/Software	
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations. Create a computational artifact for practical intent, personal expression, or to address a societal issue. Modify an existing artifact to improve or customize it. Practice 6. Testing and Refining Computational Artifacts Evaluate and refine a computational artifact multiple times

Strand (Computing S	Systems
Topic	Troubleshoo	ting
CS.T.9-12.A.a Evaluate and revise a systematic process to identify the source of a problem and the steps to correct it within individual and connected devices.		Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will understand the troubleshooting process to evaluate a predetermined situation. In the 9-12 Advanced Level: Students will use the troubleshooting process to resolve a real-world problem.
		Beyond High School: Students will continue to identify and compare more complex problems in computing systems at the collegiate level.
		 IMPORTANT CONCEPTS Some processes are better suited to troubleshoot a given problem. Processes can be fine-tuned to create a better solution.
		 KEY SKILL/PROCEDURES Evaluate a systematic process for suitability to a problem. Modify a systematic troubleshooting process.
		Content Elaborations
		 CLARIFICATIONS The troubleshooting process includes the following: Identify a problem/Gather information, Iheorize possible solutions, Test possible solutions. If no solutions result, return to step 2, Implement the solution, Do a full system test, Do a user test and Create documentation.
		CONTENT FOCUS Focus on identifying the most effective systematic process to solve a problem.

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Strand	Computing Systems		
Торіс	Troubleshoo	Troubleshooting	
		 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. 	
		 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process. 	
		 Practice 7. Communicating About Computing 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. 	

Strand	Networks and	d the Internet
Торіс	Networking	
NI.N.9-12.A.a C networking devia for a real-world s establish commu- distant devices. NI.N.9-12.A.b D to a real-world s networking proto network commu- NI.N.9-12.A.c In and reliability of describe the rela effects of how th of networks wor	onstruct a ces map solution scenario to unication between evelop a solution cenario using ocols to establish nication. nprove scalability networks to ationships and he different types k together.	 Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students are able to gather information to be able to create simple LANs and WANs with the understanding of how devices connect. In the 9-12 Advanced Level: Students will be able to develop and connect a working network model from given criteria. Beyond High School: Students should be able to fully understand how devices communicate and connect beyond the local LAN. IMPORTANT CONCEPTS Network architecture is both logical and physical subnetting. Protocols are used for network communications. KEY SKILL/PROCEDURES Choose the appropriate network protocol to use for specific communication situations. Expand a LAN to a WAN. Content Elaborations
		Know IPV4 and IPV6 addressing. Know variable-length subnetting and CIDR notation
		Know basic networking protocols.
		Distance communication can be a remote connection/VPN connection.
		 CONTENT FOCUS IPV4 and IPV6 addressing Variable length subnetting and CIDR notation Basic networking protocols

Strand	Networks an	d the Internet
Торіс	Networking	
		COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		 Practice 4. Developing and Using Abstractions 2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. 3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
		<i>Practice 5</i> . Creating Computational Artifacts 3. Modify an existing artifact to improve or customize it.

Strand	Networks and the Internet	
Торіс	Cybersecurit	ty
NI.C.9-12.A.a Id cybersecurity eth NI.C.9-12.A.b In devised solution security threat.	entify nics and law. nplement a to counter a	Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students can understand the cybersecurity impact has on business and the economy. In the 9-12 Advanced Level: Students will be able to find the cybersecurity threat and provide a plan of action to remove the threat. Beyond High School: Students will be able to intern at a company and be able to help identify and mitigate cybersecurity threats in real-time. IMPORTANT CONCEPTS • There is a difference between ethical and unethical uses of cybersecurity threat. • A plan of action should include multiple ways to secure a network and counter an attack. KEY SKILL/PROCEDURES • Remove malware threats. • Implement authentication, authorization and verification. • Implement a plan of action to remove a cybersecurity threat. Content Elaborations CLARIFICATIONS Know what virus protection software does and how it works. Understand a signature to be able to maintain integrity. Know how to detect where threats are located and how to remove these safely (i.e., safe mode.) Know how social threats are used to alter reliability (e.g., changing of data.) CONTENT FOCUS Understanding virus protection. Focus on ethics and laws regarding cybersecurit

Strand	Networks an	d the Internet
Торіс	Cybersecurit	ε γ
		 Implementing a solution to address threats. COMPUTER SCIENCE PRACTICES Practice 2. Collaborating Around Computing Cultivate working relationships with individuals possessing diverse perspectives, skills and personalities. Evaluate and select technological tools that can be used to collaborate on a project. Practice 3. Recognizing and Defining Computational Problems Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
NI.C.9-12.A.c Compare and contrast various threat actors, such as nation-states, cyber terrorist groups, organized crime or hacktivists. NI.C.9-12.A.d Explore and utilize examples of encryption methods (e.g., Vigenére, Bacon's cipher and Enigma).		 Expectations for Learning LEARNING PROGRESSION In the Foundational Level 9-12, students researched types of threat actors. In the Advanced Level 9-12, students should focus on a deeper level of understanding of how and why various threat actors break the law, what individuals and groups hope to gain or change by their actions and the mitigation of physical security attacks, such as social engineering, security policies and malicious actors. IMPORTANT CONCEPTS Compare encryption methods with a focus on real-world examples. Compare types of threat actors and their objectives. Use safe browsers and cyber practices to protect personal information. Explore and discuss real-world scenarios including social engineering and other cyber threat vectors. KEY SKILLS/PROCEDURES Discuss threat vectors and the threat actors behind attacks. Discuss the interrelationship between the CIA (confidentiality, integrity and availability) triad; a concept that focuses on the balance between the confidentiality, integrity and availability of data under the protection of information security programs.

Strand	Networks and the Internet	
Торіс	Cybersecurit	ty
		 Content Elaborations CLARIFICATIONS Cybersecurity assessment examples may include full- or limited-scope penetration tests, hardware analysis and source code audits. Undesired outcomes include a false sense of security that may result from improperly conducted assessments. CONTENT FOCUS Researching malware includes understanding the different classes of malware (e.g., potentially unwanted programs, ransomware, rootkits, trojans, viruses, worms) and the reasoning for its application by an adversary. Mitigations may include configuring file permissions, configuring host- network-based firewalls and using encryption technology for network communications. Mitigation strategies include reducing the potential vulnerabilities caused by social engineering of humans, which is an attack vector present in all systems, including hardware, software and networks. COMPUTER SCIENCE Practice 3. Recognizing and Defining Computational Problems I. Identify complex, interdisciplinary, real-world problems that can be solved computationally. Practice 6. Testing and Refining Computational Artifacts. Systematically test computational artifacts by considering all scenarios and using test cases.

Strand	Networks and	the Internet
Торіс	Internet of Thi	ings
NI.IOT.9-12.A.a Design and implement an IoT life cycle scenario that encompasses data gathering, transmission, reception and data analysis to		Expectations for Learning LEARNING PROGRESSION In grade 8: Students modeled the lifecycle of information in the IoT: data gathering, transmission, reception and analysis to recreate a real-world scenario.
demonstrate h operates and to design proc the process.	now the IoT apply these skills lucts that model	By the end of the 9-12 Foundational Level: Students are able to gather information to be able to design simple smart applications and an accompanying life cycle.
		In the 9-12 Advanced Level: Students will be able to design and implement a working smart device and its life cycle or application for a smart device life cycle. Beyond high school, students should be able to fully understand how smart devices communicating with each other create an IoT.
		 IMPORTANT CONCEPTS The IoT life cycle consists of smart devices. A smart device may receive as well as send information. Students will identify and analyze the data they gather and what they transmit across the Internet, as well as what entity receives the data and what is done with the data after it is received.
		 KEY SKILLS/PROCEDURES Demonstrate understanding of smart devices. Demonstrate the life cycle of smart device implementations. Design a smart device life cycle. Implement a smart device life cycle (advanced).
		Content Elaborations CLARIFICATIONS Smart devices, while an essential part of an IoT life cycle, must be paired with other devices to transmit and receive data. That data must then be analyzed to provide meaning from that data.
		CONTENT FOCUS Smart device life cycles.

Strand	Networks and the Internet	
Торіс	nternet of Things	
	 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. 	
	 Practice 4. Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs. 	
	 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. 	
	 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process. 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. 	
	Career Connections	
	CAREER PLANNING Have students work with professionals such as those within the district's Business Advisory Council to identify mentorship/job shadowing opportunities where they can explore how IoT relates to the world of work and how the IoT life cycle scenario is applied. Consider how this type of opportunity may lead to an internship or other work-based learning opportunity for students.	

Strand	Data and An	Data and Analysis	
Topic Data Collection and Storage		ion and Storage	
 DA.DCS.9-12.A.a Create multidimensional data collections that can be utilized through various methods to solve complex data problems. DA.DCS.9-12.A.b Investigate data storage and collection tools to analyze tradeoffs and limitations. 		Expectations for Learning LEARNING PROGRESSION In the 9-12 Foundational Level: Students will use data analysis tools and scientific practices to organize data and identify trends, patterns and outliers. Students will be able to understand the benefits of different data collection tools and pick the appropriate one to use for a problem. Students will learn how data is stored on different computer systems.	
		By the end of the 9-12 Advanced Level: Students will apply basic techniques for collecting, manipulating and interpreting small-scale multidimensional data sets (e.g., collecting and organizing user surveys, accessing real-world data sets). Students will use various data collection techniques for different types of computational problems (e.g., mobile device Global Positioning System (GPS), user surveys, embedded system sensors, open data sets, social media data sets).	
		Beyond High School: Students will apply techniques for collecting, manipulating and interpreting large-scale multidimensional data sets (e.g., collecting and organizing user surveys, accessing real-world data sets).	
		 IMPORTANT CONCEPTS A multidimensional collection is a collection of multiple sets of the same data. Multidimensional collections can vary in performance depending on the data. 	
		 KEY SKILL/PROCEDURES Utilize various methods of data collection. Manipulate and interpret small-scale multidimensional data sets. Identify the best data collection tool for a given situation. 	
		Content Elaborations CLARIFICATIONS When collecting data, be sure to address the tradeoffs and limitations of data storage.	
		 Below, are examples of multidimensional collections: A library contains data about books. A window has many panes. A video game has many NPCs who have the same attributes, but different values in those attributes. 	

Strand	Data and An	alysis
Торіс	Data Collection and Storage	
		 Data analysis tools could include: Spreadsheets, Charts, Graphs and SQL. CONTENT FOCUS Focus on how to collect, organize and manipulate data to solve real-world problems. COMPUTER SCIENCE PRACTICES <i>Practice 7.</i> Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim.

Strand	Data and Ana	alysis
Торіс	Visualization	and Communications
DA.VC.9-12.A.a Create visualization or multisensory artifacts to communicate insights and knowledge gained from complex data analysis that		Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will be able to evaluate the ability of data visualization artifacts to identify key features and relations by using scientific practices.
		In the 9-12 Advanced Level: Given a real-world relatable problem, students will perform complex data analysis to create a data visualization that produces an optimal solution.
		Beyond High School: Students will further their understanding of advanced visualization techniques. They will also look at advanced data analysis tools.
		 IMPORTANT CONCEPTS Data analysis is used to find patterns and trends. Different inputs and actions can affect behaviors. Real-world questions can be restated and interpreted as data questions. Based on the data analysis, changes can be made to improve a solution or process.
		 KEY SKILL/PROCEDURES Accurately complete complex data analysis. Create multisensory artifacts from data sets. Translate real-world questions into data analysis questions. Communicate the solutions found in the data set.
		Content Elaborations
		CLARIFICATIONS Complex data analysis could include: • relational database queries, • data regression, • spreadsheets, • inferences and • predictions.

Strand	Data and Ana	alysis
Торіс	Visualization	and Communications
		Data questions include testable hypotheses based on the data. For example, "If the price of eggs goes up, do people buy fewer eggs?"
		CONTENT FOCUS Focus on how to translate real-world questions into data questions that can be answered by data analysis. Have students create and present the visualizations based on their analysis.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems 1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
		 Practice 5. Creating Computational Artifacts 2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.
		 Practice 7. Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim. 2. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.

Strand	Data and Ana	alysis
Торіс	Inference and	d Modeling
DA.IM.9-12.A.a Create a model that simulates a complex system and uses extracted data to hypothesize, test and refine the model to discover connections or trends		Expectations for Learning LEARNING PROGRESSION In the 9-12 Foundational Level: Students will construct a model using collected data, and create a hypothesis, test it and refine it to discover connections and trends.
		In the 9-12 Advanced Level: Students will collect, analyze and reorganize multiple sets of data in order to construct a model, and create a hypothesis, test it and refine it to discover connections and trends between the multiple sets of data.
		Beyond High School: Student will collect, analyze and reorganize multiple sets of data to construct a real-world model to find patterns and be able to do prediction analysis.
		 IMPORTANT CONCEPTS Data models can have different applications. Data models can be constructed from multiple data sources.
		 KEY SKILL/PROCEDURES Demonstrate an understanding of when and when not to create a data model. Explain and correctly use advanced common model notations. Create a data model from multiple data sources.
		Content Elaborations
		CLARIFICATIONS Apply data model patterns
		Normalize to reduce data redundancy
		De-normalize to improve performance
		An example of multiple sets of data would be a high school course registration where the following exists: a schedule, prerequisites, seat maximum/minimum, teacher/course availability and early registration for more senior students.

Strand	Data and Analysis	
Торіс	Inference and Modeling	
	Below are common model notations. Associations Entity roles Subtyping Aggregation Composition OR constraint Exclusive OR (XOR) constraint	
	CONTENT FOCUS Use advanced common model notations when creating a data model from multiple sources.	
	 COMPUTER SCIENCE PRACTICES Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases. 2. Identify and fix errors using a systematic process. 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. 	
	<i>Practice</i> 7. Communicating About Computing 3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.	

Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Algorithms	
ATP.A.9-12.A.a Define and explain recursive algorithms to understand how and when to apply them. ATP.A.9-12.A.b Use iteration to effectively solve problems. ATP A 9-12 A c Use recursion to		Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students can break a problem into steps, and then, in addition to pseudocode, represent the algorithm using process and data flow diagrams. Students can explain the steps of the problem and be able to communicate why they broke the problem down the way they did. Finally, they can implement their created algorithm in an appropriate programming language and refine it using best practices.
 ATP.A.9-12.A.d Define and explain sorting and searching algorithms to understand how and when to apply them. ATP.A.9-12.A.d Use sorting and searching to analyze and organize data. ATP.A.9-12.A.f Compare and contrast classical, cluster and quantum computing algorithms. 		In the 9-12 Advanced Level: Students will use complex list algorithms such as sorting and searching. They will also understand, explain and use the concept of recursion, where a method calls itself until an exit condition is met. Students will further explain the need for cluster computing algorithms, where the need for improved performance and availability over a single computer exists. Students will explain the need for quantum computing algorithms and cryptography: where the existence of hidden problem structures can exploit in ways that classical computers cannot.
		 Beyond High School: Students will look at how to describe the efficiency of algorithms to better compare them. Additionally, they will learn how advanced algorithms are crafted for tasks such as artificial intelligence and pathing. IMPORTANT CONCEPTS A recursive method must simplify a problem and have an exit condition. Sorting and searching analyzes and organizes the data. Different sorting and searching algorithms work more efficiently with different sets of data.
		 KEY SKILL/PROCEDURES Describe how recursive algorithms can be more or less effective than iterative algorithms. Demonstrate how to rewrite simple algorithms from iterative to recursive. Explain Recursive Sorting algorithms. Explain Simple Sorting algorithms. Explain simple and binary searches.

Strand	Algorithmic [·]	Thinking and Programming
Торіс	Algorithms	
		Content Elaborations CLARIFICATIONS Use visualization to show the various searches, the efficiency of access times and completion times
		Demonstrate the construction and logic behind a decimal to binary recursive function.
		A simple sort does not utilize recursion.
		CONTENT FOCUS Focus on using already optimized algorithms for determining which should be used. Recursion should be understood and utilized, not necessarily created from scratch.
		 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. 4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
		 Practice 5. Creating Computational Artifacts 2. Create a computational artifact for practical intent, personal expression or to address a societal issue.
		 Practice 6. Testing and Refining Computational Artifacts 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.
		Career Connections
		 CAREER PLANNING Students research Quantum Computing Career Pathways using the Dynamic Career Pathways tool in OhioMeansJobs K-12. Students research the salaries and qualifications for Quantum Computing Careers. Students also practice mock interviewing for Quantum Computing Careers using questions such as: How is a qubit measured? What is a quantum logic gate? What is the difference between classical computing and quantum computing?
		List some of the engineering challenges a quantum computer engineer might face.

Strand	Algorithmic Thinking and Programming	
Торіс	Variables an	d Data Representation
 ATP.VDR.9-12.A.a Utilize different data storage structures to store larger and more complex data than variables can contain. ATP.VDR.9-12.A.b Identify the appropriate data structures or variables to use to design a 		Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will understand that variables have different storage requirements and restrictions and will be able to choose the correct variable type to use for a task. Students will be able to use parameters to pass variable information into methods and return values to get information out of a method. Students will understand scope or when the program is able to access or change a variable.
solution to a con	nplex problem.	In the 9-12 Advanced Level: Student will learn how data can be organized using different structures. Students will learn that this allows more complex pieces of information to be passed into and out of methods. Additionally, they will learn what the benefits and costs are for these advanced data structures. They will also see how these data structures can be used as templates to create multiple instances of the structure.
		Beyond High School: Students will continue to learn how to store larger and more complex pieces of data. They will also investigate connecting to larger data stores like databases and how to store information from a database in a local data structure.
		 IMPORTANT CONCEPTS Data structures can be used to represent multiple variables as one item. Advanced data types are more appropriate for certain problems. Multiple similar pieces of data can be stored in a structure called an array. Variables and data structures can be passed into a method by reference or by value.
		 KEY SKILL/PROCEDURES Code the definition of a data structure and implement multiple instances. Use a data structure to pass information into or out of a method. Describe the benefits and costs of advanced data structures. Demonstrate how data structures can be passed to and from methods and objects. Organize like data into an array.

Strand	Algorithmic Thinking and Programming	
Торіс	Variables and	d Data Representation
		Content Elaborations CLARIFICATIONS Data structures could include classes, json objects, stucts, records and xml.
		Coding a definition of a data structure involves writing out all the code necessary to use it in a program.
		An example of implementation would be objects created from a data structure.
		Data structures are used to manage program complexity. Programmers choose data structures based on functionality, storage and performance tradeoffs.
		Passing a variable by reference points to its original memory location, and changes in the method will be reflected in the passed variable.
		Passing a variable by value will create a temporary local variable that can be changed without changing the passed variable.
		Not all languages support choose to pass by value or pass by reference. In many languages, this may be automatically determined based on the data type.
		CONTENT FOCUS Strings are basically 1D arrays. A typical data table is an example of a 2D array.
		A list is like an array, but elements are ordered in some manner and can be added and removed, varying the size of the list.
		The language being studied may dictate the data structures being used.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions Extract common features from a set of interrelated processes or complex phenomena. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.

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Strand	Algorithmic ⁻	Thinking and Programming
Торіс	Control Strue	ctures
ATP.CS.9-12.A.a Write programs that use library methods and control structures and methods to solve a problem. ATP.CS.9-12.A.b Refactor a program to be smaller and more efficient.		Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will understand how to use both binary and unary Boolean statements to test a condition. They can use this to create if/then/else statements in code. They can also code the definition of a method and then use it to solve a problem. Students will understand how to create methods that have parameters and return values. Students know how control structures can be nested to form more readable complex
		In the 9-12 Advanced Level: Students will learn how to put together methods, control structures and data structures to form a well-written program. They will use methods to organize the code into readable parts, data structures to organize data for easier processing, and control structures to direct the flow of the program. They will also learn to identify and remove redundant and inefficient code from a program.
		Beyond High School: Students will expand their knowledge of methods and control structures by seeing how multiple programming languages handle them. They will also look at how programming languages turn these control structures into machine code.
		 IMPORTANT CONCEPTS Developers can use code from other sources to complete their programs. Code that appears in multiple places in a program can be put into a method for code reuse. Programs are made up of methods, control structures and data structures working together.
		 KEY SKILL/PROCEDURES Create and call multiple methods in a program. Write a program to solve a problem using methods, control structures and data structures. Identify and remove redundant and inefficient code from a program.
		Content Elaborations CLARIFICATIONS Refactoring a program involves rewriting modules to make them more efficient by simplifying algorithms, removing inefficient code and using optimal control structures.

Strand	Algorithmic Thinking and Programming	
Торіс	Control Structures	
		Complex programs are designed as systems of interacting modules, each with a specific role, coordinating for a common overall purpose. These modules can be procedures within a program; combinations of data and procedures; or independent, but interrelated, programs. Modules allow for better management of complex tasks.
		 CONTENT FOCUS Key library methods include: math-related functions (square root, sin, cos) and input and output functions such as reading and writing to and from the console and files.
		Optional 3rd party libraries include graphical user interface tools.
		 COMPUTER SCIENCE PRACTICES Practice 4. Developing and Using Abstractions 2. Evaluate existing technological functionalities and incorporate them into new designs.
		Practice 5. Creating Computational Artifacts2. Create a computational artifact for practical intent, personal expression or to address a societal issue.
		 Practice 6. Testing and Refining Computational Artifacts 3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

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Strand	Algorithmic	Thinking and Programming
Торіс	Modularity	
ATP.M.9-12.A.a Construct solutions to problems using student-created components (e.g., procedures, modules, objects).		(For ATP.M.9-12.A.a: See ATP.CS.9-12.F.b for model curriculum information) (For ATP.M.9-12.A.b: See ATP.PD.9-12.A.a for model curriculum information) (For ATP.M.9-12.A.c: See ATP.CS.9-12.A.a for model curriculum information)
Equivalent to: ATP.CS.9-12.F.b Use appropriate syntax to create and use a method.		
ATP.M.9-12.A.b Design or redesign a solution to a large- scale computational problem by identifying generalizable patterns.		
Equivalent to: ATP.PD.9-12.A.a Fully implement the most appropriate software methodology to complete a team programming project.		
ATP.M.9-12.A.c Create programming solutions by reusing existing code (e.g., libraries, Application Programming Interface (APIs), code repositories).		
Equivalent to: ATP.CS.9-12.A.a Write programs that use library functions, methods and control structures to solve a problem.		

Strand	Algorithmic	Thinking and Programming
Торіс	Program De	evelopment
ATP.PD.9-12.A.a Fully implement the most appropriate software methodology to complete a team programming project.		 Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students will be able to define different software development lifecycle methodologies, including phases, roles and workflows. Students will understand how unit, system and integration tests differ and what they are used for. They will also understand how common conventions, such as naming and commenting conventions, improve code fixes and readability. Students will also understand how source control can make finding errors easier by illustrating the changes that were made to the code.
		In the 9-12 Advanced Level: Students will learn how to implement a solution to a problem using a software methodology from inception through support. This will require them to learn how to communicate as a team and work within their assigned role. Additionally, they will see how the practices they have learned so far make the project implementation simpler.
		Beyond High School: Students will further their understanding by seeing how larger groups can operate effectively. They will see how multiple team projects can work to get complex tasks done very quickly. They will also understand some of the pitfalls and difficulties large scale projects hold, including legacy code, communication and data storage.
		 IMPORTANT CONCEPTS Software development lifecycle methodologies allow a team to work more efficiently. Software development lifecycle methodologies outline the steps for design, development, test, rollout and support for an application, and the roles of team members. Two or more programmers may be working on the same program at the same time, but on different sections. Defining coding standards and updating design documentation helps integrate the different methods each programmer is implementing.
		 KEY SKILL/PROCEDURES Solve a complex problem as a team using a single software methodology. Gather requirements from stakeholders. Collaborate with team members.

Strand	Algorithmic Thinking and Programming	
Торіс	Program De	evelopment
		Content Elaborations CLARIFICATIONS Software methodologies include Waterfall, Agile, top-down, bottom-up and RAD.
		Diverse teams can develop programs with a broad impact through careful review and by drawing on the strengths of members in different roles. Design decisions often involve tradeoffs. The development of complex programs is aided by resources such as libraries and tools to edit and manage parts of the program. Systematic analysis is critical for identifying the effects of lingering bugs.
		 Collaboration involves a shared communication medium, a common vision of the end product, regularly scheduled meetings and a clear understanding of roles.
		A stakeholder is a person with an interest or concern in the project.
		CONTENT FOCUS The focus here is to use a software methodology from beginning to end, enabling students to see the methodology in action. The students should see how specific jobs within the methodology support one another.
		 COMPUTER SCIENCE PRACTICES Practice 5. Creating Computational Artifacts Plan the development of a computational artifact using an iterative process that includes reflection on and modification of the plan, considering key features, time and resource constraints and user expectations.
		 Practice 6. Testing and Refining Computational Artifacts 1. Systematically test computational artifacts by considering all scenarios and using test cases.

Strand	Artificial Intell	ligence
Торіс	Machine Lear	ning
AI.ML.9-12.A.a Evaluate a data set used to train a real AI system by considering the size of the data set, the way that the data were acquired and labeled, the		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will illustrate how objects in an image can be segmented and labeled to construct a training set for object recognition.
storage required and the estimated time to produce the data set.	ed and the to produce	In the 9-12 Foundational Level: Students will illustrate what happens during each of the steps required when using machine learning to construct a classifier or predictor.
		In the 9-12 Advanced Level: Students evaluate a data set used to train a real Artificial Intelligence (AI) system by considering the size of the data set, the way that the data were acquired and labeled, the storage required and the estimated time to produce the data set.
		 IMPORTANT CONCEPTS A large data set is typically required to capture the diversity of a complex domain and narrow down the range of possible reasoner behaviors. There are multiple ways to construct, clean and verify a data set. There can be large costs associated with creating the data set and processing the data. Labeling training data is labor intensive and may require specialized expertise like spotting disease in x-rays. Bias can be introduced during each step of the data set creation.
		 KEY SKILLS/PROCEDURES An activity can be done with common machine learning data sets found in repositories or publicly available demographic, economic or environmental data sets.
		Content Elaborations
		CLARIFICATIONS Data sets for real-world problems may involve many features and the defining characteristics of a class may involve complex relationships among these features. To narrow down the class to be learned and distinguish it from millions of other possible classes, the learning algorithm must see many examples.

Strand	Artificial Intelligence	
Торіс	Machine Lear	ning
		 CONTENT FOCUS Uses of Big Data Analysis of data sets Bias of data sets COMPUTER SCIENCE PRACTICES Practice 3.1 Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.
AI.ML.9-12.A.t	Using a data	Expectations for Learning
visualization tool, investig imbalances in training da terms of gender, age, eth other demographic varia could result in a biased r	ol, investigate raining data in r, age, ethnicity or phic variables that	LEARNING PROGRESSION By the end of grade 8: Students will explain how the choice of training data shapes the behavior of the classifier to identify how bias can be introduced if the training set is not properly balanced.
	a biased model.	In 9-12 Foundational Level: Students will use either a supervised or unsupervised learning algorithm to train a model on real-world data, then evaluate the results.
		In the 9-12 Advanced Level: Students will investigate imbalances in training data in terms of gender, age, ethnicity or other demographic variables that could result in a biased model by using a data visualization tool.
		 IMPORTANT CONCEPTS Machine learning algorithms will take advantage of any imbalances or correlations in the training set that help lower the error rate. If the data set is not representative, correlations can be misleading.
		 KEY SKILLS/PROCEDURES Brainstorm limitations to data. Research current events that illustrate bias in Artificial Intelligence (AI) facial recognition software.
		Content Elaborations CLARIFICATIONS Data exploration to help students uncover imbalances or correlations can be done using histograms in spreadsheet software, or using any number of data visualization tools.

Strand	Artificial Intelligence	
Торіс	Machine Learning	
		CONTENT FOCUS Sources of bias in data sets Imbalances of data sets from historical data like police databases from 1900 - 2000, due to race or gender bias. For example, in the 1970s, women needed a male cosigner (father or husband) to apply for a credit card.
		COMPUTER SCIENCE PRACTICES <i>Practices 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.

Strand	Artificial Intelligence	
Торіс	Natural Intera	ction
AI.NI.9-12.A.a Identify and		Expectations for Learning
debate the issu and consciousr	ies of Ál ness.	LEARNING PROGRESSION By the end of 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.
		In the 9-12 Foundational Level: Students will construct context-free grammar to parse simple languages and use language processing tools to construct a chatbot. Use sentiment analysis tools to extract emotional tone from text.
		In the 9-12 Advanced Level: Students will identify and debate the issues of Artificial Intelligence (AI) and consciousness.
		 IMPORTANT CONCEPTS AI consciousness affects those who interact with it. Bias, as an inherent human condition, is coded into the functionality of AI. Can computers "think"?
		 KEY SKILLS/PROCEDURES Identify examples of issues related to bias, perception, privacy and accuracy in artificial intelligence.
		Content Elaborations
		CLARIFICATIONS Published in 1950, Alan Turing's paper "Computing Machinery and Intelligence" started the debate and the Strong AI Hypothesis. Edsger Dijkstra, in a 1984 paper, compared the question of whether machines can think with questions, such as "can submarines swim?" or "can airplanes fly?". Most will agree that airplanes can, in fact, fly but submarines can't swim.
		 CONTENT FOCUS Define the word "thinking." Research how computers think. Research how reliable computer decisions are.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.

Strand	Artificial Intell	igence
Торіс	Perception	
AI.P.9-12.A.a Describe some of the technical difficulties in making computer perception systems function well for diverse groups.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will 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.
		In grades 9-12 Foundational Level: Describe the limitations and advantages of various types of computer sensors.
		In the 9-12 Advanced Level: Students will describe some of the technical difficulties in making computer perception systems function well for diverse groups.
		 IMPORTANT CONCEPTS Facial Recognition software is only reliable for white males. Digital cameras are limited in their ability to create contrast on darker objects, limiting their ability to distinguish features.
		 KEY SKILLS/PROCEDURES Discuss bias created by programmers' limitations of data sets. Explore technological articles on why corporations are moving away from facial recognition software. Debate the ethics of whether or not historical data should be used in locating high-crime areas to increase police presence.
		Content Elaborations
		CLARIFICATIONS Dark or low contrast facial features are harder to recognize than bright, high contrast features. Children's speech is in a higher register and less clearly articulated than adult speech.
		CONTENT FOCUS The focus is on the cultural bias of programmers, ethics and limited data sets.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 5.3 Modify an existing artifact to improve or customize it. At all grade levels, students should be able to examine existing artifacts to understand what they do.

Strand	Artificial Intelli	igence
Торіс	Perception	
AI.P.9-12.A.b Illustrate the abstraction hierarchy for speech understanding, from waveforms to sentences, showing how knowledge at each level is used to resolve ambiguities in the levels below.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will 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. In the 9-12 Advanced Level: Students will illustrate the abstraction hierarchy for speech understanding, from waveforms to sentences, showing how knowledge at each level is used to resolve ambiguities in the levels below.
		IMPORTANT CONCEPTS The spoken language hierarchy is: • waveforms • articulatory gesture • sounds • morphemes • words • phrases • sentences
		 KEY SKILLS/PROCEDURES Demonstrate how an intelligent agent can misunderstand spoken words if you change the tone or pitch of your voice. Explain how written punctuation placement determines the meaning of a statement. Example: "Let's eat, grandma." vs "let's eat grandma." Discuss how spoken language take this into account.
		Content Elaborations
		CLARIFICATIONS To go from noisy, ambiguous signals to meaning requires recognizing structure and applying domain knowledge at multiple levels of abstraction. A classic example: The sentences "How to recognize speech" and "How to wreck a nice beach" are virtually identical at the waveform level.

Strand	Artificial Intell	igence
Торіс	Perception	
		CONTENT FOCUS How do chatbots determine responses to oral language vs. written language? Students are familiar with their smart devices such as phones and watches. They can change tone and accent while asking these devices various questions.
		COMPUTER SCIENCE PRACTICES <i>Practice 3.</i> Recognizing and Defining Computational Problems The ability to recognize appropriate and worthwhile opportunities to apply computation is a skill that develops over time and is central to computing. Solving a problem with a computational approach requires defining the problem, breaking it down into parts and evaluating each part to determine whether a computational solution is appropriate.
		 By the end of Grade 12, students should be able to: Identify complex, interdisciplinary, real-world problems that can be solved computationally. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures. Evaluate whether it is appropriate and feasible to solve a problem computationally.

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.9-12.A.a Write code to create an algorithmic search.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will model the process of solving a graph search problem using breadth-first search to draw a
		search tree. In grades 9-12 Foundational Level: Students will list an algorithm that could be used to solve a problem for each of these types of reasoning problems: classification, prediction, sequential decision making, combinatorial search, heuristic search, adversarial search, logical deduction and statistical inference.
		In the 9-12 Advanced Level: Students will write code to create an algorithmic search.
		 IMPORTANT CONCEPTS There are multiple algorithms for generating a search tree, each with its own advantages.
		 KEY SKILLS/PROCEDURES Categorizing problems. Predicting outcomes. Defining and using the various algorithms.
		Content Elaborations
		CLARIFICATIONS Some algorithms may be easier to implement in a particular programming language, work faster, require less memory to store data and be applicable in a wider variety of situations than other algorithms. Algorithms used to search and sort data are common in a variety of software applications. Encryption algorithms are used to secure data, and compression algorithms make data storage more efficient. At this level, the analysis may involve simple calculations of steps. Analysis using sophisticated mathematical notation to classify algorithm performance, like Big-O notation, is not expected.
		CONTENT FOCUS The focus of this content is on using code to create an algorithmic search.
		COMPUTER SCIENCE PRACTICES <i>Practice</i> 6.3 Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.

Strand	Artificial Intelligence	
Торіс	Representatio	on & Reasoning
AI.RR.9-12.A.b Illustrate breadth- first, depth-first and best-first search algorithms to grow a search tree.		Expectations for Learning
		LEARNING PROGRESSION By the end of grade 8: Students will model the process of solving a graph search problem using breadth-first search to draw a search tree.
		In grades 9-12 Foundational Level: Students will categorize real-world problems like classification, prediction, sequential decision problems, combination search heuristic search, adversarial search, logical deduction or statistical inference.
		In the 9-12 Advanced Level: Students will illustrate breadth-first, depth-first and best-first search algorithms to grow a search tree.
		 IMPORTANT CONCEPTS Breadth-first search finds shallow solutions quickly if they exist, but requires lots of memory. Depth-first search is better than breadth-first for cases where the number of nodes at each level grows exponentially because it uses less memory. A Binary Tree follows one simple rule that each parent node has no more than two child nodes, whereas, a Binary Search Tree is a variant of the binary tree that follows a relative order to how the nodes should be organized in a tree.
		 KEY SKILLS/PROCEDURES Illustrate breadth-first, depth-first and best-first search algorithms to grow a search tree for tic-tac-toe. Illustration is done by drawing the tree. Writing code is appropriate for advanced students (AP CSA/CSP).
		Content Elaborations
		CLARIFICATIONS There are multiple algorithms for generating a search tree, each with its own advantages.
		CONTENT FOCUS Students should begin to evaluate and refine their computational artifacts after they have gained experience testing, debugging and revising.
		COMPUTER SCIENCE PRACTICES <i>Practice 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility.
Strand	Artificial Intell	ligence
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Торіс	Societal Impa	cts
AI.SI.9-12.A.a Design an Al system to address social issues or explain how Al could be used to address a social issue.		Expectations for Learning LEARNING PROGRESSION By the end of grade 8: Students will understand tradeoffs in the design of Artificial Intelligence (AI) systems and how decisions can have unintended consequences in the function of a system.
		In grades 9-12 Foundational Level: Students will critically explore the positive and negative impacts of an AI system.
		In the 9-12 Advanced Level: Students will design an AI system to address social issues or explain how AI could be used to address a social issue.
		 IMPORTANT CONCEPTS What Can AI Do? Find trends, patterns and associations Discover inefficiencies Execute plans Learn and become better Predict future outcomes based on historical trends Inform fact-based decisions
		 KEY SKILLS/PROCEDURES Identify and research projects from organizations focusing on social issues and design potential solutions to the problems identified. Create an algorithm that will solve a social issue identified in student research.
		Content Elaborations
		CLARIFICATIONS Technology has helped societies all over the world to battle the most pressing issues and solve social problems. By promising faster technological advancement, artificial intelligence (AI) promises to provide answers to questions relating to the environment, security and society that we are all exploring today.

Strand	Artificial Intelligence		
Торіс	Societal Impacts		
	 CONTENT FOCUS Research how to solve societal issues. Students can explore fact-checking AI. Consider how computers make our work easier or harder. 		
	COMPUTER SCIENCE PRACTICES <i>Practice 6.3</i> Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability and accessibility. After students have gained experience testing (P6.2), debugging and revising (P6.1), they should begin to evaluate and refine their computational artifacts.		

	Strand Artificial Intelligence		
	Торіс	Representatio	on & Reasoning
	AI.RR.9-12.F.b For each of these		Expectations for Learning
types of reasoning problems (classification, prediction, sequential decision making, combinatorial search, heurist		ing problems prediction, sion making, earch, heuristic	LEARNING PROGRESSION By the end of grade 8: Students will model the process of solving a graph search problem using breadth-first search to draw a search tree.
	search, adversarial search, logical deduction and statistical inference) list an algorithm		In grade 9-12 Foundational Level: Students will list an algorithm that could be used to solve a problem.
	that could be use that problem.	ed to solve	In grade 9-12 Advanced Level: Students will illustrate breadth-first, depth-first and best-first search algorithms to grow a search tree.
			 IMPORTANT CONCEPTS Artificial Intelligence (AI) includes a wide variety of reasoning algorithms for solving different types of reasoning problems. Some algorithms use symbolic representations like search trees. Others are numerical in nature, such as neural nets operating on feature vectors.
			 KEY SKILLS/PROCEDURES Categorizing problems Predicting outcomes Defining and using the various algorithms
			Content Elaborations
			CLARIFICATIONS Different algorithms can be used to tie shoes or decide which path to take on the way home from school. While the end results may be similar, they may not be the same. In the example of going home, some paths could be faster, slower or more direct depending on varying factors, like time or obstacles. Algorithms can be expressed in noncomputer languages, including natural language, flowcharts and pseudocode.
			CONTENT FOCUS Al includes a wide variety of reasoning algorithms for solving different types of reasoning programs. Some use symbolic representations while others are numerical in nature.
			COMPUTER SCIENCE PRACTICES <i>Practice 3.1</i> Identify complex, interdisciplinary, real-world problems that can be solved computationally. At any level, students should be able to identify problems that have been solved computationally.

Strand	Impacts of Computing	
Торіс	Culture	
IC.Cu.9-12.A.a I alternative soluti current tool does limited resources IC.Cu.9-12.A.b	Evaluate an on where a s not exist due to s. Analyze the global stribution of urces in terms of nd influence. Design a study of pacts of classical	Expectations for Learning LEARNING PROGRESSION By the end of the 9-12 Foundational Level: Students practiced analyzing new technologies and professions, using appropriate criteria to be able to predict and recognize the true measurable impact on each part of our complex society.
impact of the dis computing resol equity, access a IC.Cu.9-12.A.c I the potential imp		In the 9-12 Advanced Level: Students will be able to evaluate, analyze, adapt and make predictions about new technologies and professions to solve real-world situations. These real-world situations will include a wide variety of economic, scarcity, social and geopolitical factors. Students will focus on individual, local and global interactions to solve these higher-level real-world situations.
computers, clustered computing and quantum computing in different fields. IC.Cu.9-12.A.d Evaluate and explore how research and commercial entities are using clustered and quantum computing as alternative solutions due to the limitations of classical computers.		Beyond High School: Students will continue to investigate the impacts of technology and computing resources on all aspects of our society and culture at the collegiate level.
		 IMPORTANT CONCEPTS Technology is not equally used or available around the world. There are often free and different alternatives to modern computing tools. It is important to account for scarcity when evaluating tools to solve a problem. Economic, social and geopolitical factors have influenced the computer's impact on the world. Computers have had a dramatic impact on our culture. Identify how emerging computer technologies are impacting how we imagine the future in both current research and cultural society.
		 KEY SKILL/PROCEDURES Evaluate a current computing tool's appropriateness for a specific problem. Compare and contrast computing tools based on appropriateness and scarcity. Describe some of the difficulties in distributing computing resources around the world. Explain how economic, social and geopolitical factors influence computing. Identify ways computation has revolutionized our culture. Predict how computers may impact our culture in the future.

Strand	Impacts of Computing	
Торіс	Culture	
		Content Elaborations CLARIFICATIONS Computer distribution differs by network availability, such as whether broadband is available, as well as hardware availability such as the number of households that have computers.
		An example of an alternative solution would be a person who does not have international phone service, but wants to talk with people from home, using a free phone app to make an online video call when both ends are connected to Wi-Fi.
		CONTENT FOCUS Focus on how computer distribution is different across the world, and how people then need to solve computing problems differently depending on their available resources.
		 COMPUTER SCIENCE PRACTICES Practice 1. Fostering an Inclusive Computing Culture Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computational products. Address the needs of diverse end-users during the design process to produce artifacts with broad accessibility and usability.
		 Practice 2. Collaborating Around Computing 4. Evaluate and select technological tools that can be used to collaborate on a project.
		<i>Practice 7.</i> Communicating About Computing 1. Select, organize and interpret large data sets from multiple sources to support a claim.

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Impacts of Computing

Topic Safety, Law and Ethics

IC.SLE.9-12.A.a Create a scenario to demonstrate typical tradeoffs between usability and security and recommend security measures based on these or other tradeoffs.

IC.SLE.9-12.A.b Evaluate and explore how research and commercial entities use intellectual property laws including copyright, trademarks, and patents to identify practical, business and ethical impacts.

Expectations for Learning

LEARNING PROGRESSION

By the end of the 9-12 Foundational Level:

Students investigated security concerns, data breaches, privacy policies, intellectual property laws, the inverse relationship of usability versus security, a user's legal rights and the Creative Commons license. All these investigations focused on both the legal and ethical impacts on our complex society.

In the 9-12 Advanced Level:

Students will further investigate the inverse relationship of usability versus security as well as all aspects of intellectual property laws. This will also include creating, solving and implementing solutions to a variety of real-world situations.

Beyond High School:

Students will continue to investigate the safety, law and ethics of digital interactions and data at the collegiate level.

IMPORTANT CONCEPTS

- Security measures must account for usability concerns to be successful.
- Security requires tradeoffs, both of usability and of other concepts, such as speed, size.
- Intellectual property laws include copyright, patent and trademark.
- Intellectual property laws have significant impact in the computing world.
- Intellectual property laws have ethical and legal implications for businesses, people and society.

KEY SKILL/PROCEDURES

- Create a realistic scenario that requires computer security.
- Explain what security tradeoffs are and how they work.
- Defend the tradeoffs of security and other concepts the student use.
- Define copyright and explain how it is protected.
- Explain what "free," "open-source" and "commercial" software types are and the differences between them.
- Argue the positive and negative impacts of copyrights.
- Describe how to research for existing intellectual property holdings.
- Evaluate and explore Terms of Use and Privacy Policies.

Strand	Impacts of Computing	
Торіс	Safety, Law and Ethics	
		Content Elaborations CLARIFICATIONS Any time personally identifiable information is being shared on a computer there should be security involved, so any scenario that the students create that includes this would be acceptable. CONTENT FOCUS Focus on using the understanding of security and usability tradeoffs to solve a problem.
		 COMPUTER SCIENCE PRACTICES Practice 7. Communicating About Computing Select, organize and interpret large data sets from multiple sources to support a claim. Describe, justify and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.

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