Arizona Computer Science Standards

October 2018 DRAFT

Arizona Department of Education

High Academic Standards for Students

Contents

Vision Statement

Arizona's K-12 students will develop a foundation of computer science knowledge and learn new approaches to problem solving and critical thinking. Students will become innovative, collaborative creators and ethical, responsible users of computing technology to ensure they have the knowledge and skills to productively participate in a global society.

Introduction

Understanding problems, their potential solutions, and the technologies, techniques, and resources needed to solve them are vital for citizens of the 21st century. The State of Arizona has created computer science standards to further this understanding. These standards allow students to develop a foundation of computer science knowledge. By learning new approaches to problem solving that capture the power of computational thinking, students become users and creators of computing technology. The computer science standards will empower students to:

- Be informed citizens who can critically engage in public discussion on computer science related topics
- Develop as learners, users, and creators of computer science knowledge and artifacts
- Understand the role of computing in the world around them
- Learn, perform, and express themselves critically in a variety of subjects and interests

As the foundation for all computing, computer science is "the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society" (Tucker et. al, 2006, p. 2). Computer science builds upon the concepts of computer literacy, educational technology, digital citizenship, and information technology. The previously listed concepts tend to focus more on using computer technologies as opposed to understanding why they work and how to create those technologies (K-12 Computer Science Framework, 2016). The differences and relationship with computer science are described below.

- ***Computer literacy*** refers to the general use of computers and programs, such as productivity software. Examples include performing an Internet search and creating a digital presentation.
- ***Educational 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 software rather than creating it. Information technology professionals often have a background in computer science.

Focus On Equity

Computer Science education has a history of significant access challenges, especially for early elementary students, students with disabilities, and women & minority students [csta-https://c.ymcdn.com/sites/www.csteachers.org/resource/resmgr/CSTAPolicyBrochure.pdf]. These Computer Science standards are intended to close the access gap for underserved populations and provide a foundation in computer science to *all* Arizona students.

All students and teachers have the opportunity to engage in rigorous, robust computer science standards. Each standard provides additional guidance and examples for implementation. Many standards include guidance and examples for use without computing devices, allowing for flexible implementation in lesson design and delivery.

The Arizona Computer Science Standards provide flexibility to allow students to demonstrate proficiency in multiple ways, thus providing a rigorous opportunity for engagement in computer science.

Acknowledgements

Numerous existing sets of standards and standards-related documents have been used in developing the Arizona Computer Science Standards. These include:

- The (Interim) CSTA K-12 Computer Science Standards, revised 2016 http://www.csteachers.org/?page=CSTA_Standards
- The K-12 Computer Science Framework https://k12cs.org/
- Approved or draft standards from the following states:
    - Nevada: http://www.doe.nv.gov/uploadedFiles/nde.doe.nv.gov/content/Standards_Instructional_Support/Nevada_Academic_Standards/Comp_Tech_Standards/DRAFTNevadaK-12ComputerScienceStandards.pdf
    - Wisconsin: https://dpi.wi.gov/sites/default/files/imce/computer-science/ComputerScienceStandardsFINALADOPTED.pdf

Computer Science Essential Concepts and Subconcepts

The Arizona Computer Science Standards for grades kindergarten through twelve are organized into five Essential Concepts:

- **Computing Systems:** This involves the interaction that people have with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) that make up a computing system communicate and process information in digital form. An understanding of hardware and software is useful when troubleshooting a computing system that does not work as intended.

- **Networks and the Internet (with Cybersecurity):** This involves the networks that connect computing systems. Computing devices do not operate in isolation. Networks connect computing devices to share information and resources and are an increasingly integral part of computing. Networks and communication systems provide greater connectivity in the computing world by providing fast, secure communication and facilitating innovation. Networking and the Internet must also consider Cybersecurity. Cybersecurity, also known as information technology security, involves the protection of computers, networks, programs, and data from unauthorized or unintentional access, manipulation, or destruction. Many organizations, such as government, military, corporations, financial institutions, hospitals, and others collect, process, and store significant amounts of data on computing devices. That data is transmitted across multiple networks to other computing devices. The confidential nature of government, financial, and other types of data requires continual monitoring and protection for the sake of continued operation of vital systems and national security.

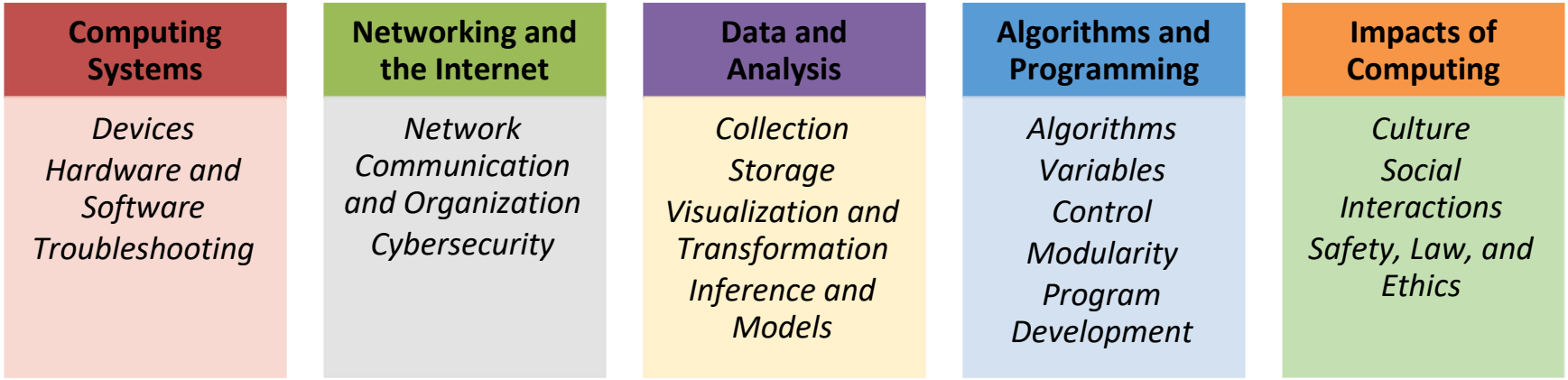
- **Data and Analysis:** This involves the data that exist and the computing systems that exist to process that data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

- **Algorithms and Programming:** Involves the use of algorithms. An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems. The development process to create meaningful and efficient programs involves choosing which information to use and how to process and store it, breaking apart large problems into smaller ones, recombining existing solutions, and analyzing different solutions.

- **Impacts of Computing:** This involves the effect that computing has on daily life. Computing affects many aspects of the world in both positive and negative ways at local, national, and global levels. Individuals and communities influence computing through their behaviors and cultural and social interactions, and in turn, computing influences new cultural practices. An informed and responsible person should understand the social implications of the digital world, including equity and access to computing.

Concepts are categories that represent major content areas in the field of computer science. They represent specific areas of disciplinary importance rather than abstract, general ideas. Each essential concept is supported by various subconcepts that represent specific ideas within each concept. Figure 1 provides a visual representation of the Essential Concepts and the supporting subconcepts.

Figure 1: Computer science essential concepts and subconcepts



Computer Science Practices for Students

The content of the Arizona Computer Science Standards is intended to support the following seven practices for students. The practices describe the behaviors and ways of thinking that computationally literate students use to fully engage in a data-rich and interconnected world.

- **Fostering an Inclusive Computing Culture:** Students will develop skills for building an inclusive and diverse computing culture, which requires strategies for incorporating perspectives from people of different genders, ethnicities, and abilities. Incorporating these perspectives involves understanding the personal, ethical, social, economic, and cultural contexts in which people operate. Considering the needs of diverse users during the design process is essential to producing inclusive computational products.

- **Collaborating Around Computing:** Students will develop skills for collaborating around computing. Collaborative computing is the process of performing a computational task by working in pairs and on teams. Collaborative computing involves asking for the contributions and feedback of others, effective collaboration can lead to better outcomes than working independently. Collaboration requires individuals to navigate and incorporate diverse perspectives, conflicting ideas, disparate skills, and distinct personalities. Students should use collaborative tools to effectively work together and to create complex artifacts.

- **Recognizing and Defining Computational Problems:** Students will develop skills for 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.

- **Developing and Using Abstractions**: Students will develop skills for developing and using abstractions. Identifying patterns and extracting common features from specific examples to create generalizations form abstractions. Using generalized solutions and parts of solutions designed for broad reuse simplifies the development process by managing complexity.

- **Creating Computational Artifacts:** Students will develop skills for creating computational artifacts. The process of developing computational artifacts embraces both creative expression and the exploration of ideas to create prototypes and solve computational problems. Students create artifacts that are personally relevant or beneficial to their community and beyond. Computational artifacts can be created by combining and modifying existing artifacts or by developing new artifacts. Examples of computational artifacts include programs, simulations, visualizations, digital animations, robotic systems, and apps.

- **Testing and Refining Computational Artifacts:** Students will develop skills for testing and refining computational artifacts. Testing and refinement is the deliberate and iterative process of improving a computational artifact. This process includes debugging (identifying and fixing errors) and comparing actual outcomes to intended outcomes. Students also respond to the changing needs and expectations of end users and improve the performance, reliability, usability, and accessibility of artifacts.

- **Communicating About Computing**: Students will develop skills for communicating about computing. Communication involves personal expression and exchanging ideas with others. In computer science, students communicate with diverse audiences about the use and effects of computation and the appropriateness of computational choices. Students write clear comments, document their work, and communicate their ideas through multiple forms of media. Clear communication includes using precise language and carefully considering possible audiences.

See **Appendix B-Computer Science Practices,** for a complete, numbered listing of the sub-practices under each practice.

Regarding the previously listed practices, computational thinking is integrated throughout each one. Computational thinking is an approach to solving problems in a way that can be implemented with a computer. It involves the use of concepts, such as *abstraction, recursion, and iteration*, to process and analyze data, and to create real and virtual artifacts (Computer Science Teachers Association & Association for Computing Machinery, 2017). Computational thinking practices such as abstraction, modeling, and decomposition connect with computer science concepts such as algorithms, automation, and data visualization. Beginning with the elementary school grades and continuing through grade 12, students should develop a foundation of computer science knowledge and learn new approaches to problem solving that captures the power of computational thinking to become both users and creators of computing technology. Figure 2 is a visual representation of the essential practices along with computational thinking.

Figure 2: Essential Practices including computational thinking

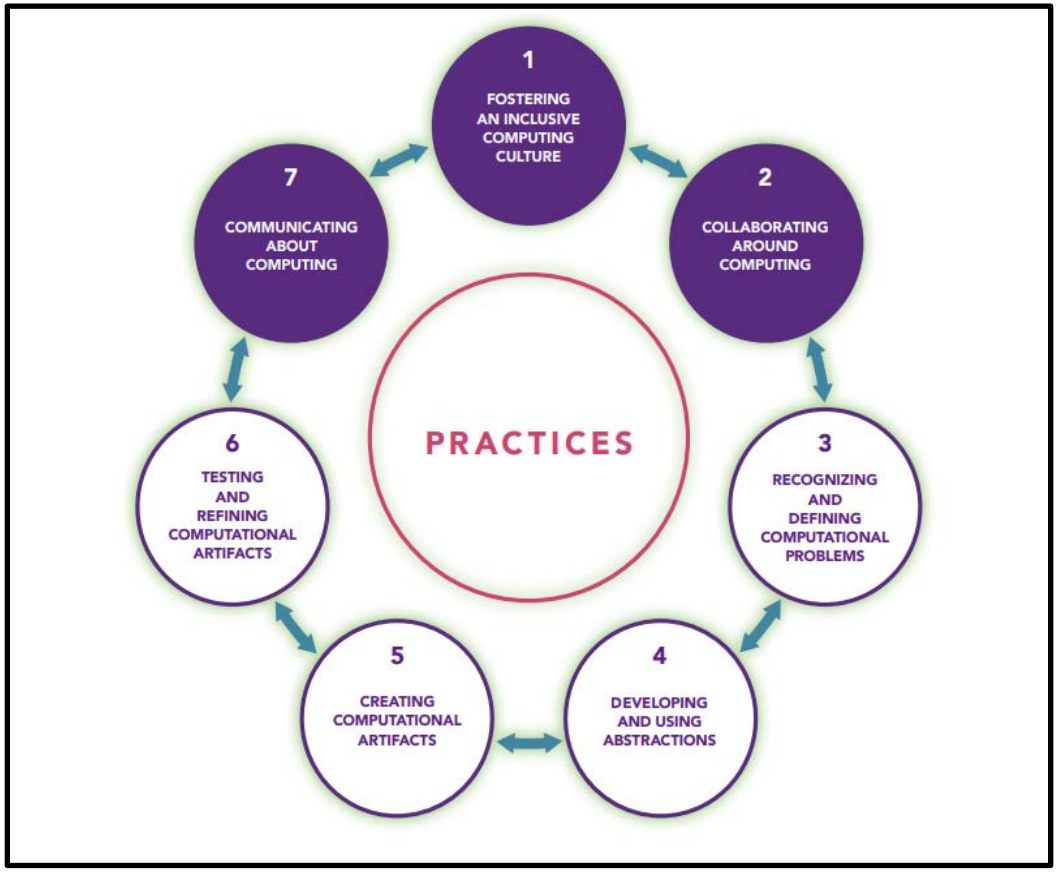
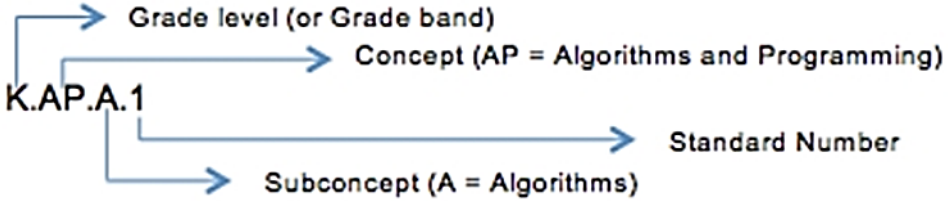


Figure 2: Practices- K-12 Computer Science Framework. (2016)

How to Read the Arizona Computer Science Standards

The Arizona Computer Science Standards are divided into Grades K, 1, 2, 3, 4, 5, 6, 7, 8, and 9-12. The standards are divided by the five main concepts. Those main concepts include computing systems, networks and the internet, data and analysis, algorithms and programming, and impacts of computing. Within each main concept there may be two to five sub concepts represented, such as algorithms, program development, variables, troubleshooting, or cybersecurity. Each standard will list the grade level, the concept, the subconcept, and the standard number. Figure 3 provides an example of the coding for a standard:

Figure 3: Standard Coding Scheme for Standards



Each standard appears like the example in Figure 4. This example shows two different subconcepts under the concept of Algorithms and Programming at the Kindergarten level.

Figure 4: Example of Complete Individual Standard

Subconcept: Algorithms	
K.AP.A.1	**With teacher assistance, model daily processes by following algorithms (sets of step-by-step instructions) to complete tasks.** *Routines, such as morning meeting, clean-up time, and dismissal, are examples of algorithms that are common in many early elementary classrooms. Just as people use algorithms to complete daily routines, they can program computers to use algorithms to complete different tasks. Algorithms are commonly implemented using a precise language that computers can interpret. For example, students begin to recognize daily step-by-step processes, such as brushing teeth or following a morning procedure, as "algorithms" that lead to an end result.* *Practice(s):* Developing and Using Abstractions: 4.4
Subconcept: Variables	
K.AP.V.1	**With teacher assistance, model the way programs store and manipulate data by using numbers or other symbols to represent information.** *Information in the real world can be represented in computer programs. Students could use thumbs up/down as representations of yes/no, use arrows when writing algorithms to represent direction, or encode and decode words using numbers, pictographs, or other symbols to represent letters or words.* Practice(s): Developing and Using Abstractions: 4.4

Kindergarten

Since the standards drive the pedagogical component of teaching and serve as a guide to how students demonstrate understanding of the content, they must be incorporated as an integral part of the overall student expectations when assessing content understanding. By the end of Kindergarten, the computer science literate student will begin the practice of utilizing devices to perform basic computer operations, such as turning a computer on and off, and communicate basic hardware and software problems. Kindergarten students will be able to explain the importance of password protection and discuss how computer networks can connect people globally. With teacher assistance, kindergarten students will begin to develop an understanding of how to model and develop algorithms and programs, and collect data to make predictions. Students will be introduced to the impacts of computing, including how people lived and worked before and after the implementation of new technology, how to work responsibly online, and the importance of keeping login information private.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
K.CS.D.1	**With teacher guidance, select and operate an appropriate device to perform a task.** *People use computing devices to perform a variety of tasks accurately and quickly. With teacher guidance, students should be able to select the appropriate device to use for tasks they are required to complete. For example, if students are asked to draw a picture, they should be able to open and use a drawing app/program to complete this task, or if they are asked to create a presentation, they should be able to open and use presentation software.* Practice(s): Fostering an inclusive Computing Culture: 1.2
Subconcept: Hardware and Software (HS)	
K.CS.HS.1	**Use appropriate terminology in identifying and describing the function of common physical components of computing systems.** *A computing system is composed of hardware and software. Hardware consists of physical components. Students should be able to identify and describe the function of external hardware, such as desktop computers, laptop computers, tablet devices, monitors, keyboards, mice, and printers.* Practice(s): Communicating about Computing: 7.2
Subconcept: Troubleshooting (T)	
K.CS.T.1	**Discuss basic hardware and software problems.** *Problems with computing systems have different causes. Students should be able to communicate a hardware or software problem (e.g., when an app or program is not working as expected, a device will not turn on, the sound does not work, etc.).* Practice(s): Testing and Refining Computational Artifacts, Communicating About Computing: 6.2, 7.3

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
K.NI.C.1	**Explain that a password helps protect the privacy of information.** *Connecting devices to a network or the Internet provides great benefit, care must be taken to use authentication measures, such as strong passwords, to protect devices and information from unauthorized access. This is an essential first step in learning about cybersecurity. Usernames and passwords, such as those on computing devices or Wi-Fi networks, provide a way of authenticating a user's identity. For example, students should enter a password independently and commit to keeping their password private.* *Practice(s):* Communicating About Computing: 7.2
Subconcept: Network, Communication, and Organization (NCO)	
K.NI. NCO.1	**With teacher guidance, students define computer networks and how they can be used to connect people to other people, places, information, and ideas.** *Small, wireless devices, such as cell phones, communicate with one another through a series of intermediary connection points, such as cellular towers. This coordination among many computing devices allows a person to voice call a friend or video chat with a family member. For example, kindergarten students understand that they are part of non-computing networks such as family, class, school, etc. Kindergarten students should be able to explain that devices are connected, though details about connection points are not expected at this level.* *Practice(s): Communicating About Computing: 7.3*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
K.DA. CVT.1	**With teacher guidance, collect and transform data using digital devices; Display data for communication in various visual formats.** *The collection and use of data about the world around them is a routine part of life and influences how people live. Many everyday objects, such as cell phones, digital toys, and cars, can contain tools (such as sensors) and computers to collect and display data from their surroundings. Students could collect data on the weather, such as sunny days versus rainy days, the temperature at the beginning of the school day and end of the school day, or the inches of rain over the course of a storm. Students could count the number of pieces of each color of candy in a bag of candy, such as Skittles or M&Ms. Students could create surveys of things that interest them, such as favorite foods, pets, or TV shows, and collect answers to their surveys from their peers and others. The data collected could then be organized into two or more visualizations, such as a bar graph, pie chart, or pictograph.* *Practice(s):* Communicating About Computing, Developing and Using Abstractions: 7.3, 4.4

Subconcept: Storage (S)	
K.DA.S.1	**Recognize that data can be collected and stored on different computing devices over time and retrieved later.** *All information stored and processed by a computing device is referred to as data. Data can be images, text documents, audio files, software programs or apps, video files, etc. It can be retrieved, copied, and stored in multiple places. As students use software to complete tasks on a computing device, they will be manipulating data. For example, students should be able to create and save a document.* *Practice(s):* Developing and Using Abstractions: 4.3
Subconcept: Inference and Models (IM)	
K.DA.IM.1	**Discuss patterns in data to make inferences or predictions.** *Data can be used to make inferences or predictions about the world. Students could analyze a Graph and pie chart of the colors in a bag of candy, identify which colors are most and least represented, and then make a prediction as to which colors will have most and least in a new bag of candy. For example, students preview a weather graph for one week in their city and make predictions about the weather for the following week.* *Practice(s):* Developing and Using Abstractions: 4.1

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
K.AP.A.1	**With teacher assistance, model daily processes by following algorithms (sets of step-by-step instructions) to complete tasks.** *Routines, such as morning meeting, clean-up time, and dismissal, are examples of algorithms that are common in many early elementary classrooms. Just as people use algorithms to complete daily routines, they can program computers to use algorithms to complete different tasks. Algorithms are commonly implemented using a precise language that computers can interpret. For example, students begin to recognize daily step-by-step processes, such as brushing teeth or following a morning procedure, as "algorithms" that lead to an end result.* *Practice(s):* Developing and Using Abstractions: 4.4
Subconcept: Variables (V)	
K.AP.V.1	**With teacher assistance, model the way programs store and manipulate data by using numbers or other symbols to represent information.** *Information in the real world can be represented in computer programs. Students could use thumbs up/down as representations of yes/no, use arrows when writing algorithms to represent direction, or encode and decode words using numbers, pictographs, or other symbols to represent letters or words.* Practice(s): Developing and Using Abstractions: 4.4

Subconcept: Control (C)	
K.AP.C.1	**With teacher assistance, identify programs with sequences and simple loops, to express ideas or address a problem.** *Programming is used as a tool to create products that reflect a wide range of interests. Control structures specify the order in which instructions are executed within a program. Computers follow instructions literally. Sequences are the order of instructions in a program. For example, sequences of instructions include steps for drawing a shape or moving a character across the screen. If the commands to program a robot are not in the correct order, the robot will not complete the task desired. Loops allow for the repetition of a sequence of code multiple times. For example, in a program to show the life cycle of a butterfly, a loop could be combined with move commands to allow continual but controlled movement of the character. For example, kindergarten students should be able to recognize loops and sequences in songs, rhymes, and games, such as the song B-I-N-G-O.* Practice(s): Creating Computational Artifacts: 5.1
Subconcept: Modularity (M)	
K.AP.M.1	**With teacher assistance, solve a problem by breaking it down into smaller parts.** *Decomposition is the act of breaking down tasks into simpler tasks. For example, Students could break down the steps needed to make a peanut butter and jelly sandwich, to brush their teeth, to draw a shape, to move a character across the screen, or to solve a level of a coding app.* Practice(s): Recognizing and Defining Computational Problems: 3.1
Subconcept: Program Development (PD)	
K.AP.PD.1	**With teacher assistance, develop plans that describe a program's sequence of events, goals, and expected outcomes.** *Programming is used as a tool to create products that reflect a wide range of interests, such as video games, interactive art projects, and digital stories. Students could create a planning document, such as a story map, a storyboard, or a sequential graphic organizer, to illustrate what an end product will do. Students at this stage may complete the planning process with help from their teachers. For example, kindergarten students could illustrate the beginning, middle, and end of a favorite story.* Practice(s): Creating Computational Artifacts, Communicating About Computing: 5.1, 7.2
K.AP.PD.2	**With teacher assistance, identify attribution (credit) when using the ideas and creations of others while developing programs.** *Using computers comes with a level of responsibility. Students should credit artifacts that were created by others, such as pictures, music, and code. Credit could be given orally, if presenting their work to the class, or in writing or orally, if sharing work on a class blog or website. Proper attribution at this stage does not require a formal citation, such as in a bibliography or works cited document.* Practice(s): Communicating About Computing: 7.3
K.AP.PD.3	**With teacher assistance, debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.** *Algorithms or programs may not always work correctly. Students should be able to use various strategies, such as changing the sequence of the steps, following the algorithm in a step-by-step manner, or trial and error to fix problems in algorithms and programs. For example, kindergarten students should be able to identify incorrect order in a series of events and place them in the correct order, such as getting ready for school or making a peanut butter sandwich.* Practice(s): Testing and Refining Computational Artifacts: 6.2

K.AP.PD.4	**With teacher assistance, using correct terminology, describe steps taken and choices made during program development.** *At this stage, students should be able to talk or write about the goals and expected outcomes of the instructions they develop they create and the choices that they made when developing their instructions. This could be done using coding journals, discussions with a teacher, or teacher created classroom blogs. For example, kindergarten students could describe their thinking about a story map or set of instructions they develop.* *Practice(s)*: Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
K.IC.C.1	**Discuss how people lived and worked before and after the implementation or adoption of new computing technology.** *Computing technology has positively and negatively changed the way people live and work. In the past, if students wanted to read about a topic, they needed access to a library to find a book about it. Today, students can view information on the Internet about a topic or they can download e-books about it directly to a device.* Practice(s): Communicating About Computing: 7.2
Subconcept: Social Interactions (SI)	
K.IC.SI.1	**Work respectfully and responsibly with others online.** *Online communication facilitates positive interactions, such as sharing ideas with many people, but the public and anonymous nature of online communication also allows intimidating and inappropriate behavior in the form of cyberbullying. Teachers should facilitate a discussion in how to avoid sharing information that is inappropriate or that could personally identify them to others, and how to. work in a kind and respectful manner.* Practice(s): Collaborating Around Computing: 2.1
Subconcept: Safety, Law, and Ethics (SLE)	
K.IC. SLE.1	**Keep login information private, and log off of devices appropriately.** *Using computers comes with a level of responsibility. Students should not share login information, keep passwords private, and log off when finished* Practice(s): Communicating About Computing:7.2

First Grade

Students learn foundational concepts by integrating basic digital literacy skills with simple ideas about computational thinking. Students learn that tools help people do things better, or more easily, or do some things that could otherwise not be done at all. Through the exploration of differences between humans, computing devices, and digital tools, students begin to understand if, when, and how they should use technology. By the end of first grade, the computer science literate student will recognize user needs and preferences while utilizing devices to perform basic computer operations, hardware, software, and apply basic troubleshooting strategies. Students will explain and practice the importance of password protection and discuss how computer networks can connect people globally. With teacher guidance, students will collect, transform, and explain how different types of data can be stored and retrieved from a computing device. First grade students will develop an understanding of how to model and identify algorithms and programs using loops and step by step instructions. First grade students will discuss the impacts of computing, including how people lived and worked before and after the implementation of new technology, how to work responsibly online, the importance of keeping login information private and logging off devices appropriately.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
1.CS.D.1	**With teacher guidance, select and operate appropriate devices and software to perform a task.** *People use computing devices to perform a variety of tasks accurately and quickly. With teacher guidance students should be able to select the appropriate app/program to use for tasks they are required to complete. For example, if students are asked to draw a picture, they should be able to open and use a drawing app/program to complete this task.* Practice(s): Fostering an inclusive Computing Culture, Communicating About Computing: 1.2, 7.3
Subconcept: Hardware and Software (HS)	
1.CS.HS.1	**Use appropriate terminology in identifying and describing the function of common physical components of computing systems.** *A computing system is composed of hardware and software. Hardware consists of physical components. Students should be able to identify and describe the function of external hardware, such as desktop computers, laptop computers, tablet devices, monitors, keyboards, mice, and printers. Students should be able to identify software such as: web browsers, games, etc.* Practice(s): Communicating about Computing: 7.2

Subconcept: Troubleshooting (T)	
1.CS.T.1	**Identify basic hardware and software problems using accurate terminology.** *Problems with computing systems have different causes. Students should be able to communicate a hardware or software problem with accurate terminology (e.g., when an app or program is not working as expected, a device will not turn on, the sound does not work, etc.).* Practice(s): Testing and Refining Computational Artifacts, Communicating About Computing: 6.3, 7.2
1.CS.T.2	**With teacher guidance, begin to use basic troubleshooting strategies.** *Students would be able to use simple troubleshooting strategies. For example, turning a device off and on to reboot it, closing and reopening an app, turning on speakers, or plugging in headphones, and then adjusting volume.* Practice(s): Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
1.NI.C.1	**Explain what passwords are and why we use them to protect personal information (e.g., name, location, phone number, home address) and keep it private.** *Connecting devices to a network or the Internet provides great benefit, care must be taken to use authentication measures, such as strong passwords, to protect devices and information from unauthorized access. This is an essential first step in learning about cybersecurity. For example, first grade students should be able to accurately enter a password to log on to a program and understand the importance of keeping passwords private in order to protect their personal information.* *Practice(s):* Communicating About Computing: 7.2
Subconcept: Network, Communication, and Organization (NCO)	
1.NI. NCO.1	**With teacher guidance, students discuss how computer networks can be used to connect people to other people, places, information, and ideas.** *Small, wireless devices, such as cell phones, communicate with one another through a series of intermediary connection points, such as cellular towers. This coordination among many computing devices allows a person to voice call a friend or video chat with a family member. Details about the connection points are not expected at this level. For example, students will participate in a class discussion about how different networks connect people, places, things and information, such as a phone call to grandma in another state, using Facetime or Skype to connect with a content area expert, connecting devices via Bluetooth, or accessing an online game through Wi-Fi.* *Practice(s): Communicating About Computing: 7.2*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
1.DA.CVT.1	**With teacher guidance, collect and transform data using digital devices; Display data for communication in various visual formats.** *The collection and use of data about the world around them is a routine part of life and influences how people live. Many everyday objects, such as cell phones, digital toys, and cars, can contain tools (such as sensors) and computers to collect and display data from their surroundings. Students could collect data on the weather, such as sunny days versus rainy days, the temperature at the beginning of the school day and end of the school day, or the inches of rain over the course of a storm. Students could count the number of pieces of each color of candy in a bag of candy, such as Skittles or M&Ms. Students could create surveys of things that interest them, such as favorite foods, pets, or TV shows, and collect answers to their surveys from their peers and others. The data collected could then be organized into two or more visualizations, such as a bar graph, pie chart, or pictograph.* *Practice(s):* Communicating About Computing, Developing and Using Abstractions: 7.1, 4.2
Subconcept: Storage (S)	
1.DA.S.1	**Explain that a variety of data (e.g., music, video, images, and text) can be stored in and retrieved from a computing device.** All information stored and processed by a computing device is referred to as data. Data can be images, text documents, audio files, software programs or apps, video files, etc. It can be retrieved, copied, and stored in multiple places. As students use software to complete tasks on a computing device, they will be manipulating data. For example, first graders should be able to retrieve files that they previously created and saved, such as, locating and opening a word processing program they saved the previous day. *Practice(s):* Developing and Using Abstractions: 4.3
Subconcept: Inference and Models (IM)	
1.DA.IM.1	**Identify patterns in data to make inferences or predictions.** *Data can be used to make inferences or predictions about the world. Students could analyze a Graph and pie chart of the colors in a bag of candy, identify the patterns for which colors are most and least represented, and then make a prediction as to which colors will have most and least in a new bag of candy.* *Practice(s):* Developing and Using Abstractions: 4.4

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
1.AP.A.1	**Model daily processes by following algorithms (sets of step-by-step instructions) to complete tasks.** *Routines, such as morning meeting, clean-up time, and dismissal, are examples of algorithms that are common in many early elementary classrooms. For example, students begin to understand and model daily step-by-step processes, such as brushing teeth, implementing a morning procedure, or following a simple recipe as "algorithms" that lead to an end result.* *Practice(s):* Developing and Using Abstractions: 4.4
Subconcept: Variables (V)	
1.AP.V.1	**Model the way programs store and manipulate data by using numbers or other symbols to represent information.** *Information in the real world can be represented in computer programs. Students could use thumbs up/down as representations of yes/no, use arrows when writing algorithms to represent direction, or encode and decode words using numbers, pictographs, or other symbols to represent letters or words.* *Practice(s):* Developing and Using Abstractions: 4.3
Subconcept: Control (C)	
1.AP.C.1	**Identify programs with sequences and simple loops, to express ideas or address a problem.** *Programming is used as a tool to create products that reflect a wide range of interests. Control structures specify the order in which instructions are executed within a program. Computers follow instructions literally. Sequences are the order of instructions in a program. For example, sequences of instructions include steps for drawing a shape or moving a character across the screen. If the commands to program a robot are not in the correct order, the robot will not complete the task desired. Loops allow for the repetition of a sequence of code multiple times. For example, in a program to show the life cycle of a butterfly, a loop could be combined with move commands to allow continual but controlled movement of the character. For example, first grade students independently identify loops and sequences in songs, rhymes, and games, such as the song B-I-N-G-O or the game Red Light/Green Light.* *Practice(s):* Creating Computational Artifacts: 5.1
Subconcept: Modularity (M)	
1.AP.M.1	**Solve a problem by breaking it down into smaller parts.** *Decomposition is the act of breaking down tasks into simpler tasks. For example, Students could break down the steps needed to make a peanut butter and jelly sandwich, to brush their teeth, to draw a shape, to move a character across the screen, or to solve a level of a coding app.* *Practice(s):* Recognizing and Defining Computational Problems: 3.1

Subconcept: Program Development (PD)	
1.AP.PD.1	**With teacher assistance identify plans that describe a program's sequence of events, goals, and expected outcomes.** *Programming is used as a tool to create products that reflect a wide range of interests, such as video games, interactive art projects, and digital stories. Students could create a planning document, such as a story map, a storyboard, or a sequential graphic organizer, to illustrate what their end product will do. Students at this stage may complete the planning process with help from their teachers. For example, students create a comic strip with at least 3 panels showing the sequence of a story.* *Practice(s):* Creating Computational Artifacts, Communicating About Computing: 5.3, 7.1
1.AP.PD.2	**With teacher assistance, give attribution (credit) when using the ideas and creations of others while developing programs.** *Using computers comes with a level of responsibility. Students should credit artifacts that were created by others, such as pictures, music, and code. Credit could be given orally, if presenting their work to the class, or in writing or orally, if sharing work on a class blog or website. Proper attribution at this stage does not require a formal citation, such as in a bibliography or works cited document.* *Practice(s):* Communicating About Computing: 7.3
1.AP.PD.3	**With teacher assistance, debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.** *Algorithms or programs may not always work correctly. Students should be able to use various strategies, such as changing the sequence of the steps, following the algorithm in a step-by-step manner, or trial and error to fix problems in algorithms and programs. For example, first graders should be able to identify and fix incorrect order in a series of events, placing them in the correct order, such as washing dishes at home. When the steps repeat, a loop is created.* *Practice(s):* Testing and Refining Computational Artifacts: 6.3
1.AP.PD.4	**Using correct terminology, describe steps taken and choices made during program development.** *At this stage, students should be able to talk or write about the goals and expected outcomes of the instructions they develop and the choices that they made when developing their instructions. This could be done using coding journals, discussions with a teacher, class presentations, or classroom blogs. For example, first grade students do a class presentation sharing the process, choices they made, and outcomes for a fictitious product they developed.* *Practice(s):* Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
1.IC.C.1	**Discuss how people live and work before and after the implementation or adoption of new computing technology.** *Computing technology has positively and negatively changed the way people live and work. In the past, if students wanted to read about a topic, they needed access to a library to find a book about it. Today, students can view and read information on the Internet about a topic or they can download e-books about it directly to a device. Such information may be available in more than one language and could be read to a student, allowing for great accessibility.* *Practice(s):* Communicating About Computing: 7.1

Subconcept: Social Interactions (SI)	
1.IC.SI.1	**Work respectfully and responsibly with others online.** *Online communication facilitates positive interactions, such as sharing ideas with many people, but the public and anonymous nature of online communication also allows intimidating and inappropriate behavior in the form of cyberbullying. Students could share their work on blogs or in other collaborative spaces online, taking care to avoid sharing information that is inappropriate or that could personally identify them to others. Students could provide feedback to others on their work in a kind and respectful manner. They should tell an adult if others are sharing things they should not share or are treating others in an unkind or disrespectful manner on online. Privacy should be considered when posting information online: such information can persist for a long time and be accessed by others, even unintended viewers.* *Practice(s):* Collaborating Around Computing: 2.1
Subconcept: Safety, Law, and Ethics (SLE)	
1.IC. SLE.1	**Keep login information private, and log off devices appropriately.** *Using computers comes with a level of responsibility, such as not sharing login information, keeping passwords private, and logging off when finished. Rules guiding personal interactions in the world, apply to online environments as well. For example, students routinely practice logging in and logging out of online resources to protect their personal information. Students should also commit to interacting with only those they know in person in online environments.* *Practice(s):* Communicating About Computing: 7.2

Second Grade

Students expand basic knowledge of digital literacy and computer science skills. By the end of second grade, students will be able to select the appropriate device and software to perform specific tasks. Students will understand that computing systems use both hardware and software to process information and will be able to use basic troubleshooting strategies with teacher guidance. Students will develop a deeper understanding of the importance and use of strong passwords to protect private information and discuss how computer networks can connect people globally. Second grade students will independently collect, transform, and display data using digital devices. Students can store, copy, search, retrieve, modify, and delete information using a computing device. Second grade students will create and follow algorithms and programs using loops and variables to solve a problem. Students will decompose steps into simpler tasks and give credit to the ideas and creations of others. Second grade students will discuss the impacts of computing by comparing how people lived and worked before and after the implementation of new technology, how to work responsibly online, the importance of keeping login information private, and logging off devices appropriately.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
2.CS.D.1	**Recognize that users have different needs and preferences for technology they used by selecting and operating appropriate devices.** *People use computing devices to perform a variety of tasks accurately and quickly. Students should be able to select the appropriate app/program to use for tasks they are required to complete. For example, if students are asked to draw a picture, they should be able to open and use a drawing app/program to complete this task, or if they are asked to create a presentation, they should be able to open and use presentation software. In addition, with teacher guidance, students should identify and discuss preferences for software with the same primary functionality.* *Practice(s):* Fostering an inclusive Computing Culture, Communicating About Computing: 1.1, 7.3
Subconcept: Hardware and Software (HS)	
2.CS.HS.1	**Understand how computing systems use both hardware (device) and software (program/app) to process information.** *A computing system is composed of hardware and software. Hardware consists of physical components. Students should be able to identify and describe the function of external hardware, such as desktop computers, laptop computers, tablet devices, monitors, keyboards, mice, and printers.* *Practice(s):* Communicating about Computing : 7.2

Subconcept: Troubleshooting (T)	
2.CS.T.1	**Explain basic hardware (device) and software (program/app) problems using accurate terminology.** *Problems with computing systems have different causes. Students at this level do not need to understand those causes, but they should be able to communicate a problem with accurate terminology (e.g., when an app or program is not working as expected, the device is frozen, the link doesn't work, the internet is not connecting,* *Practice(s):* Communicating About Computing: 7.2
2.CS.T.2	**With teacher guidance, use basic troubleshooting strategies.** *Students should be able to use simple troubleshooting strategies, including turning a device off and on to reboot it, closing and reopening an app, turning on speakers, or plugging in headphones and adjusting volume.* *Practice(s):* Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
2.NI.C.1	**Explain what passwords are and why we use them, and use strong passwords to protect devices and information from unauthorized access.** *Connecting devices to a network or the Internet provides great benefit, care must be taken to use authentication measures, such as strong passwords, to protect devices and information from unauthorized access. This is an essential first step in learning about cybersecurity. They should appropriately use and protect the passwords they are required to use. Usernames and passwords, such as those on computing devices or Wi-Fi networks, provide a way of authenticating a user's identity. For example, students learn to not share passwords and not use anyone else's password.* *Practice(s):* Communicating About Computing: 7.2
Subconcept: Network, Communication, and Organization (NCO)	
2.NI. NCO.1	**Students can discuss how computer networks can be used to connect people to other people, places, information, and ideas.** *Small, wireless devices, such as cell phones, communicate with one another through a series of intermediary connection points, such as cellular towers. This coordination among many computing devices allows a person to voice call a friend or video chat with a family member. Details about the connection points are not expected at this level. For example, students will participate in a class discussion about how different networks connect people, places, things and information, such as a phone call to grandma in another state, using conferencing software to connect with a content area expert, or accessing an online game via Wi-Fi.* *Practice(s): Communicating About Computing: 7.2*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
2.DA.CVT.1	**Collect and transform data using digital devices; Display data for communication in various visual formats.** *The collection and use of data about the world around them is a routine part of life and influences how people live. Many everyday objects, such as cell phones, digital toys, and cars, can contain tools (such as sensors) and computers to collect and display data from their surroundings. Students could collect data on the weather, such as sunny days versus rainy days, the temperature at the beginning of the school day and end of the school day, or the inches of rain over the course of a storm. Students could count the number of pieces of each color of candy in a bag of candy, such as Skittles or M&Ms. Students could create surveys of things that interest them, such as favorite foods, pets, or TV shows, and collect answers to their surveys from their peers and others. The data collected could then be organized into two or more visualizations, such as a bar graph, pie chart, or pictograph.* *Practice(s):* Communicating About Computing, Developing and Using Abstractions: 7.3, 4.2
Subconcept: Storage (S)	
2.DA.S.1	**Store, copy, search, retrieve, modify, and delete information using a computing device and define the information stored as data.** All information stored and processed by a computing device is referred to as data. Data can be images, text documents, audio files, software programs or apps, video files, etc. It can be retrieved, copied, and stored in multiple places. As students use software to complete tasks on a computing device, they will be manipulating data. For example, students will learn to save files in specific locations, such as a folder, and retrieve those files for use later. *Practice(s):* Developing and Using Abstractions: 4.1
Subconcept: Inference and Models (IM)	
2.DA.IM.1	**Describe patterns in data to make inferences or predictions.** *Data can be used to make inferences or predictions about the world. Students could analyze a Graph and pie chart of the colors in a bag of candy identify the patterns for which colors are most and least represented, and then make a prediction as to which colors will have most and least in a new bag of candy.* *Practice(s):* Developing and Using Abstractions: 4.3

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
2.AP.A.1	**Model daily processes by creating and following algorithms (sets of step-by-step instructions to complete tasks.** *Routines, such as morning meeting, clean-up time, and dismissal, are examples of algorithms that are common in many early elementary classrooms. Just as people use algorithms to complete daily routines, they can program computers to use algorithms to complete different tasks. Algorithms are commonly implemented using a precise language that computers can interpret. For example, students begin to understand and model daily step-by-step processes, such as brushing teeth, implementing a morning procedure, or following a simple recipe as "algorithms" that lead to an end result.* *Practice(s):* Developing and Using Abstractions: 4.3
Subconcept: Variables (V)	
2.AP.V.1	**Model the way programs store and manipulate data by using numbers or other symbols to represent information.** *Information in the real world can be represented in computer programs. Students could use thumbs up/down as representations of yes/no, use arrows when writing algorithms to represent direction, or encode and decode words using numbers, pictographs, or other symbols to represent letters or words.* *Practice(s):* Developing and Using Abstractions: 4.3
Subconcept: Control (C)	
2.AP.C.1	**Develop programs with sequences and simple loops, to express ideas or address a problem.** *Programming is used as a tool to create products that reflect a wide range of interests. Control structures specify the order in which instructions are executed within a program. Computers follow instructions literally. Sequences are the order of instructions in a program. For example, sequences of instructions include steps for drawing a shape or moving a character across the screen. If the commands to program a robot are not in the correct order, the robot will not complete the task desired. Loops allow for the repetition of a sequence of code multiple times. For example, in a program to show the life cycle of a butterfly, a loop could be combined with move commands to allow continual but controlled movement of the character. For example: students independently identify loops and sequences in songs, rhymes, and games, such as the song Head, Shoulders, Knees and Toes* *Practice(s):* Creating Computational Artifacts: 5.2
Subconcept: Modularity (M)	
2.AP.M.1	**Decompose (break down) the steps needed to solve a problem into a precise sequence of instructions.** *Decomposition is the act of breaking down tasks into simpler tasks. Students could break down the steps needed to make a peanut butter and jelly sandwich, to brush their teeth, to draw a shape, to move a character across the screen, or to solve a level of a coding app.* *Practice(s):* Recognizing and Defining Computational Problems: 3.2

Subconcept: Program Development (PD)	
2.AP.PD.1	**Develop plans that describe a program's sequence of events, goals, and expected outcomes.** *Programming is used as a tool to create products that reflect a wide range of interests, such as video games, interactive art projects, and digital stories. Students could create a planning document, such as a story map, a storyboard, or a sequential graphic organizer, to illustrate what an end product will do. Students at this stage may complete the planning process with help from their teachers. For example, students create a graphic organizer modeling the life cycle of a plant.* *Practice(s):* Creating Computational Artifacts, Communicating About Computing: 5.2, 7.2
2.AP.PD.2	**Give attribution (credit) when using the ideas and creations of others while developing programs.** *Using computers comes with a level of responsibility. Students should credit artifacts that were created by others, such as pictures, music, and code. Proper attribution at this stage does not require a formal citation, such as in a bibliography or works cited document. For example, students can give attribution in written form, at a minimum, by listing a website where they got the information, picture, or music.* *Practice(s):* Communicating About Computing: 7.3
2.AP.PD.3	**Debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.** *Algorithms or programs may not always work correctly. Students should be able to use various strategies, such as changing the sequence of the steps, following the algorithm in a step-by-step manner, or trial and error to fix problems in algorithms and programs. For example: Students could use arrows on a grid to map out a path to a specific coordinate, such as a treasure map. If the steps were repeated, it would create a loop.* *Practice(s):* Testing and Refining Computational Artifacts: 6.2
2.AP.PD.4	**Using correct terminology, describe steps taken and choices made during the iterative process of program (procedure) development.** *At this stage, students should be able to talk or write about the goals and expected outcomes of the programs they create and the choices that they made when creating programs. This could be done using coding journals, or discussions with a teacher. Students work together to explain the steps in their procedure.* *Practice(s):* Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
2.IC.C.1	**Compare how people live and work before and after the implementation or adoption of new computing technology.** *Computing technology has positively and negatively changed the way people live and work. In the past, if students wanted to read about a topic, they needed access to a library to find a book about it. Today, students can view and read information on the Internet about a topic or they can download e-books about it directly to a device. Such information may be available in more than one language and could be read to a student, allowing for great accessibility.* *Practice(s):* Communicating About Computing: 7.1
Subconcept: Social Interactions (SI)	
2.IC.SI.1	**Work respectfully and responsibly with others online.** *Online communication facilitates positive interactions, such as sharing ideas with many people, but the public and anonymous nature of online communication also allows intimidating and inappropriate behavior in the form of cyberbullying. Students could share their work on blogs or in other collaborative spaces online, taking care to avoid sharing information that is inappropriate or that could personally identify them to others. Students could provide feedback to others on their work in a kind and respectful manner. They should tell an adult if others are sharing things they should not share or are treating others in an unkind or disrespectful manner on online. Privacy should be considered when posting information online: such information can persist for a long time and be accessed by others, even unintended viewers.* *Practice(s):* Collaborating Around Computing: 2.1
Subconcept: Safety, Law, and Ethics (SLE)	
2.IC. SLE.1	**Keep login information private, and log off of devices appropriately.** *Using computers comes with a level of responsibility, such as not sharing login information, keeping passwords private, and logging off when finished. Rules guiding personal interactions in the world apply to online environments as well. For example, students routinely practice logging in and logging out of online resources to protect their personal information. Students should also commit to interacting with only those they know in person in online environments.* *Practice(s):* Communicating About Computing: 7.2

Third Grade

The computer science literate third grade student will explore a variety of computing devices and tools to further develop their computational thinking and problem-solving skills. Students plan, make predictions, solve problems, and draw conclusions about data, programs, and computational artifacts by collaborating locally, nationally, and globally with peers. Students practice the importance of protecting personal information and respecting the rights of others.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
3.CS.D.1	**Identify how internal and external parts of computing devices function to form a system within a single device and hardware that connects to the device to extend capability.** *Keyboard input or a mouse click could cause an action to happen or information to be displayed on a screen; this could only happen because the computer has a processor to evaluate what is happening externally and produce corresponding responses. Students describe how devices and components interact using correct terminology.* *Practice(s): Communicating About Computing, Recognizing and Defining Computational Problems: 7.2, 3.2*
Subconcept: Hardware and Software (HS)	
3.CS.HS.1	**Recognize that hardware (devices) and software (programs/apps) communicate in a special language that the computing system can understand.** *Computing systems convert instructions, such as "print," "save," or "crop," into a special language that the computer can understand. Students discuss the process that happens when hardware communicates with software.* *Practice(s): Communicating About Computing: 7.2*
3.CS.HS.2	**Recognize that hardware (devices) can only accomplish the specific tasks the software (programs/apps) is designed to accomplish.** *Cameras can take pictures because the camera software allows them to do so. Students discuss examples of different hardware and the tasks they can accomplish.* *Practice(s): Communicating About Computing: 7.2*

Subconcept: Troubleshooting (T)	
3.CS.T.1	**Identify and use common troubleshooting strategies to solve simple hardware and software problems.** *Although computing systems may vary, common troubleshooting strategies, such as checking connections and power or swapping a working part in place of a potentially defective part can be used to restore functionality. Restarting a computer (rebooting) is commonly effective because it resets the machine. Computing devices are composed of an interconnected system of hardware and software, troubleshooting strategies may need to address both.* *Practice(s): Communicating About Computing: 7.2*

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
3.NI.C.1	**Identify real-world cybersecurity problems and how personal information can be protected.** *Just as we protect our personal property online, we need to protect our devices and the information stored on them. Information can be protected using various security measures. These measures can be physical and/or digital. For example, discussion topics could be based on current events related to cybersecurity or topics that are applicable to students and the programs/devices they use such as adding passwords to lock devices.* *Practice(s): Communicating about Computing, Recognizing and Defining Computational Problems: 7.1, 3.1*
Subconcept: Network, Communication, and Organization (NCO)	
3.NI. NCO.1	**Model how information flows in a physical or wireless path to travel to be sent and received is sent and received through a physical or wireless path.** *There are physical paths for communicating information, such as Ethernet cables, and wireless* paths (Wifi). *Often, information travels on a combination of physical and wireless paths. Wireless paths originate from a physical connection point and travel through multiple devices and wired or wireless connections to their end point. Models could include visual, physical, or alternate representations.* *Practice(s): Developing and Using Abstractions: 4.3*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
3.DA.CVT.1	**Select tools from a specified list to collect, organize, and present data visually to highlight relationships and support a claim.** *Tools are chosen based upon the type of measurement they use as well as the type of data people wish to observe. Organizing data can make interpreting and communicating it to others easier. Data points can be clustered by a number of commonalities.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts: 4.1, 5.1*
Subconcept: Storage (S)	
3.DA.S.1	**Recognize different file extensions.** *Music, images, video, and text require different amounts of storage. Video will often require more storage than music or images alone because video combines both. Students discuss common file extensions, such as .doc, .pdf, and .jpeg.* *Practice(s): Communicating About Computing: 7.2*
Subconcept: Inference and Models (IM)	
3.DA.IM.1	**Use a computational tool to draw conclusions, make predictions, and answer questions utilizing a specified data set.** *People use data to highlight or predict outcomes. Basing inferences or predictions on data does not guarantee their accuracy; the data must be relevant and of sufficient quantity. A computational tool can be anything used or analyzed to draw conclusions, make predictions, or answer questions.* *Practice(s): Communicating about Computing, Collaborate around Computing: 7.2, 2.4*

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
3.AP.A.1	**Recognize and compare multiple algorithms for the same task and determine which are effective.** *Different algorithms can achieve the same result, though sometimes one algorithm might be most appropriate for a specific task.. Students look at different ways to solve the same task and decide which would be the best solution. For example, students might compare algorithms that describe how to get ready for school or how to tie their shoes. Students could use a map and plan multiple algorithms to get from one point to another. Another example might be to write different algorithms to draw a regular polygon and determine which algorithm would be the easiest to modify or repurpose to draw a different polygon.* *Practice(s):* Developing and Using Abstractions, 4.4

Subconcept: Variables (V)	
3.AP.V.1	**Create programs that use variables to store and modify data.** *Variables are used to store and modify data. At this level, understanding how to use variables is sufficient. Students may use mathematical operations to add to the score of a game or subtract from the number of lives in a game. Programs can imply either digital or paper-based designs.* *Practice(s):* Creating Computational Artifacts: 5.2
Subconcept: Control (C)	
3.AP.C.1	**Create programs that include sequences, events, loops, and/or conditionals.** *Control structures specify the order (sequence) in which instructions are executed within a program and can be combined to support the creation of more complex programs. If dialogue is not sequenced correctly when programming a simple animated story, the story will not make sense. Events allow portions of a program to run based on a specific action. Students could write a program to explain the water cycle and when a specific component is clicked (event), the program would show information about that part of the water cycle. Loops allow for the repetition of a sequence of code multiple times. In a program that produces an animation about a famous historical character, students could use a loop to have the character walk across the screen as they introduce themselves. Conditionals allow for the execution of a portion of code in a program when a certain condition is true. Students could write a math game that asks multiplication fact questions and then uses a conditional to check whether or not the answer that was entered is correct.* Practice(s): Creating Computational Artifacts: 5.2
Subconcept: Modularity (M)	
3.AP.M.1	**Decompose problems into smaller, manageable subproblems to facilitate the program development process.** *Decomposition is the act of breaking down a task into multiple simpler tasks. Decomposition also enables different people to work on different parts at the same time. For example, students could create an animation by separating a story into different scenes. For each scene, they would select a background, place characters, and program actions.* Practice(s): Recognizing and Defining Computational Problems: 3.2
Subconcept: Program Development (PD)	
3.AP.PD.1	**With teacher guidance, use an iterative process to plan the development of a program by including others' perspectives and considering user preferences.** *Planning is an important part of the iterative process of program development. Students outline key features, time and resource constraints, and user expectations. With teacher guidance, students should document the plan as, for example, a storyboard, flowchart, pseudocode, or story map.* Practice(s): Fostering an Inclusive Computing Culture, Creating Computational Artifacts: 1.1, 5.1

3.AP.PD.2	**Observe intellectual property rights and give appropriate attribution when creating or remixing programs.** *Intellectual property rights can vary by country but copyright laws give the creator of a work a set of rights that prevents others from copying the work and using it in ways that the creator may not like. Students should identify if ideas were borrowed or adjusted, and credit the original creator. Students should also consider common licenses that place limitations or restrictions on the use of computational artifacts, such as images and music downloaded from the Internet. At this stage, attribution should be written in the format required by the teacher and should always be included on any programs shared online.* Practice(s): Creating Computational Artifacts, Communicating About Computing: 5.2, 7.3
3.AP.PD.3	**Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.** *As students develop programs they should continuously test those programs to see that they do what was expected and fix (debug), any errors. Students should also be able to successfully debug simple errors in programs created by others. Identifying a mistake in a math problem, for example; Sally solved the following problem as 11, there were five groups with six apples in each. How many apples were there? Was she correct? Fix her mistake if she was incorrect.* Practice(s): Testing and Refining Computational Artifacts: 6.1, 6.2
3.AP.PD.4	With teacher guidance, students take on varying roles, **when collaborating with peers during the design, implementation, and review stages of program development.** *Collaborative computing is the process of performing a computational task by working in pairs or on teams. Because it involves asking for the contributions and feedback of others, effective collaboration can lead to better outcomes than working independently. Students should take turns in different roles during program development, such as note taker, facilitator, program tester, or "driver" of the computer.* Practice(s): Collaborating Around Computing: 2.2
3.AP.PD.5	**Describe choices made during program (procedure) development using code comments, presentations, and/or demonstrations.** *People communicate about their code to help others understand and use their programs. Another purpose of communicating one's design choices is to show an understanding of one's work. These explanations could manifest themselves as in-line code comments for collaborators and assessors, or as part of a summative presentation, such as a code walk-through or coding journal. Students work together to explain the steps in their procedure.* Practice(s): Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
3.IC.C.1	**Identify computing technologies that have changed the world.** *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. With guidance from their teacher, students discuss 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, in areas, such as robotics, wireless Internet, mobile computing devices, GPS systems, wearable computing, or how social media has influenced social and political changes.* Practice(s): Recognizing and Defining Computational Problems: 3.1
3.IC.C.2	**With teacher guidance, brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.** *The development and modification of computing technology are driven by people's needs and wants and can affect groups differently. 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. For example, 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 own tastes.* Practice(s): Fostering an Inclusive Computing Culture: 1.2
Subconcept: Social Interactions (SI)	
3.IC.SI.1	**Seek opportunities for local collaboration to facilitate communication and innovation.** *Computing influences many social institutions such as family, education, religion, and the economy. People can work in different places and at different times to collaborate and share ideas when they use technologies that reach across the globe. Computing provides the possibility for collaboration and sharing of ideas and allows the benefit of diverse perspectives. These social interactions affect how local and global groups interact with each other, and alternatively, these interactions can change the nature of groups. For example, a class can discuss ideas in the same class, school, or in another state or nation through interactive webinars or pen pals.* Practice(s): Fostering an Inclusive Computing Culture: 1.1
Subconcept: Safety, Law, and Ethics (SLE)	
3.IC. SLE.1	**Use material that is publicly available and/or permissible to use.** *Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media, such as video, photos, and music, on the Internet, creates the opportunity for unauthorized use, such as online piracy and disregard of copyrights. Students should consider the licenses for the 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.* Practice(s): Communicating About Computing: 7.3

Fourth Grade

By the end of fourth grade, the computer literate student refines their skills as they construct programs and use algorithms to accomplish a task. Analyzing a variety of hardware and software tools, students further develop their computational thinking and problem solving skills. Working independently and collaboratively students decompose larger problems into smaller tasks. Students understand that responsible computing use includes protecting personal information and respecting the rights of others.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
4.CS.D.1	**With teacher guidance, model how internal and external parts of computing** *connect multiple devices in a computing system*. *Computing devices may be connected to other devices or components to extend their capabilities, such as sensing and sending information. Connections can take many forms, such as physical or wireless. Together, devices and components form a system of interdependent parts that interact for a common purpose. Students model the process that happens when multiple devices form a system* *Practice(s): Communicating About Computing, Recognizing and Defining Computational Problems, Creating Computational Artifacts: 7.3, 3.1, 5.2*
Subconcept: Hardware and Software (HS)	
4.CS.HS.1	**Recognize that bits serve as the basic unit of data in computing systems and can represent a variety of information.** *Hardware and software communicate in binary digits commonly represented in 0s and 1s. Students discuss how bits are a unit of data.* *Practice(s): Communicating About Computing: 7.2*
4.CS.HS.2	**Recognize that a single piece of hardware can accomplish different tasks depending on** *its* **software.** *A photo filter application (software) works with a camera (hardware) to produce a variety of effects that change the appearance of an image. This image is transmitted and stored as bits, or binary digits, which are commonly represented as 0s and 1s. All information, including instructions, is encoded as bits. Students discuss a variety of software and hardware that work together.* *Practice(s): Practice(s): Communicating About Computing: 7.2*

Subconcept: Troubleshooting (T)	
4.CS.T.1	**Develop** *and apply simple troubleshooting strategies* **to solve simple hardware and software problems.** *Although computing systems may vary, common troubleshooting strategies such as checking connections and power, or swapping a working part in place of a potentially defective part, can be used to restore functionality. Restarting a device (rebooting) is commonly effective because it resets the machine. Because computing devices are composed of an interconnected system of hardware and software, troubleshooting strategies may need to address both.* *Practice(s): Recognizing and Defining Computational Problems, Collaborating Around Computing: 3.1, 2.4*

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
4.NI.C.1	**Discuss real-world cybersecurity problems and how personal information can be protected.** *Just as we protect our personal property online, we also need to protect our devices and the information stored on them. Information can be protected using various security measures. These measures can be physical and/or digital. For example, discussion topics could be based on current events related to cybersecurity or topics that are applicable to students and the programs/devices they use.* *Practice(s): Communicating about Computing, Recognizing and Defining Computational Problems: 7.2, 3.3*
Subconcept: Network, Communication, and Organization (NCO)	
4.NI. NCO.1	**Model how information is decomposed, transmitted as packets through multiple devices over networks and reassembled at the destination.** *There are physical paths for communicating information, such as Ethernet cables, and wireless paths, such as Wi-Fi. Often, information travels on a combination of physical and wireless paths. Information is broken down into smaller pieces called packets, which are sent over the network and reassembled at the destination. Routers and switches are used to properly send packets across paths to their destinations.* *Practice(s): Developing and Using Abstractions: 4.4*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
4.DA. CVT.1	**Select tools to collect, organize, and present data visually to highlight relationships and support a claim.** *Tools are chosen based upon the type of measurement they use as well as the type of data people wish to observe. Organizing data can make interpreting and communicating it to others easier.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts: 4.1, 5.1*

Subconcept: Storage (S)	
4.DA.S.1	**Recognize different file extensions and the different amounts of storage required for each type.** *Music, images, video, and text require different amounts of storage. Video will often require more storage than music or images alone because video combines both. Students discuss common file extensions, such as .doc, .pdf, and .jpeg and give examples of files that require different amounts of storage.* *Practice(s): Communicating About Computing: 7.2*
Subconcept: Inference and Models (IM)	
4.DA.IM.1	**Use a computational tool to manipulate data to draw conclusions, make predictions, and answer questions.** *People use data to highlight or propose cause-and-effect relationships and predict outcomes. Basing inferences or predictions on data does not guarantee their accuracy; the data must be relevant and of sufficient quantity.* *Practice(s): Communicating about Computing, Creating Computational Artifacts, Collaborate around Computing: 7.2, 5.2, 2.4*

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
4.AP.A.1	**Compare and refine multiple algorithms for the same task and determine which is the most effective.** Different algorithms can achieve the same result, though sometimes one algorithm might be most appropriate for a specific situation. Students should be able to look at different ways to solve the same task and decide which would be the best solution. For example, students might compare algorithms that describe how to get ready for school or how to tie their shoes. Students could use a map and plan multiple algorithms to get from one point to another. They could look at routes suggested by mapping software and change the route to something that would be better, based on which route is shortest or fastest or would avoid a problem. Another example might be to write different algorithms to draw a regular polygon and determine which algorithm would be the easiest to modify or repurpose to draw a different polygon. *Practice(s):* Testing and Refining Computational Artifacts, Recognizing and Defining Computational Problems: 6.3
Subconcept: Variables (V)	
4.AP.V.1	**Create programs that use variables to store and modify data** *Variables are used to store and modify data. At this level, understanding how to use variables is sufficient, without a fuller understanding of the technical aspects of variables (such as identifiers and memory locations. Students may use mathematical operations to add to the score of a game or subtract from the number of lives in a game. Programs can imply either digital or paper-based designs.* *Practice(s):* Creating Computational Artifacts: 5.2

Subconcept: Control (C)	
4.AP.C.1	**Create programs that include sequences, events, loops, and/or conditionals.** *Control structures specify the order (sequence) in which instructions are executed within a program and can be combined to support the creation of more complex programs. If dialogue is not sequenced correctly when programming a simple animated story, the story will not make sense. Events allow portions of a program to run based on a specific action. Students could write a program to explain the water cycle and when a specific component is clicked (event), the program would show information about that part of the water cycle. Loops allow for the repetition of a sequence of code multiple times. In a program that produces an animation about a famous historical character, students could use a loop to have the character walk across the screen as they introduce themselves. Conditionals allow for the execution of a portion of code in a program when a certain condition is true. Students could write a math game that asks multiplication fact questions and then uses a conditional to check whether or not the answer that was entered is correct.* Practice(s): Creating Computational Artifacts: 5.2
Subconcept: Modularity (M)	
4.AP.M.1	**Decompose problems into smaller, manageable subproblems to facilitate the program development process.** *Decomposition is the act of breaking down a task into multiple simpler tasks. Decomposition also enables different people to work on different parts at the same time. For example, students could create an animation by separating a story into different scenes. For each scene, they would select a background, place characters, and program actions.* Practice(s): Recognizing and Defining Computational Problems: 3.2
4.AP.M.2	**Modify, remix, or incorporate portions of an existing program into one's own work to add more advanced features.** *Programs can be broken down into smaller parts, which can be incorporated into new or existing programs. For example, students could modify prewritten code from a single-player game to create a two-player game with slightly different rules, remix and add another scene to an animated story, use code to make a ball bounce from another program in a new basketball game, or modify an image created by another student.* Practice(s): Creating Computational Artifacts: 5.3
Subconcept: Program Development (PD)	
4.AP.PD.1	**Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences.** *Planning is an important part of the iterative process of program development. Students outline key features, time and resource constraints, and user expectations. Students should document the plan as, for example, a storyboard, flowchart, pseudocode, or story map.* Practice(s): Fostering an Inclusive Computing Culture, Creating Computational Artifacts: 1.1, 5.1

4.AP.PD.2	**Observe intellectual property rights and give appropriate attribution when creating or remixing programs.** *Intellectual property rights can vary by country but copyright laws give the creator of a work a set of rights that prevents others from copying the work and using it in ways that the creator may not like. Students should identify instances of remixing, when ideas are borrowed and iterated upon, and credit the original creator. Students should also consider common licenses that place limitations or restrictions on the use of computational artifacts, such as images and music downloaded from the Internet. At this stage, attribution should be written in the format required by the teacher and should always be included on any programs shared online.* Practice(s): Creating Computational Artifacts, Communicating About Computing: 5.2, 7.3
4.AP.PD.3	**Test and debug (identify and fix errors) a program/app or algorithm to ensure it runs as intended.** *As students develop programs they should continuously test those programs to see that they do what was expected and fix (debug), any errors. Students should also be able to successfully debug simple errors in programs created by others.* Practice(s): Testing and Refining Computational Artifacts: 6.1, 6.2
4.AP.PD.4	**With teacher guidance, students take on varying roles when collaborating with peers during the design, implementation, and review stages of program development.** *Collaborative computing is the process of performing a computational task by working in pairs or on teams. Because it involves asking for the contributions and feedback of others, effective collaboration can lead to better outcomes than working independently. Students should take turns in different roles during program development, such as note taker, facilitator, program tester, or "driver" of the computer.* Practice(s): Collaborating Around Computing: 2.2
4.AP.PD.5	**Describe choices made during program development using code comments, presentations, and/or demonstrations.** *People communicate about their code to help others understand and use their programs. Another purpose of communicating one's design choices is to show an understanding of one's work. These explanations could manifest themselves as in-line code comments for collaborators and assessors, or as part of a summative presentation, such as a code walk-through or coding journal.* Practice(s): Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
4.IC.C.1	**Identify and discuss computing technologies that have changed the world.** *New computing technology is created and existing technologies are modified for many reasons, including to order to increase their benefits, decrease their risks, and meet societal needs. Students, with guidance from their teacher, should discuss topics that relate to the history of technology and the changes in the world due to technology. Students discuss how culture influences changes in technology. Topics could be based on current news content in areas, such as robotics, wireless Internet, mobile computing devices, GPS systems, wearable computing, or how social media has influenced social and political changes.* Practice(s): Recognizing and Defining Computational Problems: 3.1

4.IC.C.2	**Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.** *The development and modification of computing technology are driven by people's needs and wants and can affect groups differently. 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. For example, 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 share their own tastes.* Practice(s): Fostering an Inclusive Computing Culture: 1.2
Subconcept: Social Interactions (SI)	
4.IC.SI.1	**Seek opportunities for local and nationally collaboration to facilitate communication and innovation.** *Computing influences many social institutions such as family, education, religion, and the economy. People can work in different places and at different times to collaborate and share ideas when they use technologies that reach across the globe. Computing provides the possibility for collaboration and sharing of ideas and allows the benefit of diverse perspectives. These social interactions affect how local and global groups interact with each other, and alternatively, these interactions can change the nature of groups. For example, a class can discuss ideas in the same class, school, or in another state or nation through interactive webinars.* Practice(s): Fostering an Inclusive Computing Culture: 1.1
Subconcept: Safety, Law, and Ethics (SLE)	
4.IC.SLE.1	**Use material that is publicly available and/or permissible to use.** *Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media, such as video, photos, and music, on the Internet, creates the opportunity for unauthorized use, such as online piracy and disregard of copyrights. Students should consider the licenses for the 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.* Practice(s): Communicating About Computing: 7.3

Fifth Grade

The computer literate student independently and collaboratively constructs programs and uses algorithms to accomplish real world tasks. Students continue to decompose larger problems into smaller tasks, recognize the impacts of computing and computing devices and model how computing systems work. The accurate use of terminology as well as the responsible use of technology will continue with emphasis on intellectual property rights.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
5.CS.D.1	**Analyze and model how internal and external parts of computing devices communicate as a system.** *Computing devices often depend on other devices or components. A robot depends on a physically attached light sensor to detect changes in brightness, whereas the light sensor depends on the robot for power. A smartphone can use wirelessly connected headphones to send audio information, and the headphones require a music source.* *Practice(s): Communicating About Computing, Recognizing and Defining Computational Problems, Creating Computational Artifacts, Testing and Refining Computational Artifacts: 7.2, 3.2, 5.2, 6.3*
5.CS.D.2	**Explain how computing devices affect humans in positive and negative ways.** *The use of computing devices has potential consequences, especially with regard to privacy and security.* *Practice(s): Fostering an Inclusive Computing Culture, Communicating About Computing: 1.1, 7.2*
Subconcept: Hardware and Software (HS)	
5.CS.HS.1	**Model how information is transformed into binary digits to be stored or processed.** *Hardware and software communicate in binary digits commonly represented in 0s and 1s. Information is transformed into binary digits, for example a song is stored as more binary digits than a photo.* *Practice(s): Communicating About Computing, Creating Computational Artifacts: 7.2, 5.2*
5.CS.HS.2	**Demonstrate and explain how hardware can accomplish different tasks depending on the software.** *In order for a person to accomplish tasks with a computer, both hardware and software are needed. At this stage, a model should only include the basic elements of a computer system, such as input, output, processor, sensors, and storage. Students could draw a model on paper or in a drawing program, program a animation to demonstrate it, or demonstrate it by acting it out in some way.* *Practice(s): Communicating About Computing, Creating Computational Artifacts: 7.2, 5.3*

Subconcept: Troubleshooting (T)	
5.CS.T.1	**Apply potential solutions and solve simple hardware and software problems using common troubleshooting strategies.** *Although computing systems may vary, common troubleshooting strategies such as checking connections in power or swapping a working part in place of a potentially defective part can be used to restore functionality. Restarting a device (rebooting) is commonly effective because it resets the computer machine. Computing devices are composed of an interconnected system of hardware and software, troubleshooting strategies may need to address both. In fifth grade students begin troubleshooting complex problems through networks, routers, and switches.* *Practice(s): Recognizing and Defining Computational Problems, Developing and Using Abstractions: 3.2, 4.1*

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
5.NI.C.1	**Identify solutions to real-world cybersecurity problems and how personal information can be protected.** *Just as we protect our personal property online, we also need to protect our devices and the information stored on them. Information can be protected using various security measures. These measures can be physical and/or digital. For example, discussion topics could be based on current events related to cybersecurity or topics that are applicable to students and the programs/devices they use.* *Practice(s): Communicating about Computing, Recognizing and Defining Computational Problems: 7.2, 3.1*
Subconcept: Network, Communication, and Organization (NCO)	
5.NI. NCO.1	**Analyze the advantages and disadvantages of various network types.** *There are physical paths for communicating information, such as Ethernet cables, and wireless paths, such as Wi-Fi or cellular data. The choice of device and type of connection will affect the path information travels and the potential bandwidth (the capacity to transmit data or bits in a given timeframe).* *Practice(s): Developing and Using Abstractions, Collaborating Around Computing: 4.1, 2.4*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
5.DA.CVT.1	**Select tools to collect, organize, manipulate, and present data visually through multiple representations to highlight relationships and support a claim.** *Tools are chosen based upon the type of measurement they use as well as the type of data people wish to observe. Organizing data can make interpreting and communicating it to others easier. Data points can be clustered by a number of commonalities. The same data could be manipulated and displayed in different formats to emphasize particular aspects or parts of the data set.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts: 4.1, 5.1*
Subconcept: Storage (S)	
5.DA.S.1	**Discuss different file extensions and how they are stored and retrieved on a computing device.** *Music, images, video, and text require different amounts of storage. Video will often require more storage than music or images alone because video combines both. For example, two pictures of the same object can require different amounts of storage based upon their resolution.* *Practice(s): Communicating About Computing: 7.2*
Subconcept: Inference and Models (IM)	
5.DA.IM.1	**Use data to propose cause-and-effect relationships, predict outcomes, or communicate an idea.** *People use data to highlight or propose cause-and-effect relationships and predict outcomes. Basing inferences or predictions on data does not guarantee their accuracy; the data must be relevant and of sufficient quantity.* *Practice(s): Communicating About Computing, Developing and Using Abstractions, Collaborate around Computing: 7.1, 4.3, 2.4*

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
5.AP.A.1	**Compare, test, and refine multiple algorithms for the same task and determine which is the most effective.** Different algorithms can achieve the same result, though sometimes one algorithm might be most appropriate for a specific situation. Students should be able to look at different ways to solve the same task and decide which would be the best solution. For example, students could use a map and plan multiple algorithms to get from one point to another. They could look at routes suggested by mapping software and change the route to something that would be better, based on which route is shortest or fastest or would avoid a problem. Students might compare algorithms that describe how to get ready for school. Another example might be to write different algorithms to draw a regular polygon and determine which algorithm would be the easiest to modify or repurpose to draw a different polygon. Students test their algorithms to verify their effectiveness. *Practice(s):* Testing and Refining Computational Artifacts, Recognizing and Defining Computational Problems: 6.1, 6.3

Subconcept: Variables (V)	
5.AP.V.1	**Recognizing that the data type determines the values that can be stored and the operations that can be performed on the data.** *Variables are the vehicle through which computer programs store different types of data. At this level, understanding how to use variables is sufficient, without a fuller understanding of the technical aspects of variables (such as identifiers and memory locations). Data types vary by programming language, but many have types for numbers and text. Examples of operations associated with those types include multiplying numbers and combining text. Some visual, block-based languages do not have explicitly declared types but still have certain operations that apply only to particular types of data in a program. Programs can imply either digital or paper-based designs. Students* create programs that use variables to store and modify data. *Practice(s):* Creating Computational Artifacts: 5.2
Subconcept: Control (C)	
5.AP.C.1	**Create programs that include sequences, events, loops, and conditionals.** *Control structures specify the order (sequence) in which instructions are executed within a program and can be combined to support the creation of more complex programs. For example, if dialogue is not sequenced correctly when programming a simple animated story, the story will not make sense. Events allow portions of a program to run based on a specific action. For example, students could write a program to explain the water cycle and when a specific component is clicked (event), the program would show information about that part of the water cycle. Loops allow for the repetition of a sequence of code multiple times. For example, in a program that produces an animation about a famous historical character, students could use a loop to have the character walk across the screen as they introduce themselves. Conditionals allow for the execution of a portion of code in a program when a certain condition is true. For example, students could write a math game that asks multiplication fact questions and then uses a conditional to check whether or not the answer that was entered is correct.* Practice(s): Creating Computational Artifacts: 5.1
Subconcept: Modularity (M)	
5.AP.M.1	**Decompose problems into manageable subproblems to facilitate the program development process.** *Decomposition is the act of breaking down a task into multiple, simpler tasks. Decomposition also enables different people to work on different parts at the same time. Students could create an animation by separating a story into different scenes. For each scene, they would select a background, place characters, and program actions.* Practice(s): Recognizing and Defining Computational Problems: 3.2

5.AP.M.2	**Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.** *Programs can be broken down into smaller parts, which can be incorporated into new or existing programs. For example, students could modify prewritten code from a single-player game to create a two-player game with slightly different rules, remix and add another scene to an animated story, use code to make a ball bounce from another program in a new basketball game, or modify an image created by another student.* Practice(s): Creating Computational Artifacts: 5.3
Subconcept: Program Development (PD)	
5.AP.PD.1	**Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences.** *Planning is an important part of the iterative process of program development. Students outline key features, time and resource constraints, and user expectations. Students should document the plan as, for example, a storyboard, flowchart, pseudocode, or story map.* Practice(s): Fostering an Inclusive Computing Culture, Creating Computational Artifacts: 1.1, 5.1
5.AP.PD.2	**Observe intellectual property rights and give appropriate attribution when creating or remixing programs.** *Intellectual property rights can vary by country but copyright laws give the creator of a work a set of rights that prevents others from copying the work and using it in ways that the creator may not like. Students should identify instances of remixing, when ideas are borrowed and iterated upon, and credit the original creator. Students should also consider common licenses that place limitations or restrictions on the use of computational artifacts, such as images and music downloaded from the Internet. At this stage, attribution should be written in the format required by the teacher and should always be included on any programs shared online.* Practice(s): Creating Computational Artifacts, Communicating About Computing: 5.2, 7.3
5.AP.PD.3	**Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.** *As students develop programs they should continuously test those programs to see that they do what was expected and fix (debug), any errors. Students should also be able to successfully debug simple errors in programs created by others.* Practice(s): Testing and Refining Computational Artifacts: 6.1, 6.2
5.AP.PD.4	**Take on varying roles when collaborating with peers during the design, implementation, and review stages of program development.** *Collaborative computing is the process of performing a computational task by working in pairs or on teams. Because it involves asking for the contributions and feedback of others, effective collaboration can lead to better outcomes than working independently. Students should take turns in different roles during program development, such as note taker, facilitator, program tester, or "driver" of the computer.* Practice(s): Collaborating Around Computing: 2.2

5.AP.PD.5	**Describe choices made during program development using code comments, presentations, and demonstrations.** *People communicate about their code to help others understand and use their programs. Another purpose of communicating one's design choices is to show an understanding of one's work. These explanations could manifest themselves as in-line code comments for collaborators and assessors, or as part of a summative presentation, such as a code walk-through or coding journal.* Practice(s): Communicating About Computing: 7.2

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
5.IC.C.1	**Discuss computing technologies that have changed the world.** *New computing technology is created and existing technologies are modified for many reasons, including in order to increase their benefits, decrease their risks, and meet societal needs. Students discuss topics that relate to the history of technology and the changes in the world due to technology. Students discuss how culture influences changes in technology. Topics could be based on current news content in areas, such as robotics, wireless Internet, mobile computing devices, GPS systems, wearable computing, or how social media has influenced social, cultural and political changes.* Practice(s): Recognizing and Defining Computational Problems: 3.1
5.IC.C.2	**Design ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.** *The development and modification of computing technology are driven by people's needs and wants and can affect groups differently. 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. For example, 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 own tastes.* Practice(s): Fostering an Inclusive Computing Culture: 1.2
Subconcept: Social Interactions (SI)	
5.IC.SI.1	**Seek opportunities for local and global collaboration to facilitate communication and innovation.** *Computing influences many social institutions such as family, education, religion, and the economy. People can work in different places and at different times to collaborate and share ideas when they use technologies that reach across the globe. Computing provides the possibility for collaboration and sharing of ideas and allows the benefit of diverse perspectives. These social interactions affect how local and global groups interact with each other, and alternatively, these interactions can change the nature of groups. For example, a class can discuss ideas in the same class, school, or in another state or nation through interactive webinars.* Practice(s): Fostering an Inclusive Computing Culture: 1.1

Subconcept: Safety, Law, and Ethics (SLE)	
5.IC.SLE.1	**Use public domain or creative commons media, and refrain from copying or using material created by others without permission.** *Ethical complications arise from the opportunities provided by computing. The ease of sending and receiving copies of media, such as video, photos, and music, on the Internet, creates the opportunity for unauthorized use, such as online piracy and disregard of copyrights. Students should consider the licenses for the 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.* Practice(s): Communicating About Computing: 7.3

Sixth Grade

Students will deepen their understanding of computing devices as they begin to explore the application of computer science knowledge to real-world problems. The computer science literate student will explore how devices process data and address potential problems. They will investigate the process of data transmission and the need for security concerns. Individually and in small groups they will consider reliability and validity of computational models used to process and represent data. They will also identify possible solutions to programming challenges based on the user's needs. Successful students can implement programming skills using parameters to meet a project's goal and timeline. Computer science literate students will be able to identify the advantages and disadvantages of computing technologies in everyday activities, including bias, accessibility, and privacy.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
6.CS.D.1	**Compare computing device designs based on how humans interact with them.** *The study of human–computer interaction (HCI) can improve the design of devices, including both hardware and software. Teachers can guide students to consider usability through several lenses. For example, teachers can have students compare computing devices that have different methods of human interaction (keyboard/mouse/trackpad, touchscreen, voice commands, facial recognition/fingerprint sensing, etc)* *Practice(s): Recognizing and Defining Computational Problems: 3.3*
Subconcept: Hardware and Software (HS)	
6.CS.HS.1	**Explain how hardware and software can be used to collect and exchange data.** *Collecting and exchanging data involves input, output, storage, and processing. For example, students can describe how components of a device are used to collect data. Such components might include: accelerometer, Global Position System (GPS), microphone, fingerprint sensor, etc.* Practice(s): Creating Computational Artifacts: 5.1
Subconcept: Troubleshooting (T)	
6.CS.T.1	**Identify problems that can occur in computing devices and their components within a system.** *Since a computing device may interact with interconnected devices within a system, problems may not be due to the computing device itself but to devices or components connected to it. For example, students can discuss why the internet might not be working on their device. It could be airplane mode, no signal (wifi or mobile data), component malfunction, interference, etc.* Practice(s): Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
6.NI.C.1	**Identify multiple methods of encryption to secure the transmission of information.** *Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet. The students will identify different methods of encoding and decoding for encryptions used to hide or secure information. Examples of encryption methods could include: Substitution ciphers (mono-alphabetic or polyalphabetic) and Caesar ciphers.* *Practice(s):* Developing and Using Abstractions: 4.4
6.NI.C.2	**Identify different physical and digital security measures that protect electronic information.** *Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. Examples of digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol such as HTTPS to ensure secure data transmission.* Practice(s): Communicating About Computing: 7.2
Subconcept: Network, Communication, and Organization (NCO)	
6.NI. NCO.1	**Discuss how protocols are used in transmitting data across networks and the Internet.** *Protocols are rules that define how messages are sent between computers. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to check for and handle errors in transmission. The priority at this level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected. For example, students could discuss their protocols or processes for communicating with their friends. They can discuss handshakes, turn-taking, whispering vs yelling, etc. The students can compare these protocols with how computers communicate.* Practice(s): Developing and Using Abstractions: 4.4

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
6.DA. CVT.1	**Compare different computational tools used to collect, analyze and present data that is meaningful and useful.** *As students continue to explore ways to gather, organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose. Examples of these computational tools could include Microsoft Excel and Google Sheets.* Practice(s): Testing and Refining Computational Artifacts: 6.3

Subconcept: Storage (S)	
6.DA.S.1	**Identify multiple encoding schemes used to represent data, including binary and ASCII.** *Students should explore the same data in multiple ways. For example, students could compare representations of the same color using binary, RGB values, hex codes (low-level representations), or forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).* Practice(s): Developing and Using Abstractions: 4.0
Subconcept: Inference and Models (IM)	
6.DA.IM.1	**Discuss the validity of a computational model based on the reliability of the data.** *A model may be a programmed simulation of events or a representation of how various data is related. In order to refine a model, students need to consider which data points are relevant, how data points relate to each other, and if the data is accurate. For example, students can discuss how valid a poll (political, social media, student poll) is based on how reliable the data is. Students will discuss if predictions can be made based on the poll.* Practice(s): Creating Computational Artifacts, Developing and Using Abstractions: 5.3, 4.4

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
6.AP.A.1	**Identify planning strategies such as flowcharts or pseudocode, to simulate algorithms that solve problems.** *Students should be able to select planning strategies to organize and sequence an algorithm that addresses a problem, even though they may not actually program the solutions. For example, students might express an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost.* *Practice(s): Developing and Using Abstractions: 4.4, 4.1*
Subconcept: Variables (V)	
6.AP.V.1	**Identify variables that represent different data types and perform operations on their values.** *A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. When planning and developing programs, students should decide when and how to declare and name new variables. Students should use naming conventions to improve program readability. For example, possible operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.* *Practice(s): Creating Computational Artifacts: 5.1, 5.2*

Subconcept: Control (C)	
6.AP.C.1	**Design programs that combine control structures, including nested loops and compound conditionals.** *Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another. For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.* *Practice(s): Creating Computational Artifacts: 5.1, 5.2*
Subconcept: Modularity (M)	
6.AP.M.1	**Decompose problems into parts to facilitate the design, implementation, and review of programs.** *In order to understand how programs are designed and used, problems should be broken down into smaller pieces that are easier to work with.* *Practice(s): Recognizing and Defining Computational Problems: 3.2*
6.AP.M.2	**Use procedures to organize code and make it easier to reuse.** *Students should compare procedures and/or functions that are used multiple times within a program to repeat groups of instructions. These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as "drawCircle." By adding a radius parameter, the user can easily draw circles of different sizes.* *Practice(s): Developing and Using Abstractions: 4.1, 4.3*
Subconcept: Program Development (PD)	
6.AP.PD.1	**Seek and incorporate feedback from team members and users to refine a solution that meets user needs.** *Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language. Students should seek diverse perspectives throughout the design process to improve their computational artifacts. For example, considerations of the end-user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.* *Practice(s): Collaborating Around Computing, Fostering an Inclusive Computing Culture: 2.3, 1.1*
6.AP.PD.2	**Incorporate existing code into programs and give attribution.** *Building on the work of others enables students to produce more interesting and powerful creations. Students should use portions of code in their own programs and websites. For example, when creating a side-scrolling game, students may incorporate portions of code that create a realistic jump movement from another person's game. They may also import Creative Commons-licensed images to use in the background. Students should give attribution to the original creators to acknowledge their contributions.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts, Communicating About Computing: 4.2, 5.2, 7.3*

6.AP.PD.3	**Test programs using a range of inputs and identify expected outputs.** *At this level, testing should become a deliberate process that is more iterative, systematic, and proactive. For example, having students enter data into Microsoft Excel or Google Sheets to see what outputs are produced.* *Practice(s): Testing and Refining Computational Artifacts: 6.1*
6.AP.PD.4	**Maintain a timeline with specific tasks while collaboratively developing computational artifacts.** *Collaboration is a common and crucial practice in program development. Often, many individuals and groups work on the interdependent parts of a project together. For example, students should assume pre-defined roles within their teams and manage the project workflow using structured timelines.* *Practice(s): Collaborating Around Computing: 2.2*
6.AP.PD.5	**Document programs in order to make them easier to follow, test, and debug.** *Documentation allows creators and others to more easily use and understand a program. Students should provide documentation for end users that explains their artifacts and how they function. For example, students could provide a project overview and clear user instructions. They should also incorporate comments into their programs and communicate their process throughout the design, development, and user experience phases.* *Practice(s): Communicating About Computing: 7.2*

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
6.IC.C.1	**Identify some of the tradeoffs associated with computing technologies that can affect people's everyday activities and career options.** Advancements in computer technology are neither wholly positive nor negative. However, the ways that people use computing technologies have tradeoffs. Students should consider current events related to broad ideas, including privacy, communication, and automation. For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will reduce the number of taxi and shared-ride drivers, but will create more software engineering and cybersecurity jobs. Practice(s): Communicating About Computing: 7.2
6.IC.C.2	**Identify issues of bias and accessibility in the design of existing technologies.** Students should identify, with teacher's guidance, how various technological tools have different levels of usability. For example, facial recognition software that works better for certain skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population. For example, ways of improving accessibility of technological tools can include allowing a user to change font sizes and colors. This will make an interface usable for people with low vision and benefits users in situations, such as in bright daylight or a dark room. Practice(s): Fostering an Inclusive Computing Culture: 1.2

Subconcept: Social Interactions (SI)	
6.IC.SI.1	**Identify the advantages of creating a computational product by collaborating with others using digital technologies.** Different digital technologies can be used to gather services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities). For example, a group of students could combine animations to produce a digital community creation. They could also solicit feedback from many people though use of online communities and electronic surveys. Practice(s): Collaborating Around Computing, Creating Computational Artifacts: 2.4, 5.2
Subconcept: Safety, Law, and Ethics (SLE)	
6.IC. SLE.1	**Describe how some digital information can be public or can be kept private and secure.** Sharing information online can help establish, maintain, and strengthen connections between people. Students should consider current events related to broad ideas, including privacy, communication, and automation. For example, students can discuss how their privacy settings on social media affect who can view their information. Practice(s): Communicating About Computing: 7.2

Seventh Grade

Students will deepen their understanding of computing devices as they continue to explore the application of computer science knowledge to real-world problems. The computer science literate student will evaluate how devices process data and address potential problems through project development. They will investigate the need for security measures and protocols for data transmission. Successful students will be able to integrate reliable and valid computational models to process data that is meaningful and useful. They can evaluate possible solutions to programming challenges based on the user's needs. Students will implement programming skills using parameters to meet a project's goal and timeline. Computer science literate students will be able to compare and contrast possible solutions utilizing computing technologies to solve everyday challenges, taking into consideration bias, accessibility, and privacy.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
7.CS.D.1	**Identify some advantages, disadvantages, and consequences with the design of computer devices based on an analysis of how users interact with devices.** *The study of human–computer interaction (HCI) can improve the design of devices, including both hardware and software. Teachers can guide students to consider usability through several lenses, including accessibility, ergonomics, and learnability. For example, assistive devices provide capabilities such as scanning written information and converting it to speech.* *Practice(s): Recognizing and Defining Computational Problems: 3.3*
Subconcept: Hardware and Software (HS)	
7.CS.HS.1	**Design projects that combine hardware and software to collect and exchange data.** *Collecting and exchanging data involves input, output, storage, and processing. When possible, students should select the hardware and software components for their project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics. For example, components for a mobile app could include: accelerometer, Global Position System (GPS), microphone, fingerprint sensor, etc.* Practice(s): Creating Computational Artifacts: 5.1
Subconcept: Troubleshooting (T)	
7.CS.T.1	**Evaluate strategies to fix problems with computing devices and their components within a system.** *Since a computing device may interact with interconnected devices within a system, problems may not be due to the computing device itself but to devices or components connected to it. For example, troubleshooting strategies include following a troubleshooting flow diagram, making changes to software to see if hardware will work, checking connections and settings, and swapping in working components.* Practice(s): Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
7.NI.C.1	**Evaluate multiple methods of encryption for the secure transmission of information.** *Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet. The students will examine the different levels of complexity used to hide or secure information. For example, students explore different methods of securing messages using methods such as Caesar ciphers or steganography (i.e., hiding messages inside a picture or other data).* *Practice(s):* Developing and Using Abstractions: 4.4
7.NI.C.2	**Explain how physical and digital security measures protect electronic information.** *Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. For example, digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol such as HTTPS to ensure secure data transmission.* Practice(s): Communicating About Computing: 7.2
Subconcept: Network, Communication, and Organization (NCO)	
7.NI. NCO.1	**Compare and contrast models to understand the many protocols used for data transmission.** *Protocols are rules that define how messages are sent between computers. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to check for and handle errors in transmission. For example, students should examine how data is sent using protocols to choose the fastest path, to deal with missing information, and to deliver sensitive data securely. The priority at this level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected.* Practice(s): Developing and Using Abstractions: 4.4

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
7.DA. CVT.1	**Collect and analyze data using computational tools to create models that are meaningful and useful.** *As students continue to build on their ability to organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose. For example, students use computational tools such as Microsoft Excel or Google Sheets to solve a problem that is relevant and meaningful.* Practice(s): Testing and Refining Computational Artifacts: 6.3

Subconcept: Storage (S)	
7.DA.S.1	**Use multiple encoding schemes to represent data, including binary and ASCII.** *Students should represent the same data in multiple ways. For example, students could represent the same color using binary, RGB values, hex codes (low-level representations), as well as forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).* Practice(s): Developing and Using Abstractions: 4.0
Subconcept: Inference and Models (IM)	
7.DA.IM.1	**Use computational models and determine the reliability and validity of data they generate.** *A model may be a programmed simulation of events or a representation of how various data are related. To refine a model, students need to consider which data points are relevant, how data points relate to each other, and if the data are accurate. For example, students may make a prediction about how far a ball will travel based on a table of data related to the height and angle of a track.* Practice(s): Creating Computational Artifacts, Developing and Using Abstractions: 5.3, 4.4

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
7.AP.A.1	**Use planning strategies, such as flowcharts or pseudocode, to develop algorithms to address complex problems.** *Complex problems are problems that would be difficult for students to solve computationally. Students should use pseudocode and/or flowcharts to organize and sequence an algorithm that addresses a complex problem, even though they may not actually program the solutions. For example, students might follow an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost.* *Practice(s): Developing and Using Abstractions: 4.4, 4.1*
Subconcept: Variables (V)	
7.AP.V.1	**Compare and contrast variables that represent different data types and perform operations on their values.** *A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. When planning and developing programs, students should decide when and how to declare and name new variables. Students should use naming conventions to improve program readability. For example, possible operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.* *Practice(s): Creating Computational Artifacts: 5.1, 5.2*

Subconcept: Control (C)	
7.AP.C.1	**Design and develop programs that combine control structures, including nested loops and compound conditionals.** *Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another. For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.* *Practice(s): Creating Computational Artifacts: 5.1*
Subconcept: Modularity (M)	
7.AP.M.1	**Decompose problems into parts to facilitate the design, implementation, and review of programs.** *In order to design, implement and evaluate programs students will break down problems into smaller parts. For example, students might code one part of a game at a time (sprites, motion, interaction, backgrounds, etc).* *Practice(s): Recognizing and Defining Computational Problems: 3.2*
7.AP.M.2	**Use procedures with parameters to organize code and make it easier to reuse.** *Students should use procedures and/or functions that are used multiple times within a program to repeat groups of instructions. These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as "drawCircle." By adding a radius parameter, the user can easily draw circles of different sizes.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts: 4.1, 4.3, 5.1, 5.2*
Subconcept: Program Development (PD)	
7.AP.PD.1	**Seek and incorporate feedback from team members and users to refine a solution that meets user needs.** *Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language. Students should begin to seek diverse perspectives throughout the design process to improve their computational artifacts. Considerations of the end-user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.* *Practice(s): Collaborating Around Computing, Fostering an Inclusive Computing Culture: 2.3, 1.1*
7.AP.PD.2	**Incorporate existing code and media into programs, and give attribution.** *Building on the work of others enables students to produce more interesting and powerful creations. Students should use portions of code and/or digital media in their own programs and websites. For example, when creating a side-scrolling game, students may incorporate portions of code that create a realistic jump movement from another person's game. They may also import Creative Commons-licensed images to use in the background. Students should give attribution to the original creators to acknowledge their contributions.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts, Communicating About Computing: 4.2, 5.2, 7.3*

7.AP.PD.3	**Systematically test and refine programs using a range of possible inputs.** *At this level, testing should become a deliberate process that is more iterative, systematic, and proactive students should begin to test programs by considering potential errors, such as what will happen if a user enters invalid input (e.g., negative numbers and 0 instead of positive numbers).* *Practice(s): Testing and Refining Computational Artifacts: 6.1*
7.AP.PD.4	**Distribute and execute tasks while maintaining a project timeline when collaboratively developing computational artifacts.** *Collaboration is a common and crucial practice in program development. Often, many individuals and groups work on the interdependent parts of a project together. Students should assume pre-defined roles within their teams and manage the project workflow using structured timelines. With teacher guidance, they will begin to create collective goals, expectations, and equitable workloads. For example, students may divide the design stage of a game into planning the storyboard, flowchart, and different parts of the game mechanics. They can then distribute tasks and roles among members of the team and assign deadlines.* *Practice(s): Collaborating Around Computing: 2.2*
7.AP.PD.5	**Document programs to make them easier to follow, test, and debug.** *Documentation allows creators and others to more easily use and understand a program. Students should provide documentation for end users that explains their artifacts and how they function. For example, students could provide a project overview and clear user instructions. They should also incorporate comments into their programs and communicate their process throughout the design, development, and user experience phases.* *Practice(s): Communicating About Computing: 7.2*

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
7.IC.C.1	**Explain how some of the tradeoffs associated with computing technologies can affect people's everyday activities and career options.** *Advancements in computer technology are neither wholly positive nor negative. However, the ways that people use computing technologies have tradeoffs. Students should consider current events related to broad ideas, including privacy, communication, and automation. For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will reduce the number of taxi and shared-ride drivers, but will create more software engineering and cybersecurity jobs.* Practice(s): Communicating About Computing: 7.2
7.IC.C.2	**Discuss how bias and accessibility issues can impact the functionality of existing technologies.** *Students should discuss the usability of various technology tools (e.g., apps, games, and devices) with the teacher's guidance. For example, facial recognition software that works better for certain skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population.* Practice(s): Fostering an Inclusive Computing Culture: 1.2

Subconcept: Social Interactions (SI)	
7.IC.SI.1	**Describe the process for creating a computational product by collaborating with others using digital technologies.** *Crowdsourcing can be used as a platform to gather services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities). For example, a group of students could combine animations to produce a digital community creation. They could also solicit feedback from many people though use of online communities and electronic surveys.* Practice(s): Collaborating Around Computing, Creating Computational Artifacts: 2.4, 5.2
Subconcept: Safety, Law, and Ethics (SLE)	
7.IC. SLE.1	**Identify the benefits and risks associated with sharing information digitally.** Sharing information online can help establish, maintain, and strengthen connections between people. For example, it allows artists and designers to display their talents and reach a broad audience. However, security attacks often start with personal information that is publicly available online. Social engineering is based on tricking people into revealing sensitive information and can be thwarted by being wary of attacks, such as phishing and spoofing. Practice(s): Communicating About Computing: 7.2

Eighth Grade

Students will apply their understanding of computing devices as they implement applications of computer science knowledge to real-world problems. The computer literate student will apply programming skills to process data and address problems using computing devices. They will implement security measures and protocols for data transmission to address vulnerabilities. They can also collect and represent reliable and valid computational models. Successful students can integrate possible solutions to programming challenges based on the user's needs. They will achieve this by implementing programming skills using parameters to meet a project's goal and timeline. Computer science literate students will be able to utilize computing technologies and develop possible solutions to solve everyday challenges, taking into consideration bias, accessibility, and privacy.

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
8.CS.D.1	**Improve the design of computing devices based on an analysis of how users interact them, and consider unintended consequences.** *The study of human–computer interaction (HCI) can improve the design of devices, including both hardware and software. Students should make recommendations for existing devices (e.g., a laptop, phone, or tablet) or design their own components or interface (e.g., create their own controllers). Teachers can guide students to consider usability through several lenses, including accessibility, ergonomics, and learnability. For example, assistive devices provide capabilities such as scanning written information and converting it to speech.* *Practice(s): Recognizing and Defining Computational Problems: 3.3*
Subconcept: Hardware and Software (HS)	
8.CS.HS.1	**Design and evaluate projects that combine hardware and software components to collect and exchange data.** *Collecting and exchanging data involves input, output, storage, and processing. When possible, students should select the hardware and software components for their project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics. For example, components for a mobile app could include: accelerometer, GPS, and speech recognition. The choice of a device that connects wirelessly through a Bluetooth connection versus a physical USB connection involves a tradeoff between mobility and the need for an additional power source for the wireless device.* Practice(s): Creating Computational Artifacts: 5.1

Subconcept: Troubleshooting (T)	
8.CS.T.1	**Systematically identify and develop strategies to fix problems with computing devices and their components.** *Since a computing device may interact with interconnected devices within a system, problems may not be due to the computing device itself but to devices or components connected to it. Just as pilots use checklists to troubleshoot problems with aircraft systems, students should use a similar, structured process to troubleshoot problems with computing systems and ensure that potential solutions are not overlooked. Examples of troubleshooting strategies include following a troubleshooting flow diagram, making changes to software to see if hardware will work, checking connections and settings, and swapping in working components.* Practice(s): Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
8.NI.C.1	**Apply multiple methods of encryption to model the secure transmission of information.** Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet. Students should encode and decode messages using a variety of encryption methods, and they should understand the different levels of complexity used to hide or secure information. For example, students could secure messages using methods such as Caesar cyphers or steganography (i.e., hiding messages inside a picture or other data). They can also model more complicated methods, such as public key encryption, through unplugged activities. *Practice(s):* Developing and Using Abstractions: 4.4
8.NI.C.2	**Evaluate how various physical and digital security measures protect electronic information and how a lack of such measures could lead to vulnerabilities.** Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. Examples of digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol such as HTTPS to ensure secure data transmission. Examples of vulnerabilities include password strength, awareness of how data is used, as well as threats to personal and professional data. Practice(s): Communicating About Computing: 7.2

Subconcept: Network, Communication, and Organization (NCO)	
8.NI. NCO.1	**Develop models to illustrate the role of protocols in transmitting data across networks and the Internet.** Protocols are rules that define how messages are sent. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to check for and handle errors in transmission. Students should model how data is sent using protocols to choose the fastest path, to deal with missing information, and to deliver sensitive data securely. For example, students can be given a data transmission scenario and asked to determine which protocol should be used and why. The priority at this level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected. Practice(s): Developing and Using Abstractions: 4.4

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
8.DA. CVT.1	**Collect data using computational tools and transform the data to make it more meaningful and useful.** *As students continue to build on their ability to organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose. Students should transform data to remove errors, highlight or expose relationships, and/or make it easier for computers to process. Data cleaning is an important transformation for ensuring consistent format and reducing noise and errors (e.g., removing irrelevant responses in a survey). An example of a transformation that highlights a relationship is representing males and females as percentages of a whole instead of as individual counts.* Practice(s): Testing and Refining Computational Artifacts: 6.3
Subconcept: Storage (S)	
8.DA.S.1	**Represent data using multiple encoding schemes including binary and ASCII.** *Data representations occur at multiple levels of abstraction, from the physical storage of bits to the arrangement of information into organized formats (e.g., tables). Students should represent the same data in multiple ways. For example, students could represent the same color using binary, RGB values, hex codes (low-level representations), as well as forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).* Practice(s): Developing and Using Abstractions: 4.0

Subconcept: Inference and Models (IM)	
8.DA.IM.1	**Design computational models and evaluate them based on the reliability and validity of the data they generate.** *A model may be a programmed simulation of events or a representation of how various data is related. To refine a model, students need to consider which data points are relevant, how data points relate to each other, and if the data is accurate. For example, students may make a prediction about how far a ball will travel based on a table of data they designed related to the height and angle of a track. The students could then test and refine their model by comparing predicted versus actual results and considering whether other factors are relevant (e.g., size and mass of the ball). Additionally, students could refine game mechanics based on tests to make the game more balanced or fair.* Practice(s): Creating Computational Artifacts, Developing and Using Abstractions: 5.3, 4.4

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
8.AP.A.1	**Develop planning strategies, such as flowcharts or pseudocode, to develop algorithms to address complex problems.** *Complex problems are problems that would be difficult for students to solve computationally. Students should use pseudocode and/or flowcharts to organize and sequence an algorithm that addresses a complex problem, even though they may not actually program the solutions. For example, students might express an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost. Testing the algorithm with a wide range of inputs and users allows students to refine their recommendation algorithm and to identify other inputs they may have initially excluded.* *Practice(s): Developing and Using Abstractions: 4.4, 4.1*
Subconcept: Variables (V)	
8.AP.V.1	**Create named variables that represent different data types and perform operations on their values.** *A variable is like a container with a name, in which the contents may change, but the name (identifier) does not. When planning and developing programs, students should decide when and how to declare and name new variables. Students should use naming conventions to improve program readability. Examples of operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.* *Practice(s): Creating Computational Artifacts: 5.1, 5.2*

Subconcept: Control (C)	
8.AP.C.1	**Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.** *Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another. For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.* *Practice(s): Creating Computational Artifacts: 5.1, 5.2*
Subconcept: Modularity (M)	
8.AP.M.1	**Decompose problems into parts to facilitate the design, implementation, and review of programs.** In order to design, implement and evaluate programs, students will break down problems into smaller parts. For example, students might code one part of a game at a time (sprites, motion, interaction, backgrounds, etc). *Practice(s): Recognizing and Defining Computational Problems: 3.2*
8.AP.M.2	**Create procedures with parameters to organize code and make it easier to reuse.** *Students should create procedures and/or functions that are used multiple times within a program to repeat groups of instructions. These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as "drawCircle." By adding a radius parameter, the user can easily draw circles of different sizes.* *Practice(s): Developing and Using Abstractions: 4.1, 4.3*
Subconcept: Program Development (PD)	
8.AP.PD.1	**Seek and incorporate feedback from team members and users to refine a solution that meets user needs.** *Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language. Students should begin to seek diverse perspectives throughout the design process to improve their computational artifacts. Considerations of the end-user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.* *Practice(s): Collaborating Around Computing, Fostering an Inclusive Computing Culture: 2.3, 1.1*
8.AP.PD.2	**Incorporate existing code, media, and libraries into original programs, and give attribution.** *Building on the work of others enables students to produce more interesting and powerful creations. Students should use portions of code, algorithms, and/or digital media in their own programs and websites. At this level, they may also import libraries and connect to web application program interfaces (APIs). For example, when creating a side-scrolling game, students may incorporate portions of code that create a realistic jump movement from another person's game. They may also import Creative Commons-licensed images to use in the background. Students should give attribution to the original creators to acknowledge their contributions.* *Practice(s): Developing and Using Abstractions, Creating Computational Artifacts, Communicating About Computing: 4.2, 5.2, 7.3*

8.AP.PD.3	**Systematically test and refine programs using a range of possible inputs.** *At this level, testing should become a deliberate process that is more iterative, systematic, and proactive. Students should begin to test programs by considering potential errors, such as what will happen if a user enters invalid input (e.g., negative numbers and 0 instead of positive numbers).* *Practice(s): Testing and Refining Computational Artifacts: 6.1*
8.AP.PD.4	**Distribute and execute tasks while maintaining a project timeline when collaboratively developing computational artifacts.** *Collaboration is a common and crucial practice in program development. Often, many individuals and groups work on the interdependent parts of a project together. Students should assume pre-defined roles within their teams and manage the project workflow using structured timelines. With teacher guidance, they will begin to create collective goals, expectations, and equitable workloads. For example, students may divide the design stage of a game into planning the storyboard, flowchart, and different parts of the game mechanics. They can then distribute tasks and roles among members of the team and assign deadlines.* *Practice(s): Collaborating Around Computing: 2.2*
8.AP.PD.5	**Document programs to make them easier to follow, test, and debug.** *Documentation allows creators and others to more easily use and understand a program. Students should provide documentation for end users that explains their artifacts and how they function. For example, students could provide a project overview and clear user instructions. They should also incorporate comments into their programs and communicate their process throughout the design, development, and user experience phases.* *Practice(s): Communicating About Computing: 7.2*

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
8.IC.C.1	**Compare and contrast tradeoffs associated with computing technologies that affect people's everyday activities and career options.** Advancements in computer technology are neither wholly positive nor negative. However, the ways that people use computing technologies have tradeoffs. Students should consider current events related to broad ideas, including privacy, communication, and automation. For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will reduce the number of taxi and shared-ride drivers, but will create more software engineering and cybersecurity jobs. Practice(s): Communicating About Computing: 7.2

8.IC.C.2	**Develop a solution to address an issue of bias or accessibility in the design of existing technologies.** Students should test and discuss the usability of various technology tools (e.g., apps, games, and devices) with the teacher's guidance. For example, facial recognition software that works better for certain skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population. When discussing accessibility, students may notice that allowing a user to change font sizes and colors will not only make an interface usable for people with low vision but also benefits users in various situations, such as in bright daylight or a dark room. Practice(s): Fostering an Inclusive Computing Culture: 1.2
Subconcept: Social Interactions (SI)	
8.IC.SI.1	**Collaborate with contributors by using digital technologies when creating a computational product.** Crowdsourcing can be used as a platform to gather services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities). For example, a group of students could combine animations to produce a digital community creation. They could also solicit feedback from many people though use of online communities and electronic surveys. Practice(s): Collaborating Around Computing, Creating Computational Artifacts: 2.4, 5.2
Subconcept: Safety, Law, and Ethics (SLE)	
8.IC. SLE.1	**Evaluate the benefits and risks associated with sharing information digitally.** Sharing information online can help establish, maintain, and strengthen connections between people. For example, it allows artists and designers to display their talents and reach a broad audience. However, security attacks often start with personal information that is publicly available online. Social engineering is based on tricking people into revealing sensitive information and can be thwarted by being wary of attacks, such as phishing and spoofing. For example, students could brainstorm reasons why individuals would want to share information online and the potential risks of doing so. Practice(s): Communicating About Computing: 7.2

High School

Students build on K–8 experiences and learn more technical and sophisticated applications. Students refine their skills in differentiating problems or subproblems that are best solved by computing systems or digital tools and those that are best solved by humans. Students will further develop their computational thinking and problem solving skills to support the selection and appropriate use of technology. Computer science literate students will be able to explore how abstractions are integrated in computing systems within software and hardware. They can also evaluate security measures in order to protect sensitive data. Students will utilize data visualizations to represent and communicate real-world phenomena. Individually and in small groups they will consider the scalability and reliability of networks, including data storage; and collaboratively use algorithms to develop computational solutions to solve real-world challenges. Students will develop guidelines and strategies to solve computational problems. Successful students will implement computational solutions across disciplines, taking into consideration innovation, privacy, bias and equity, personal, ethical, social, economic, and cultural practices. High school students also have expanded learning opportunities in both the Career and Technical Education (CTE) and Advanced Placement (AP) programs

Concept: Computing Systems (CS)

Subconcept: Devices (D)	
HS.CS.D.1	**Explain how abstractions hide the underlying implementation details of computing systems embedded in everyday objects.** *Computing devices are often integrated with other systems, including biological, mechanical, and social systems. Students could explore how a medical device can be embedded inside a person to monitor and regulate his or her health, a hearing aid (a type of assistive device) can filter out certain frequencies and magnify others, a monitoring device installed in a motor vehicle can track a person's driving patterns and habits, or a facial recognition device can be integrated into a security system to identify a person. The usability, dependability, security, and accessibility of these devices, and the systems with which they are integrated are important considerations in their evolving design. Students are not expected to create integrated or embedded systems at this level.* *Practice(s):* Developing and Using Abstractions: 4.1
Subconcept: Hardware and Software (HS)	
HS.CS. HS.1	**Describe levels of abstraction and interactions between application software, system software, and hardware layers.** *At its most basic level, a computer is composed of physical hardware and electrical impulses. Multiple layers of software are built upon the hardware and interact with the layers above and below them to reduce complexity. System software manages a computing device's resources so that software can interact with hardware. For example, text editing software interacts with the operating system to receive input from the keyboard, convert the input to bits for storage, and interpret the bits as readable text to display on the monitor. System software is used on many different types of devices, such as smart TVs, assistive devices, virtual components, cloud components, and drones. For example, students may explore the progression from voltage to binary signal to logic gates to adders and so on. Knowledge of specific, advanced terms for computer architecture, such as BIOS, kernel, or bus, is not expected at this level.* *Practice(s):* Developing and Using Abstractions: 4.1

Subconcept: Troubleshooting (T)	
HS.CS.T.1	**Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.** *Troubleshooting complex problems involves the use of multiple sources when researching, evaluating, and implementing potential solutions. Troubleshooting also relies on experience, such as when people recognize that a problem is similar to one they have seen before or adapt solutions that have worked in the past. Examples of complex troubleshooting strategies include resolving connectivity problems, adjusting system configurations and settings, ensuring hardware and software compatibility, and transferring data from one device to another. Students could create a flow chart, a job aid for a help desk employee, or an expert system.* *Practice(s):* Testing and Refining Computational Artifacts: 6.2

Concept: Networks and the Internet (NI)

Subconcept: Cybersecurity (C)	
HS.NI.C.1	**Describe how sensitive data can be affected by malware and other attacks.** *Network security depends on a combination of hardware, software, and practices that control access to data and systems. Potential security problems, such as denial-of-service attacks, ransomware, viruses, worms, spyware, and phishing, present threats to sensitive data. Students might reflect on case studies or current events in which governments or organizations experienced data leaks or data loss as a result of these types of attacks.* *Practice(s): Communicating About Computing: 7.2*
HS.NI.C.2	**Recommend security measures to address various scenarios based on factors such as efficiency, feasibility, and ethical impacts.** *Security measures may include physical security tokens, two-factor authentication, and biometric verification. The timely and reliable access to data and information services by authorized users, referred to as availability, and is ensured through adequate bandwidth, backups, and other measures. Students should systematically evaluate different security measures based on the requirements or constraints of a situation, such as through a cost-benefit analysis. Eventually, students should include more factors in their evaluations, such as how efficiency affects feasibility or whether a proposed approach raises ethical concerns, and make recommendations based on their analysis.* *Practice(s): Recognizing and Defining Computational Problems: 3.3*
HS.NI.C.3	**Compare various security measures, considering tradeoffs between the usability and security of a computing system.** *Choosing security measures involves tradeoffs between the usability and security of the system. The needs of users and the sensitivity of data determine the level of security implemented. Students might discuss computer security policies in place at the local level that present a tradeoff between usability and security, such as a web filter that prevents access to many educational sites but keeps the campus network safe.* *Practice(s): Testing and Refining Computational Artifacts: 6.3*

Subconcept: Network, Communication, and Organization (NCO)	
HS.NI.NCO.1	**Evaluate the scalability and reliability of networks, by describing the relationship between routers, switches, servers, topology, and addressing.** *Each device is assigned an address that uniquely identifies it on the network. Routers function by comparing IP addresses to determine the pathways packets should take to reach their destination. Switches function by comparing MAC addresses to determine which computers or network segments will receive frames. Students could use online network simulators to experiment with these factors.* *Practice(s): Developing and Using Abstractions: 4.1*

Concept: Data and Analysis (DA)

Subconcept: Collection, Visualization and Transformation (CVT)	
HG.DA.CVT.1	**Create interactive data visualizations using software tools to help others better understand real-world phenomena.** *People use software tools or programming to create powerful, interactive data visualizations and perform a range of mathematical operations to transform and analyze data. Students should model phenomena as systems, with rules governing the interactions within the system and evaluate these models against real-world observations.* *Practice(s): Developing and Using Abstractions: 4.4*
Subconcept: Storage (S)	
HS.DA.S.1	**Translate between different bit representations of real-world phenomena, such as characters, numbers, and images.** *Most computing systems use different numerical representations of non-numerical data. For example, convert hexadecimal color codes to decimal numbers, or represent characters in their ASCII/Unicode representation.* *Practice(s): Developing and Using Abstractions: 4.1*
HS.DA.S.2	**Evaluate the tradeoffs in how and where data is stored.** *People make choices about how and where data is stored. Students might consider the cost, speed, reliability, accessibility, privacy, and integrity tradeoffs between storing photo data on a mobile device versus in the cloud. Students should evaluate whether a chosen solution is most appropriate for a particular problem.* *Practice(s): Recognizing and Defining Computational Problems: 3.3*

Subconcept: Inference and Models (IM)	
HS.DA.IM.1	**Analyze computational models to better understand real-world phenomena.** *Computational models make predictions about processes or phenomenon based on selected data and features that can be represented in a spreadsheet or other organizational software. The amount, quality, and diversity of data and the features chosen can affect the quality of a model and ability to understand a system. Predictions or inferences are tested to validate models. Students should model phenomena as systems, with rules governing the interactions within the system. Students should analyze and evaluate these models against real-world observations.* *Practice(s): Developing and Using Abstractions: 4.4*

Concept: Algorithms and Programming (AP)

Subconcept: Algorithms (A)	
HS.AP.A.1	**Create prototypes that use algorithms for practical intent, personal expression, or to address a societal issue** *A prototype is a computational artifact that demonstrates the core functionality of a product or process. Prototypes are useful for getting early feedback in the design process, and can yield insight into the feasibility of a product. The process of developing computational artifacts embraces both creative expression and the exploration of ideas to create prototypes and solve computational problems. Students create artifacts that are personally relevant or beneficial to their community and beyond. Students should develop computational artifacts in response to a task or a computational problem that demonstrate the performance, reusability, and ease of implementation of an algorithm.* *Practice(s): Creating Computational Artifacts: 5.2*
Subconcept: Variables (V)	
HS.AP.V.1	**Use lists to simplify solutions, generalizing computational problems instead of repeatedly using simple variables.** *Students should be able to identify common features in multiple segments of code and substitute a single segment that uses lists (arrays) to account for the differences.* *Practice(s): Developing and Using Abstractions: 4.1*
Subconcept: Control (C)	
HS.AP.C.1	**Justify the selection of specific control structures and explain the benefits and drawbacks of choices made, when tradeoffs involve readability and program performance.** *Readability refers to how clear the program is to other programmers and can be improved through documentation. The discussion of performance is limited to a theoretical understanding of execution time; a quantitative analysis is not expected. Control structures at this level may include conditional statements, loops, event handlers, and recursion. Students might compare several implementations of the same algorithm with different structures and discuss the tradeoffs of each implementation.* *Practice(s): Recognizing and Defining Computational Problems: 5.2*

HS.AP.C.2	**Use events that initiate instructions to design and iteratively develop computational artifacts** *In this context, relevant computational artifacts include programs, mobile apps, or web apps for practical intent, personal expression, or to address a societal issue. Events can be user-initiated, such as a button press, or system-initiated, such as a timer firing. At previous levels, students have learned to create and call procedures. Here, students design procedures that are called by events.* *Practice(s): Creating Computational Artifacts: 5.1*
Subconcept: Modularity (M)	
HS.AP.M.1	**Decompose problems into smaller components using constructs such as procedures, modules, and/or objects.** *At this level, students should decompose complex problems into manageable subproblems that could potentially be solved with programs or procedures that already exist. A game program can be made up of objects representing different characters, methods defining how each behaves, and procedures for various events.* *Practice(s): Recognizing and Defining Computational Problems: 3.2*
HS.AP.M.2	**Use procedures within a program, combinations of data and procedures, or independent but interrelated programs to design and iteratively develop computational artifacts.** *Computational artifacts can be created by combining and modifying existing artifacts or by developing new artifacts. Complex programs are designed as systems of interacting procedures, each with a specific role, coordinating for a common overall purpose. The focus at this level is understanding a program as a system with relationships between procedures.* *Practice(s): Creating Computational Artifacts: 5.2*
Subconcept: Program Development (PD)	
HS.AP.PD.1	**Evaluate and refine computational artifacts to make them more usable and accessible.** *Testing and refinement is the deliberate and iterative process of improving a computational artifact. This process includes debugging (identifying and fixing errors) and comparing actual outcomes to intended outcomes. Students should respond to the changing needs and expectations of end users and improve the performance, reliability, usability, and accessibility of artifacts. At this level, students should work through a systematic process that includes feedback from broad audiences.* *Practice(s): Testing and Refining Computational Artifacts: 6.3*
HS.AP.PD.2	**Use team roles and collaborative tools to design and iteratively develop computational artifacts.** *Most software is developed in teams which can include pair programming or other collaborative structures. Team roles in pair programming are alternating driver and navigator but could be more specialized in larger teams. Students may choose to use collaborative tools to aid their team, such as a version control system or project management interface.* *Practice(s): Collaborating Around Computing: 2.1*
HS.AP.PD.3	**Document design decisions using text, graphics, presentations, and/or demonstrations in the development of complex programs.** *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. Students might track their design decisions while developing a program, then choose a representation to communicate how each piece of their program contributes to the program as a whole. *Practice(s): Communicating About Computing: 7.2*

Concept: Impacts of Computing (IC)

Subconcept: Culture (C)	
HS.IC.C.1	**Evaluate the ways access to computing impacts personal, ethical, social, economic, and cultural practices.** *Computing may improve, harm, or maintain practices. Equity deficits, such as minimal exposure to computing, access to education, and training opportunities, are related to larger, systemic problems in society. Students should be able to evaluate the accessibility of a product to a broad group of end users, such as people who lack access to broadband or who have various disabilities.* *Practice(s): Fostering an Inclusive Computing Culture: 1.2*
HS.IC.C.2	**Test and refine computational artifacts to reduce bias and equity deficits.** *Biases could include incorrect assumptions developers have made about their user base or data. Students should begin to identify potential bias during the design process to maximize accessibility in product design and become aware of professionally accepted accessibility standards to evaluate computational artifacts for accessibility.* *Practice(s): Fostering an Inclusive Computing Culture: 1.2*
HS.IC.C.3	**Demonstrate ways a given algorithm applies to problems across disciplines.** *Computation can share features with disciplines such as art and music by algorithmically translating human intention into an artifact. Students should be able to identify real-world problems that span multiple disciplines and can be solved computationally, such as increasing bike safety with new helmet technology.* *Practice(s): Recognizing and Defining Computational Problems: 3.1*

Subconcept: Social Interactions (SI)	
HS.IC.SI.1	**Analyze the impact of collaborative tools and methods that increase social connectivity.** *Many aspects of society, especially careers, have been affected by the degree of communication afforded by computing. The increased connectivity between people in different cultures and in different career fields has changed the nature and content of many careers. Students should explore different collaborative tools and methods used to solicit input from team members, classmates, and others, such as participation in online forums or local communities. For example, students could compare ways different social media tools could help a team become more cohesive.* *Practice(s): Collaborating Around Computing: 2.4*

Subconcept: Safety, Law, and Ethics (SLE)	
HS.IC.SLE.1	**Explain the beneficial and harmful effects that intellectual property laws can have on innovation.** *Laws govern many aspects of computing, such as privacy, data, property, information, and identity. These laws can have beneficial and harmful effects, such as expediting or delaying advancements in computing and protecting or infringing upon people's rights. International differences in laws and ethics have implications for computing. For examples, laws that mandate the blocking of some file-sharing websites may reduce online piracy but can restrict the right to access information. Students should be aware of intellectual property laws and be able to explain how they are can be used to protect the interests of innovators or can be potentially be misused.* *Practice(s): Communicating About Computing: 7.3*
HS.IC.SLE.2	**Explain the privacy concerns related to the collection and generation of data through automated processes that may not be evident to users.** *Data can be collected and aggregated across millions of people, even when they are not actively engaging with or physically near the data collection devices. This automated and non-evident collection can raise privacy concerns, such as social media sites mining an account even when the user is not online. Students might review situations where this automated collection has led to unintended consequences or accidental breaches in privacy.* *Practice(s): Communicating About Computing: 7.2*
HS.IC.SLE.3	**Evaluate the social and economic implications of privacy in the context of safety, law, or ethics.** *Laws govern many aspects of computing, such as privacy, data, property, information, and identity. International differences in laws and ethics have implications for computing. Students might review case studies or current events which present an ethical dilemma when an individual's right to privacy is at odds with the safety, security, or wellbeing of a community.* *Practice(s): Communicating About Computing: 7.3*

Appendix A-Computer Science Glossary

The following glossary includes definitions of commonly-used computer science terms and was borrowed (with permission) from the K–12 Computer Science Framework. This section is intended to increase teacher understanding and use of computer science terminology.

Abstraction: Pulling out specific difference to make one solution work for multiple problems.

- (Process): The process of reducing complexity by focusing on the main idea. By hiding details irrelevant to the question at hand and bringing together related and useful details, abstraction reduces complexity and allows one to focus on the problem. In elementary classrooms, abstraction is hiding unnecessary details to make it easier to think about a problem.
- (Product): A new representation of a thing, a system, or a problem that helpfully reframes a problem by hiding details irrelevant to the question at hand.

Algorithm: A step-by-step process to complete a task. A list of steps to finish a task. A set of instructions that can be performed with or without a computer.

For example, the collection of steps to make a peanut butter and jelly sandwich is an algorithm.

App: A type of application software, often designed to run on a mobile device, such as a smartphone or tablet computer (also known as a mobile application).

Artifact: Anything created by a human. See "computational artifact" for the computer science-specific definition.

ASCII: (American Standard Code for Information Interchange) is the most common format for text files in computers and on the Internet. In an ASCII file, each alphabetic, numeric, or special character is represented with a 7-bit binary number (a string of seven 0s or 1s). 128 possible characters are defined.

Automation: The process of linking disparate systems and software in such a way that they become self-acting or self-regulating.

Backup: The process of making copies of data or data files to use in the event the original data or data files are lost or destroyed.

Binary: A system of notation representing data using two symbols (usually 1 and 0).

Block-based programming language: Any programming language that lets users create programs by manipulating "blocks" or graphical programming elements, rather than writing code using text. (Sometimes called visual coding, drag and drop programming, or graphical programming blocks)

Bug: An error in a software program. It may cause a program to unexpectedly quit or behave in an unintended manner. The process of removing errors (bugs) is called debugging.

Cloud: Remote servers that store data and are accessed from the Internet.

Code: Any set of instructions expressed in a programming language. One or more commands or algorithm(s) designed to be carried out by a computer. See also: program

Command: An instruction for the computer. Many commands put together make up algorithms and computer programs.

Computational artifact: Anything created by a human using a computational thinking process and a computing device. A computational artifact can be, but is not limited to, a program, image, audio, video, presentation, or web page file.

Computational models: Used to make predictions about processes or phenomenon based on selected data and features that can be represented by organizational software.

Computational thinking: Mental processes and strategies that include: decomposition (breaking larger problems into smaller, more manageable problems), pattern matching (finding repeating patterns), abstraction (identifying specific changes that would make one solution work for multiple problems), and algorithms (a step-by-step set of instructions that can be acted upon by a computer).

Computer science: The study of computers and algorithmic processes including their principles, hardware and software design, their applications, and their impact on society.

Conditionals: Statements that only run under certain conditions or situations.

Data: Information. Often, quantities, characters, or symbols that are the inputs and outputs of computer programs.

Debugging: Finding and fixing errors in programs.

Decompose: Break a problem down into smaller pieces.

Decryption: The process of taking encoded or encrypted text or other data and converting it back into text that you or the computer can read and understand.

Digital divide: the gulf between those who have ready access to computers and the Internet, and those who do not.

Encryption: The process of encoding messages or information in such a way that only authorized parties can read it.

Event: An action that causes something to happen

Execution: The process of executing an instruction or instruction set.

For loop: A loop with a predetermined beginning, end, and increment (step interval)

Function: A type of procedure or routine. Some programming languages make a distinction between a function, which returns a value, and a procedure, which performs some operation, but does not return a value. Note: This definition differs from that used in math. A piece of code that you can easily call over and over again. Functions are sometimes called 'procedures.'

GPS: Abbreviation for "Global Positioning System." GPS is a satellite navigation system used to determine the ground position of an object.

Hacking: Appropriately applying ingenuity. Cleverly solving a programming problem. Using a computer to gain unauthorized access to data within a system.

Hardware: The physical components that make up a computing system, computer, or computing device.

Hierarchy: An organizational structure in which items are ranked according to levels of importance.

HTTP: (Hypertext Transfer Protocol) is the set of rules for transferring files (text, graphic images, sound, video, and other multimedia files) on the World Wide Web.

HTTPS: A web transfer protocol that encrypts and decrypts user page requests as well as the pages that are returned by the Web server. The use of HTTPS protects against eavesdropping and attacks.

Input: The signals or instructions sent to a computer.

Internet: The global collection of computer networks and their connections, all using shared protocols to communicate. A group of computers and servers that are connected to each other.

Iterative: Involving the repeating of a process with the aim of approaching a desired goal, target, or result.

Logic (Boolean): Boolean logic deals with the basic operations of truth values: AND, OR, NOT and combinations thereof.

Loop: A programming structure that repeats a sequence of instructions as long as a specific condition is true.

Looping: Repetition, using a loop. The action of doing something over and over again.

Lossless: Data compression without loss of information.

Lossy: Data compression in which unnecessary information is discarded.

Memory: Temporary storage used by computing devices.

Model: A representation of (some part of) a problem or a system. (Modeling: the act of creating a model.) Note: This definition differs from that used in science.

Nested loop: A loop within a loop, an inner loop within the body of an outer loop.

Network: A group of computing devices (personal computers, phones, servers, switches, routers, and so on) connected by cables or wireless media for the exchange of information and resources.

Operating system: Software that communicates with the hardware and allows other programs to run. An operating system (or "OS") is comprised of system software, or the fundamental files a computer needs to boot up and function. Every desktop computer, tablet, and smartphone includes an operating system that provides basic functionality for the device.

Operation: An action, resulting from a single instruction that changes the state of data.

Packets: Small chunks of information that have been carefully formed from larger chunks of information.

Pair programming: A technique in which two developers (or students) team together and work on one computer. The terms "driver" and "navigator" are often used for the two roles. In a classroom setting, teachers often specify that students switch roles frequently, or within a specific period of time.

Paradigm (programming): A theory or a group of ideas about how something should be done, made, or thought about. A philosophical or theoretical framework of any kind. Common programming paradigms are object-oriented, functional, imperative, declarative, procedural, logic, and symbolic.

Parallelism: The simultaneous execution on multiple processors of different parts of a program.

Parameter: A special kind of variable used in a procedure to refer to one of the pieces of data provided as input to the procedure. These pieces of data are called arguments. An ordered list of parameters is usually included in the definition of a subroutine so each

time the subroutine is called, its arguments for that call can be assigned to the corresponding parameters. An extra piece of information that you pass to a function to customize it for a specific need.

Pattern matching: Finding similarities between things.

Persistence: Trying again and again, even when something is very hard.

Piracy: The illegal copying, distribution, or use of software.

Procedure: An independent code module that fulfills some concrete task and is referenced within a larger body of source code. This kind of code item can also be called a function or a subroutine. The fundamental role of a procedure is to offer a single point of reference for some small goal or task that the developer or programmer can trigger by invoking the procedure itself. A procedure may also be referred to as a function, subroutine, routine, method, or subprogram.

Processor: The hardware within a computer or device that executes a program. The CPU (central processing unit) is often referred to as the brain of a computer.

Program (n): A set of instructions that the computer executes in order to achieve a particular objective. Program (v): To produce a program by programming. An algorithm that has been coded into something that can be run by a machine.

Programming (v): The craft of analyzing problems and designing, writing, testing, and maintaining programs to solve them. The art of creating a program.

Protocol: The special set of rules that end points in a telecommunication connection use when they communicate. Protocols specify interactions between the communicating entities.

Prototype: An early approximation of a final product or information system, often built for demonstration purposes.

Pseudocode: A detailed yet readable description of what a computer program or algorithm must do, expressed in a formally-styled natural language rather than in a programming language.

Remix: making changes to an existing procedure.

RGB: (red, green, and blue) Refers to a system for representing the colors to be used on a computer display. Red, green, and blue can be combined in various proportions to obtain any color in the visible spectrum.

Routing; router; routing: Establishing the path that data packets traverse from source to destination. A device or software that determines the routing for a data packet.

Run program: Cause the computer to execute the commands written in a program.

Security: The protection against access to, or alteration of, computing resources, through the use of technology, processes, and training.

Servers: Computers that exist only to provide things to others.

Simulate: To imitate the operation of a real world process or system over time.

Simulation: Imitation of the operation of a real world process or system over time.

Software: Programs that run on a computer system, computer, or other computing device.

SMTP: A standard protocol for sending emails across the Internet. The communication between mail servers, by default, uses port 25. IMAP: a mail protocol used for accessing email on a remote web server from a local client.

Storage: A place (usually a device) into which data can be entered, in which it can be held, and from which it can be retrieved at a later time. A process through which digital data is saved within a data storage device by means of computing technology. Storage is a mechanism that enables a computer to retain data, either temporarily or permanently.

String: A sequence of letters, numbers, and/or other symbols. A string might represent a name, address, or song title. Some functions commonly associated with strings are length, concatenation, and substring.

Structure: The concept of encapsulation without specifying a particular paradigm.

Subroutine: A callable unit of code, a type of procedure.

Switch: A high-speed device that receives incoming data packets and redirects them to their destination on a local area network (LAN).

System: A collection of elements or components that work together for a common purpose. A collection of computing hardware and software integrated for the purpose of accomplishing shared tasks.

Topology: The physical and logical configuration of a network; the arrangement of a network, including its nodes and connecting links. A logical topology details how devices appear connected to the user. A physical topology is how devices are actually interconnected with wires and cables.

Troubleshooting: A systematic approach to problem solving that is often used to find and resolve a problem, error, or fault within software or a computer system.

User: A person for whom a hardware or software product is designed (as distinguished from the developers).

Variable: A symbolic name that is used to keep track of a value that can change while a program is running. Variables are not just used for numbers. They can also hold text, including whole sentences ("strings"), or the logical values "true" or "false." A variable has a data type and is associated with a data storage location; its value is normally changed during the course of program execution. A placeholder for a piece of information that can change. Note: This definition differs from that used in math.

Wearable computing: Miniature electronic devices that are worn under, with or on top of clothing.

Sources for definitions in this glossary:

CAS-Prim: Computing at School. Computing in the national curriculum: A guide for primary teachers (http://www.computingatschool.org.uk/data/uploads/CASPrimaryComputing.pdf)

Code.org: Creative Commons License (CC BY-NC-SA 4.0) (https://code.org/curriculum/docs/k-5/glossary)

Computer Science Teachers Association: CSTA K–12 Computer Science Standards (2011) https://csta.acm.org/Curriculum/sub/K12Standards.html

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MA-DLCS: Massachusetts Digital Literacy and Computer Science Standards, Glossary (Draft, December 2015)

NIST/DADS: National Institute of Science and Technology Dictionary of Algorithms and Data Structures. (https://xlinux.nist.gov/dads//)

Techopedia: Techopedia. (https://www.techopedia.com/dictionary)

TechTarget: TechTarget Network. (http://www.techtarget.com/network)

TechTerms: Tech Terms Computer Dictionary. (http://www.techterms.com)

Appendix B-Computer Science Practices

There are seven core practices of computer science. The practices naturally integrate with one another and contain language that intentionally overlaps to illuminate the connections among them. Unlike the core concepts, the practices are not delineated by grade bands. Conversely, like the core concepts, they are meant to build upon each other. (Adapted from: K-12 Computer Science Framework, 2016)

Practices-All practices list skills that students should be able to incorporate by the end of 12th grade
Practice 1. Fostering an Inclusive Computing Culture: Building an inclusive and diverse computing culture requires strategies for incorporating perspectives from people of different genders, ethnicities, and abilities. Incorporating these perspectives involves understanding the personal, ethical, social, economic, and cultural contexts in which people operate. Considering the needs of diverse users during the design process is essential to producing inclusive computational products.
1.1. Include the unique perspectives of others and reflect on one's own perspectives when designing and developing computational products.
1.2. Address the needs of diverse end users during the design process to produce artifacts with broad accessibility and usability.
1.3. Employ self- and peer-advocacy to address bias in interactions, product design, and development methods.
Practice 2. Collaborating Around Computing: Collaborative computing is the process of performing a computational task by working in pairs and on teams. Because it involves asking for the contributions and feedback of others, effective collaboration can lead to better outcomes than working independently. Collaboration requires individuals to navigate and incorporate diverse perspectives, conflicting ideas, disparate skills, and distinct personalities. Students should use collaborative tools to effectively work together and to create complex artifacts.
2.1. Cultivate working relationships with individuals possessing diverse perspectives, skills, and personalities.
2.2. Create team norms, expectations, and equitable workloads to increase efficiency and effectiveness.
2.3. Solicit and incorporate feedback from, and provide constructive feedback to, team members and other stakeholders.
2.4. Evaluate and select technological tools that can be used to collaborate on a project.

Practice 3. 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.
3.1. Identify complex, interdisciplinary, real-world problems that can be solved computationally.
3.2. Decompose complex real-world problems into manageable subproblems that could integrate existing solutions or procedures.
3.3. Evaluate whether it is appropriate and feasible to solve a problem computationally.
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.
4.1. Extract common features from a set of interrelated processes or complex phenomena.
4.2. Evaluate existing technological functionalities and incorporate them into new designs.
4.3. Create modules and develop points of interaction that can apply to multiple situations and reduce complexity.
4.4. Model phenomena and processes and simulate systems to understand and evaluate potential outcomes.
Practice 5. Creating Computational Artifacts: The process of developing computational artifacts embraces both creative expression and the exploration of ideas to create prototypes and solve computational problems. Students create artifacts that are personally relevant or beneficial to their community and beyond. Computational artifacts can be created by combining and modifying existing artifacts or by developing new artifacts. Examples of computational artifacts include programs, simulations, visualizations, digital animations, robotic systems, and apps.
5.1. 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.
5.2. Create a computational artifact for practical intent, personal expression, or to address a societal issue.
5.3. Modify an existing artifact to improve or customize it.
Practice 6. Testing and Refining Computational Artifacts: Testing and refinement is the deliberate and iterative process of improving a computational artifact. This process includes debugging (identifying and fixing errors) and comparing actual outcomes to intended outcomes. Students also respond to the changing needs and expectations of end users and improve the performance, reliability, usability, and accessibility of artifacts.

6.1. Systematically test computational artifacts by considering all scenarios and using test cases.
6.2. Identify and fix errors using a systematic process.
6.3. Evaluate and refine a computational artifact multiple times to enhance its performance, reliability, usability, and accessibility.
Practice 7. Communicating About Computing: Communication involves personal expression and exchanging ideas with others. In computer science, students communicate with diverse audiences about the use and effects of computation and the appropriateness of computational choices. Students write clear comments, document their work, and communicate their ideas through multiple forms of media. Clear communication includes using precise language and carefully considering possible audiences.
7.1. Select, organize, and interpret large data sets from multiple sources to support a claim.
7.2. Describe, justify, and document computational processes and solutions using appropriate terminology consistent with the intended audience and purpose.
7.3. Articulate ideas responsibly by observing intellectual property rights and giving appropriate attribution.