Computer Science Essential Concepts
And
Subconcepts

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Concept: Impacts of Computing

Kindergarten - Highschool

Computer Science Essential Concepts and Subconcepts

The Arizona Computer Science Standards for grades kindergarten through twelve are organized into five Essential Concepts:
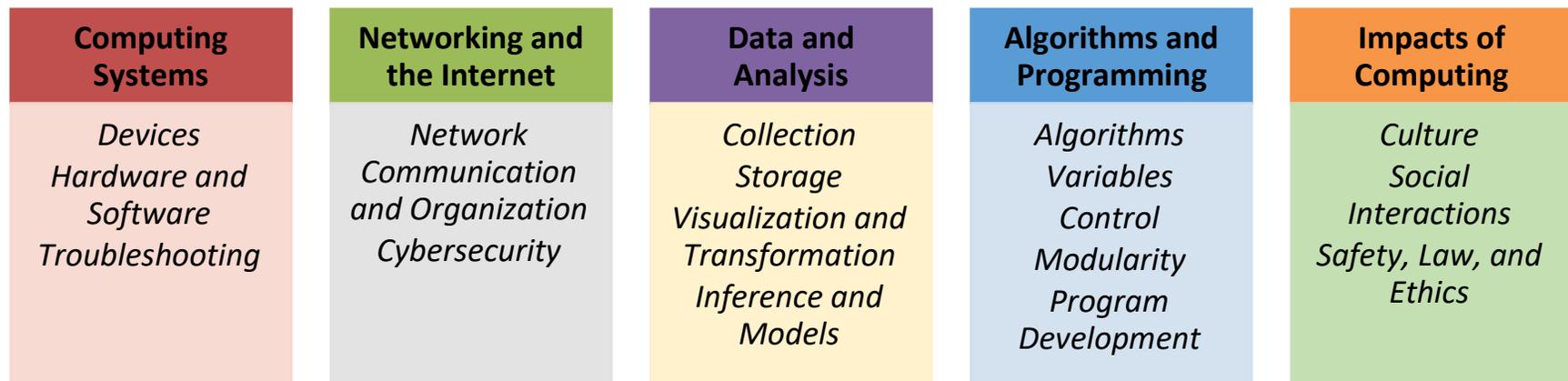
- **Computing Systems:** This involves the interaction that people have with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) 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. Computing Systems has three subconcepts, they are: Devices, Hardware and Software, and Troubleshooting.

- **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. This concept has two subconcepts within it, they are: Cybersecurity, and Network Communication and Organization.

- **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. This concept has three subconcepts, they are: Collection, Visualization and Transformation, Storage, and Inference and Models

- **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. This concept has 5 subconcepts, they are: Algorithms, Variables, Control, Modularity, and Program Development

- **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. This concept has 3 subconcepts, they are: Culture, Social Interactions, and Safety, Law, and Ethics

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.
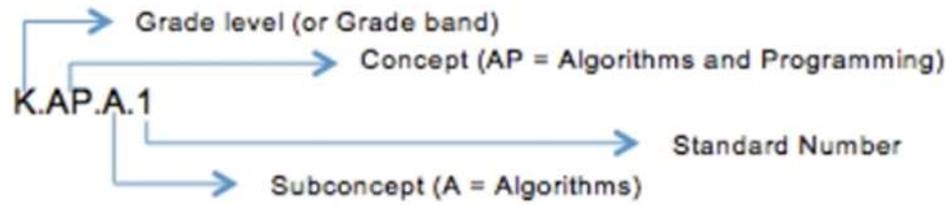
Figure 1: Computer science essential concepts and subconcepts

Computing Systems	Networking and the Internet	Data and Analysis	Algorithms and Programming	Impacts of Computing
Devices *Hardware and Software* *Troubleshooting*	*Network Communication and Organization* *Cybersecurity*	*Collection* *Storage* *Visualization and Transformation* *Inference and Models*	*Algorithms* *Variables* *Control* *Modularity* *Program Development*	*Culture* *Social Interactions* *Safety, Law, and Ethics*

The pages following break the concepts and subconcepts down by Concept, from Kindergarten through High School. Each Concept is labeled and separated from the next. This will allow teachers to more easily track progression within the standards.

Each standard will list the grade level, the concept, the subconcept, and the standard number. Figure 2 provides an example of the coding for, and how to read, a standard:

Figure 2: Standard Coding Scheme for Standards

Grade level (or Grade band)

Concept (AP = Algorithms and Programming)

K.AP.A.1

Standard Number

Subconcept (A = Algorithms)

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
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
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

	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
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
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
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
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
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
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*