Computer Science Essential Concepts

And

Subconcepts

Concept: Data and Analysis

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.

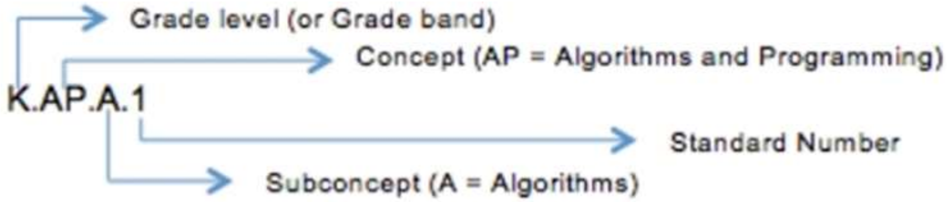
Figure 1: Computer science essential concepts and subconcepts

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

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



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

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
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
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*

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*
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*
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
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
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
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*