# Foundational Concepts

Foundational Concepts focus on understanding computing systems (hardware and software). This core concept also includes computational thinking and its applications and emphasizes the importance of collaboration for computer science. Hardware includes the physical components of computing systems while software consists of the programs and data necessary to operate and execute specific tasks using these systems. An understanding of hardware and software and their interactions is a foundational concept and students should learn how systems use both to represent and process information. Computational thinking is a thought process that revolves around solving a variety of problems. In this Implementation Guidebook, we will focus on four main components of computational thinking: 1) algorithms, 2) pattern recognition, 3) decomposition, and 4) abstraction.

Collaborating Around Computing is the K-12 Computer Science Framework's Practice #2 and collaboration is one of the 4Cs in the 21st century skills. We should empower students by incorporating collaboration throughout their exploration of computer science concepts and practices to prepare them for their future workspace. These foundational building blocks set the stage for the remaining five concepts including algorithmic thinking, programming concepts, data and analysis, networking and the Internet and impacts of computing.

| | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| Sub Concepts | **Computing Systems Hardware** | Students identify and apply the functions of common physical components of hardware (keyboard, mouse, monitor, etc.) and differentiate between a variety of devices (iPad, desktop, laptop, etc.) | Students perform grade-appropriate tasks with proficiency using a range of digital devices. Students recognize how software and hardware interact with one another. | Students systematically analyze and fix problems that occur with computing devices and their components. Students recognize the advantages and limitations of computer hardware. | |
| | **Computing Systems Software** | Students identify and apply basic functions to navigate software. | Students locate and utilize grade-appropriate software. Students model procifient use of advanced online tools to communicate key ideas | Students identify advantages and limitations of software on computing devices in order to improve user experience. | |
| | **Computational Thinking** | Students use computational thinking to ask questions, conduct investigations, solve problems and test solutions with teacher guidance. | Students use computational thinking to ask questions, conduct investigations, solve problems and test solutions independently. | Students use computational thinking to ask questions, conduct investigations, solve problems and test solutions across multiple disciplines. | |
| | **Collaboration About Computer Science** | Students work collaboratively to connect with other learners using digital tools. | Students use digital tools to communicate key ideas and details collaboratively to inform, persuade, and/or entertain. | Students understand how collaboration is essential to computer science and apply collaborative skills to develop computational solutions. | |

# Algorithmic Thinking

An algorithm is a step-by-step process to complete a task, and algorithms can be executed by both humans and computers. To create an algorithm, students must first decide how to break down the problem or task into manageable parts. After using decomposition, students can create logical and sequential steps to solve the task. Flowcharts, conditionals, or visual aids may be utilized to assist in designing and describing the algorithm. As students apply algorithmic thinking to a variety of problems in their K-12 career, they will further develop the conceptual and problem-solving skills necessary to design more efficient and effective algorithms, including sequencing, selection, and iteration.

| Sub Concepts | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| | **Logical or Sequential Thinking** | Students will classify, sort and categorize events and/or items in a logical order with or without a computing device. | Students will use items or events to predict the outcomes of given algorithms and create ciphers. | Students will analyze algorithmic processes and automation to describe how the use of technology enhances performance and increases efficiency. | Students will create artifacts to collect feedback and demonstrate their knowledge of using algorithms to solve computational problems. |
| | **Breaking Down Problems Into Parts** | Students will evaluate problem-solving strategies and communicate effective solutions to a problem. | Students will identify and evaluate problems, pose questions for investigation, and communicate processes to an audience. Students will decompose an existing algorithm to identify areas for improvement. | Students will evaluate and identify the different components of algorithmic processess. | Students will problem solve using effective communication that demonstrates their in-depth knowledge of computer science vocabulary. |
| | **Create Step by Step Processes to Solve Problems** | Students will brainstorm and organize information to create a visualizual representation of concepts and elements. | Students will work collaboratively to plan or create an algorithm using a flowchart as well as identifying and eliminating errors through debugging. | Students will utilize variables and data types to create efficient algorithms. | Students will design and develop programs using general computational problems while incorporating feedback. |

# Programming Concepts

A program is a set of instructions a computing device executes to achieve a particular objective. These instructions can come in a variety of forms, but programming represents an opportunity for students to expand their knowledge and application of computational thinking, collaboration, hardware and software application, and designing algorithms. In the primary grades, students will build on their understanding of programming concepts by using physical devices that require students to push buttons in sequential order on the device to solve a problem and begin to explore block-based programming. In later grades, students will develop even more complex programs using a variety of programming languages, which might include more advanced block-based programming or text-based programming. The focus is not on learning a particular programming language, as these will change by the time the student graduates. Rather, the goal is to build a set of skills that can be applied to programming in general, including the craft.

| | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| Sub Concepts | **Using and Troubleshooting Existing Code** | | Students will work collaboratively to test simple algorithms and programs to identify errors and practice debugging. | Students will incorporate continuous improvement through the iterative design process. Students will collaborate with others to improve performance and eliminate errors. | As programs become more complex, students will need to rely more heavily on the iterative design process to improve the efficiency of programs and user experiences. |
| | **Developing Code to Solve a Problem** | | Students can decompose problems into simple algorithms and programs and can use pattern recognition to develop simple loops. Students should develop procedures both as individuals and as teams. | Students can decompose problems into sub-problems and isolate the steps to solve each sub-problem. Students can consider ways to reuse procedures to solve similar problems and isolate these steps through abstraction. | Students can apply a variety of control structures (boolean logic, nest loops, compound conditionals and third-party libraries) in code to solve more complex problems. |
| | **Concepts of Programming (Language Exposure)** | | Students will be able to identify a problem and come up with a solution by decomposing a problem into smaller easier-to-solve steps. Students will also begin to recoginze that information can be represented in more than one way. | Students should begin practicing with a programming platform that will allow them to apply various programming concepts. Students will be introduced to coding jargon including comments, libraries, attributions, and functions. | Students learn to develop variable plans to manage data within a program. Students can select the proper attributes of variables to maximize program efficiency and readibility. Students can use libraries and open-source code with proper attribution. |

# Data and Analysis

In our expansive digital world, computing systems are being used to collect, store, organize, explore, analyze, and process large quantities of data. Data can include a variety of information across a range of formats including numbers, images, text, audio or video files, software programs, or apps. Understanding the process of how data is used to make a variety of decisions is a crucial skill for students in the 21st century and beyond.

This core concept begins with data collection, using a variety of age-appropriate tools and processes, followed by data organization and reliable representation. Spreadsheets, databases, tables, charts, graphs, tabulating, and statistical analysis are just a few examples of the tools for data organization and representation. Further analysis of data aids students in discovering relationships within the data, including emerging patterns or evidence of a phenomenon or process. Beginning in middle school and expanding in high school, students can develop and critically evaluate computational models that are based on existing data.

Communicating About Computing is the K-12 Computer Science Framework's Practice #7, and communication is one of the 4Cs in the 21st Century Skills. Both support the idea that clear communication of data is necessary to articulate ideas responsibly and effectively. Ideally, communication of data can be used to identify trends, make predictions or inferences, and solve problems.

| | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| Sub Concepts | **Organizing, Clustering, or Categorizing Data** | Students recognize that data can be grouped in a variety of ways. Students will use age-appropriate tools and processes to collect and organize data. | Students collect and organize more complex sets of data. Students will also identify solutions and connect collected data to real-life events. | | |
| | **Cleaning or Transforming Data to Discover Useful Information** | Students utilize data by interpreting charts, identifying relationships, and discovering solutions within the organized data. | Students manipulate a data set by rearranging or removing unnecessary data in order to answer questions. | Students examine, improve, clean or change data by reorganizing or removing elements. Students use data to make adjustments to computational models. | Students identify patterns in data from complex systems by using data analysis tools and techniques. |
| | **Displaying or Visualizing Data** | Students collect and organize data to create digital representations. | Students use data to identify relationships, predict outcomes, communicate ideas, and answer questions using a variety of computing and data visualization representations. | Students use encoding schemes to represent data utilizing characters, symbols, and alphabets | Students analyze data using computing and data visualization methods to find solutions. |
| | **Communicating Data for Decision Making or Problem Solving** | | Students describe examples of data sets from everyday life and produce published results. | | Students create computational models that display multiple relationships within data collected from a process or phenomenon. |

# Networking and the Internet

This core concept allows students to understand the connectivity of their digital world, including how information is packaged and transmitted across networks and the Internet. A network is a group of computing devices (personal computers, phones, servers, switches, routers, etc.) connected by cables or wireless media that enable the exchange of information and resources. The Internet is a global collection of computer networks and their connections, all using shared protocols to communicate. In addition, this concept also focuses on how to troubleshoot these systems. Many of the other core concepts are essential for understanding this concept as it brings together data, hardware and software, algorithmic thinking, and programming to design and securely use these networks and connections.

Embedded in this concept is the understanding of both physical and digital security measures to protect electronic information and intellectual property and laws in the digital space. Students' education around cybersecurity can lead to a safer digital environment, including creating more effective passwords, understanding the differences between secure and non-secure websites, and understanding what personal data is collected and shared across these networks.

| | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| Sub Concepts | **Connectivity and Issues** | | | Students identify and solve basic connectivity issues. Students understand the relationship between the type of network, connectivity issues, and troubleshooting methods. | Students identify and solve advanced connectivity issues. Students understand and apply more sophisticated methods for preventing and troubleshooting connectivity issues. |
| | **Data is Transferred Using Protocols or Rules** | | Students understand there are tools and techniques to improve the outcome of an Internet search. | Students understand rules for data transfer on the Internet. Students analyze different ways to secure data and enhance cybersecurity methods. | Students evaluate and discuss rules and protocols for transferring data on the Internet and their importance for cybersecurity. Students analyze these processes for efficiency, feasibility, and ethical impacts. |
| | **Protecting Data/Personal Information** | Students understand behaviors that promote safe usage of digital devices, tools, and the Internet. | Students demonstrate safe behaviors online deeming them a "good digital citizen." Students begin to understand the permanence of actions in the digital world. | Students understand the risks and benefits of online security and data protection. Students understand intellectual property and its relation to accessing and using digital media. | Students understand Internet and technology-related laws, enabling them to make informed decisions when online. Students recognize their digital identity may be permanent and could impact their future opportunities. |

# Impacts of Computing

Computer science impacts society on a variety of levels, and we should empower students to move from being passive users of computing devices to critically evaluating how computer science affects their daily lives. These impacts might include reflecting on new ways to interact with others through digital media, how we receive up-to-date information about what is happening in our world, the potential of medical devices to improve our health and well-being or using drones and algorithms to determine how to maximize production of a crop. Computer science is everywhere and for it to fully benefit everyone, we must increase our understanding of its applications. Thus, it is essential for students to understand both the benefits and risks of computer science. Finally, The K-12 Computer Science Framework suggests the Impacts of Computing influences culture, supports networking and social interaction, and students need to know the fundamentals of digital citizenship to interact safely with computing devices. Computer science is one of the fastest growing industries and computer programmers are needed within every field, including healthcare, transportation, entertainment, and banking. All students will benefit from learning computer science concepts and practices, allowing them to better understand the world around them, improve their logical reasoning and problem-solving skills, and increase their creativity and collaboration. Rather than being an avocational part of education only for students interested in a computer science career, computer science is now a foundational part of Tennessee K-12 education that is accessible to all students.

| | Grade Bands | Early Elementary (K-2) | Upper Elementary (3-5) | Middle (6-8) | High (9-12) |
|---|---|---|---|---|---|
| Sub Concepts | **Innovations Due to Computer Science** | | Students can explain how software and hardware can be developed to address all user's needs. | Students will analyze computer science innovations and assess their effects on society, both positive and negative. | Students will understand current innovations in computer science and how these might adapt, change, and be developed to meet future needs. |
| | **Benefits and Risks to Users and Developers Due to Computational Systems** | Students will learn the appropriate skills to navigate safely in a digital environment. | Students will understand both the positive and negative impacts of computer science and how laws and tools can be used to develop positive digital environments. | Students will critically evaluate the advantages and disadvantages of computer science in regards to data collection, globalization, and Internet censorship. | Students will investigate and debate issues surrounding social and economic implications of computer science in relation to safety, law and ethics. |
| | **How Jobs/Careers Use Computer Science & Computational Thinking** | | | Students will understand the role computational thinking and computer science play in a variety of educational pathways and careers. | The student will research and analyze the impacts of computing technologies on career fields/pathways to make informed decisions about their future. |