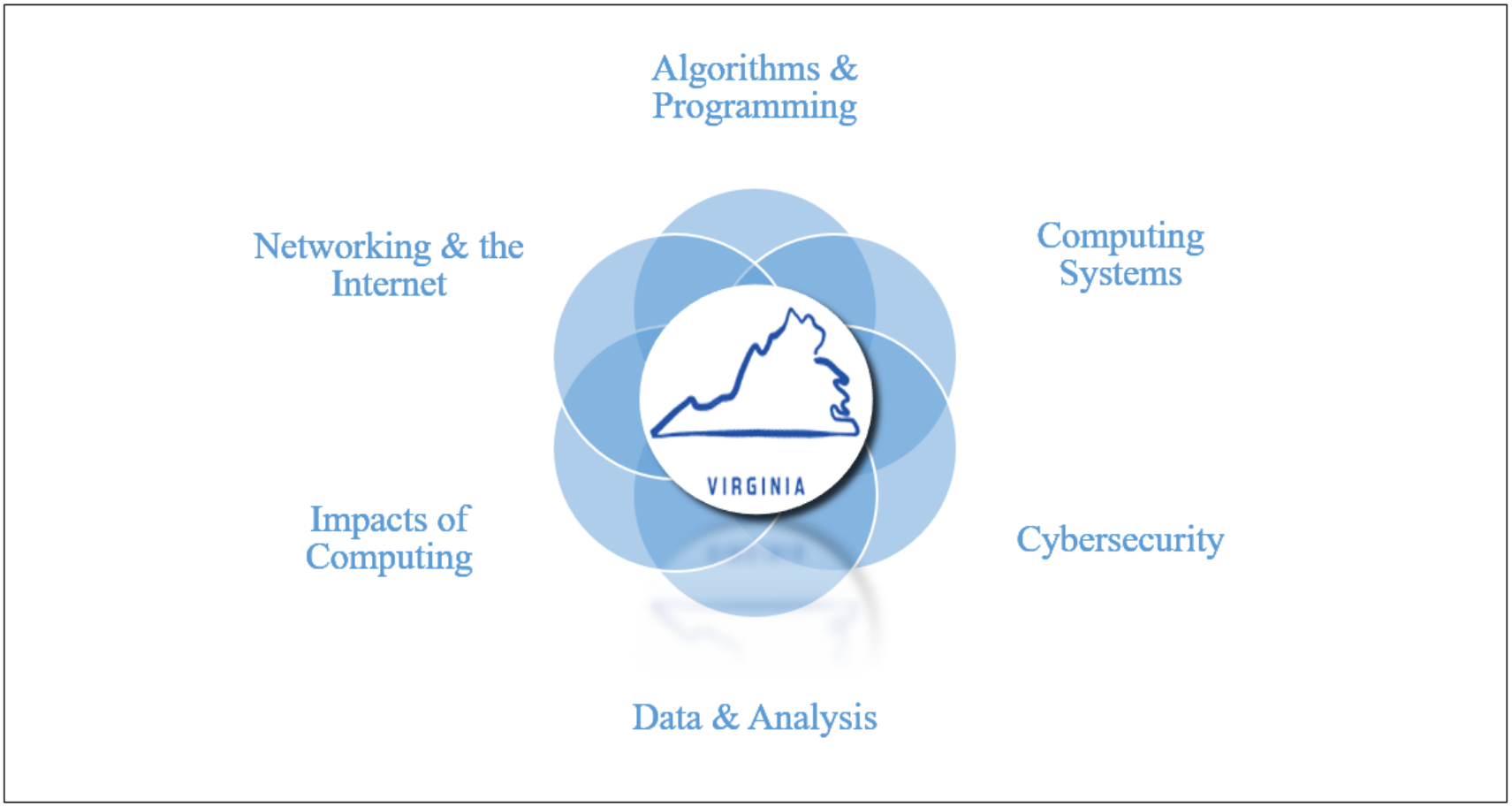
Computer Science Standards of Learning

Curriculum Framework



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The 2017 *Computer Science Curriculum Framework* can be found on the Virginia Department of Education's Web site.

Introduction

The *Computer Science Standards of Learning* Curriculum Framework amplifies the *Computer Science Standards of Learning for Virginia Public Schools* and defines the content knowledge, skills, and understandings that are measured by the Standards of Learning. The Computer Science Curriculum Framework provides additional guidance to school divisions and their teachers as they develop an instructional program appropriate for their students. It assists teachers as they plan their lessons by identifying essential questions and vocabulary to drive instruction and defining the essential skills students should demonstrate. This supplemental framework delineates in greater specificity the minimum content that all teachers should teach and all students should learn.

School divisions should use the *Computer Science Curriculum Framework* as a resource for developing sound curricular and instructional programs. This framework should not limit the scope of instructional programs. Additional knowledge and skills that can enrich instruction and enhance students' understanding of the content identified in the Standards of Learning should be included as part of quality learning experiences.

Each topic in the *Computer Science Standards of Learning* Curriculum Framework is developed around the Standards of Learning. The format of the Curriculum Framework facilitates teacher planning by broadening the context of the standards and identifying essential student skills that should be the focus of instruction for each standard.

Context of the Standard

The Context of the Standard provides educators an explanation of the standard, including a description and the vertical development of the concept. This context will support teachers in incorporating computer science content into discipline-specific lessons. The intention of the Computer Science standards in grades K-8 is that Computer Science principles be integrated throughout content area instruction.

Essential Skills

The Essential Skills define student performance expectations aligned to each standard. The intent of the K-8 computer science standards is that the concepts are integrated into existing disciplines and this will result in these skills being emphasized differently in each content area. The expectation is that these Essential Skills are partnered with content area performance expectations as appropriate in instruction. At the high school level, the expectations in the 2017 *Computer Science Standards of Learning Curriculum Framework* are to be used in the support of standalone computer courses; the essential skills outlined in the document are not intended to be integrated into other coursework unless a teacher chooses to use the content to support discipline practices.

Essential Questions
Each standard has identified key questions to drive classroom instruction. These questions lead teachers and students toward the big ideas of each concept and provide a more holistic viewpoint used to lead instruction relating to the context of each standard.

Essential Vocabulary
In order to effectively communicate Computer Science concepts, essential vocabulary terms are defined in grade-level appropriate terms. These definitions are found in the glossary (Appendix A).

Grade Seven

The seventh-grade standards emphasize constructing programs and utilizing algorithms to accomplish a task. Students continue to decompose larger problems into smaller tasks and recognize the impacts of computing and computing devices. Students in seventh grade explore processing data as well as its transmission over networks. The accurate use of terminology as well as the responsible use of technology will continue to be built upon. The foundational understanding of computing and the use of technology will be an integral component of successful acquisition of skills across content areas.

Algorithms and Programming

7.1 The student will construct programs to accomplish a task as a means of creative expression or scientific exploration using a block-based or text-based programming language, both independently and collaboratively,

a. combining control structures such as if-statements and loops including compound conditionals; and
b. creating clearly named variables that represent different data types, including numeric and non-numeric data, and perform operations on their values.

Context of the Standard
Programs are collections of code organized in algorithms that can accomplish a variety of tasks. Programs can be developed to perform calculations, manipulate data, or simply to be creative. Programs can involve different control structures such as loops and if-statements; these control structures are blocks of programming that analyze variables within the program code to adjust and use accurate values as they change. Control structures help students develop their problem solving skills and foster computational thinking. Effective variable use, to include the use of identified variables to perform operations, makes the problem solving process easier and faster. One consideration in programming is the *flow of control*. This refers to the order that commands are run by the computer. The order of the commands, or sequencing, can have dramatic impacts on whether a program runs correctly. By repeating commands the programmer has fewer lines to write, and less opportunities to make mistakes. Conditionals (if-statements) are added to a program to control whether or not commands are run. An if-statement acts as a door. If the condition is true, the door opens and commands connected to the statement are run, otherwise they are skipped. This allows programs to respond to user input and events. In seventh grade, students should add compound conditionals to their programs. A compound condition specifies a combination of other conditions, allowing for two or more conditions to be tested in a single statement, such as “if-and” and “if-or.”

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Create programs that include control structures or compound conditionals using block or text-based applications. • Work with a partner or group to create a program. • Appropriately apply variables in programs to meet desired outcomes. • Combine and nest if-statements and loops to create more complex programs.	Students should *investigate* these concepts: • How does combining control structures increase efficiency in the construction of programs? • What roles can different types of variables serve in program construction? • How do compound conditionals reduce the amount of code needed in a program?	Students should *apply* these terms in context: • If-statements • Compound conditionals

7.2 The student will document programs to make them easier to follow, test, and debug.

Context of the Standard
Proper documentation helps keep track of all aspects of an application and improves on the quality of the program. Documentation allows programmers and reviewers to understand the intention behind a particular portion of code. Documentation comments are formatted to describe portions of the program but are not integrated into the program flow. Often, a programmer will write code and not return to it for lengths of time; documentation can be used to remind them of the intention behind their code and is very useful in debugging, as it signals how the program should be acting.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Embed proper documentation into individual and group designed programs. • Use documentation when identifying personal work. • Interpret documentation within existing programs.	Students should *investigate* these concepts: • What does it mean to document programs? • How does documentation assist in the testing and debugging process?	Students should *apply* these terms in context: • Debugging • Documentation

7.3 The student will distribute tasks and maintain a project timeline when collaboratively developing computational artifacts.

Context of the Standard
Development of computational artifacts (program, image, audio, etc.) is often a collaborative effort. Working well in a group requires students to practice strategies such as delegation of responsibility, peer-review, and assigning self-imposed deadlines. These deadlines are used to construct a timeline that informs group participants of responsibilities and expectations when completing a project such as the development of a computational artifact. The creation of appropriate and realistic timelines is difficult to many students, particularly when working in groups. Students may need teacher guidance and scaffolding in the timeline construction process as well as regular reminders to look back and revise timelines as needed throughout the process.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Construct a timeline for a project or the development of a program that reflects the expectations and responsibilities of the members of a group. • Use and revise a timeline when completing a group project.	Students should *investigate* these concepts: • How do timelines help in the completion of a project or in the completion of a program? • What tasks or expectations should be included in a timeline? • How does the use of a timeline facilitate group work?	Students should *apply* these terms in context:

7.4 The student will decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs.

Context of the Standard
Decomposition breaks problems down into smaller pieces (subproblems). Problem decomposition allows for complex tasks to be solved in manageable chunks. Once a program has been broken down, it enables different group members to work on different parts at the same time. Decomposition can occur in the planning and design stage, allowing for the separate subprograms to be more easily tackled, or can occur when debugging a long and complex program. Students will practice this skill on programs they wrote and programs written by others.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Breakdown code into parts to facilitate creation of a program. • Use decomposition in all parts of the program development process (i.e., plan, design, and review).	Students should *investigate* these concepts: • Why does breaking a problem down into smaller problems make the overall task easier? • How does decomposing a program into subproblem help programmers when debugging a program? • How can decomposition be applied throughout the development process? • Why would using subproblems in a program be thought of as a time saving measure?	Students should *apply* these terms in context: • Decompose • Subprogram

Computing Systems

7.5 The student will describe how the Internet connects devices and networks all over the world. *Exclusion: Specific devices used to implement the Internet are beyond the scope of these standards.*

Context of the Standard
The Internet is a global network of computers. All computer devices (including PCs, laptops, game consoles and smartphones) that are connected to the Internet form part of this network. Some of the computers in this network are called web servers. A web server is a computer which holds websites for other computers linked to the Internet to access. Holding a website is known as 'hosting'. A web server may host one or many websites and webpages. Sending information to a web server is known as uploading. Receiving information from a web server is known as downloading.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Describe how the Internet connects devices and networks globally.	Students should *investigate* these concepts: • What effect has the Internet had on global communication?	Students should *apply* these terms in context: • Internet

Cybersecurity

7.6 The student will describe how physical and digital security measures protect electronic information.

Context of the Standard
Students will extend their knowledge of the need for physical and digital security measures to understanding and explaining that both types of measures protect our data and personal information. Students can explore different types of security measures and understand how each one protects us in different ways from different types of electronic breaches and attacks. Physical security measures include locking rooms with devices, badges, fingerprints, security cameras, paper shredding, etc. Digital security measures include firewalls, anti-virus software, strong passwords, anti-spyware, etc. In seventh grade, students will take this a step further from sixth grade by describing how these security measures can be applied in a setting.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Understand why data security is necessary.	Students should *investigate* these concepts: • Why is data security necessary? • How do physical security measures protect us?	Students should *apply* these terms in context: • Password • Firewall

Essential Skills	Essential Questions	Essential Vocabulary
• Distinguish between physical and digital security measures. • Explain how and why physical security measures protect us. • Apply examples of physical and digital security measures in a setting.	• How do digital security measures protect us? • Why should a student implement security measures when working with digital information?	

7.7 The student will identify existing cybersecurity concerns associated with Internet use and Internet-based systems and potential options to address these issues.

Context of the Standard
Cybersecurity is a growing industry in the world as more of our personal, financial, government, and military information is transmitted electronically and housed in data centers. Today's cybersecurity concerns are varied and complex and include actions like breaching of private information from governmental or business sources, the use of ransomware to withhold access to a computing system, or global threats from the hacking of confidential data by hostile entities. Cybersecurity encompasses many aspects of data protection in our society. Some examples are the protection of privacy, military information, credit card and banking information, social media profiles, etc. Measures to prevent loss of data or other cyberthreats, including both physical and digital security measures, must be practiced at all time. These can include logging out of accounts on public computers, use of strong passwords, and those outlined in Standard 7.6. In seventh grade, students will begin to understand how data is vulnerable and what steps are taken to protect it.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Explain the necessity of cybersecurity. • Explain risks associated with the use of public devices and unsecure WiFi. • Describe physical and digital security measures to improve cybersecurity.	Students should *investigate* these concepts: • What are some examples of recent breaches in cybersecurity? • What are the risks of using public devices and public WiFi connections? • How can we protect our data on the Internet?	Students should *apply* these terms in context: • Cybersecurity • Identity Theft

Data and Analysis

7.8 The student will discuss the correctness of a model representing a system by comparing the model's generated results with data that were observed in the system being modeled.

Context of the Standard
Models and simulations allow students to represent systems that are too large, too small, or otherwise difficult to study in a classroom setting. Computer models and simulations are necessary when the data sets are too large for human evaluation. There are limitless applications for computer models and simulations. A simulation is a virtual representation of a process that reflects how a real physical situation would most likely happen. Simulations are created using models that were developed based on data. Some examples of simulations are performance of cars in various weather conditions, rocket launches, growth of a population, and the ability of a vaccine to fight a disease. Models are also constructed to test hypotheses. The data generated from the model are used to evaluate whether the models are accurate, to make adjustments, and draw conclusions. Models and simulations need to be tested for accuracy and refined as necessary.

Context of the Standard
In sixth grade, students used models to represent systems and simulations to represent processes and to support hypotheses. In seventh grade, students will use real-world data to determine if the models and simulations are accurate and adjust the models/simulations to improve accuracy.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Compare output of the model with observed data. • Determine if a model accurately represents a system. • Identify components of a model and discuss how each component affects the generated results.	Students should *investigate* these concepts: • How can we use a model to make predictions? • What are some systems that can be modeled with a computer program? • How can we determine if a model is accurate? • What are some components of a model that can be modified?	Students should *apply* these terms in context: • Data • Parameter • Output • Input

7.9 The student will refine computational models based on the data they have generated.

Context of the Standard
Models are used in many disciplines to test and isolate specific systems while eliminating some of the complexity that can make results muddy or unclear. Because of this simplification, models need to be tested against real-world data. By designing a model and refining it based upon these data, researchers and designers can gain certainty that the model is valid and its results are meaningful. Students will create and refine computational models to simulate a system. Through this process they will gain insight into how mathematics, science, and computer science are used to understand our world.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Use actual data to test the model and compare the results. • Modify a model to more accurately represent a system when the model does not match the data. • Analyze a model to determine if the data generated reflects the physical phenomena.	Students should *investigate* these concepts: • What data can be used to test the model? • How can we determine if the model is accurate? • What changes can be made to the model to increase the accuracy?	Students should *apply* these terms in context: • Computational thinking • Command • Variable

Impacts of Computing

7.10 The student will explain how advances in technology have contributed to Virginia's prosperity and role in the global economy.

Context of the Standard
Students will explore a variety of technology fields in which Virginia has acted as a leader. Virginia's transportation system, which includes highways, railroads, air transportation, and shipping, moves raw materials to factories and finished products to markets. Virginia has a large number of communications and other technology industries. Virginia exports agricultural and manufactured products, including tobacco, poultry, coal, and large ships. Advances in transportation, communications, and technology have facilitated migration and led to economic development in Virginia. The students will investigate these industries' history, purpose, and how Virginia emerged in a leadership role.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Identify advances in technology in Virginia. • Explain contributions based on technology to Virginia's prosperity. • Explain the role of technology in Virginia within the global economy.	Students should *investigate* these concepts: • What role have technological innovations played in Virginia's economy? • What technology is generated in Virginia that impacts the global economy?	Students should *apply* these terms in context: • Technology • Global economy • Goods and services

7.11 The student will describe the development of new technologies in communication, entertainment, and business and their impact on American life.

Context of the Standard
Since before the Industrial Revolution, advances in technology have been influenced by and have influenced society. As the pace of technological advance increases and becomes more highly specified, these influences can be seen in all aspects of American life - how people interact, how data is stored, the importance of data security, financial transactions, and many more. Students will investigate new and developing technologies. Communication industry technological advancement may include but are not limited to: social media, machine learning, Internet of things, driverless cars, security and privacy, networking, branding, funnel marketing. Business industry technological advancements may include but are not limited to: traceability and safety software, database advancements, customer scheduling, big data and machine learning, automation, and augmented reality. Entertainment industry technological advancement may include but are not limited to: downloading digital music, video streaming, ticket sales, marketing and receiving, licensing, voice technology, and holograms. Students will examine the cause and effect nature between these technologies and various aspects of society, economy, and culture.

Essential Skills	Essential Questions	Essential Vocabulary
Students should *demonstrate* these skills: • Identify and describe new technologies in communication industry. • Identify and describe new technologies in entertainment industry. • Identify and describe new technologies in business. • Analyze the impact of new technologies on American life.	Students should *investigate* these concepts: • What are examples of new technologies in the communication industry? Entertainment industry? Business industry? • How have new computing technologies impacted American life? • Have the impact of new technologies been positive? Negative? Helpful? Useful?	Students should *apply* these terms in context: • Culture • Automation • Technology • Data

7.12 The student will explore careers related to the Internet.

Context of the Standard
There are many options for careers that utilize data collection and analysis. Students will explore various aspects of these careers such as type of work, pay rate, and education needed. The use of computer skills is not limited to computer fields; many fields require workers to use computing devices, analyze data, use models and simulations, and use different types of software and hardware when completing tasks. Careers in data science are in high demand; companies are finding it difficult to find workers in this field. Several computer careers are outlined below. • A data analyst's role is to collect, process, and perform statistical data analyses with the goal of helping companies make better business decisions. • A data scientist possesses a combination of analytic, machine learning, data mining, and statistical skills in addition to experience with algorithms and coding.

Context of the Standard
• Data engineers are the designers, builders, and managers of the information or big data infrastructure. • A data architect creates the blueprints for data management systems to integrate, centralize, protect, and maintain data sources. Current information on education, pay, and employment projections can be found through the U.S.Bureau of Labor Statistics (https://www.bls.gov/emp/).

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Research careers in computing and non-computing fields.	Explore a *career field* to answer the following questions: • What are potential career pathways related to the Internet? • What are the pros and cons to these fields? • What is the salary? Work environment? • Will there be a strong demand for that career in the future? • What are the trends that could influence the demand in the future? • Will there be local jobs in that field? Where are most jobs in this field? • What skills, education, languages and experience are required in that field?	Students should *apply* these terms in context: • Pay rate • Career Pathway • Internet • Workplace readiness skill • Salary

Networking and the Internet

7.13 The student will outline the advantages and disadvantages of transmitting information over the Internet, including speed, reliability, cost, and security.

Context of the Standard
There are a variety of factors to consider when evaluating data transmission over the Internet. Compared to physically sending documents or media, the Internet allows for relatively fast transfer at a low cost. However, sometimes the integrity of a file can be compromised if there is an error in transmission. There is also always a possibility that information can be hacked if it is sent via unsecured channels. Students will explore the different components to sending these messages, such as the medium for data transmission, and make determination of the advantages and disadvantages.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Explain different types of data and their speed when going from one device to another. • Compare the speed and reliability of various data transmission media. • Describe the advantages and disadvantages of transporting information over the Internet.	Students should *investigate* these concepts: • What are advantages in using the Internet to transmit information? • What are disadvantages in using the Internet to transmit information?	Students should *apply* these terms in context: • Internet speed • Data transmission • Reliability • Internet • IP address

7.14 The student will explain why protocols are necessary in data transmission. Model the role of protocols in transmitting data across networks and the Internet.

Context of the Standard
When computers communicate over networks, they break down messages into small chunks called packets. In order to reliably communicate among networked computing devices, all the devices need to create and interpret these packets based on a universally agreed-upon set of rules. Once these rules are in place, no one has to approve a new website or oversee additions to the network. The rules that govern communication among computing devices are called a protocol. Protocols allow computing devices to send and receive messages using the same series of steps for every instance of communication, whether they are sending messages across the room or across the planet. *Students are not expected to identify specific rules governing the functionality of transmission protocol in seventh grade. They should describe the overall purpose of a protocol in general terms.*

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Identify the purpose of a transmission protocol. • Describe the function of a simple transmission protocol.	Students should *investigate* these concepts: • How can you send something to someone you do not know? • Why do people need a protocol to send data back and forth?	Students should *apply* these terms in context: • Data transmission • Protocols • Network • Internet

7.15 The student will model how information is broken down into smaller pieces, transmitted as packets through multiple devices over networks and the Internet, and reassembled at the destination.

Context of the Standard
Due to the constraints of networks in handling large files, when data in many forms has to be sent, they are broken down into smaller structures of data - called packets - before transmission. Packets are reassembled to the original data chunk once they reach their destination according to the appropriate protocol. This process allows large items to be sent at relatively quick speeds and, due to built in redundancies of packets, also solves problems related to corruption of files occurring at some stage of sending. Students will model how these messages are broken up, transmitted, and put back together to maximize data integrity and efficiency.

Essential Skills	**Essential Questions**	**Essential Vocabulary**
Students should *demonstrate* these skills: • Explain the purpose of data packets. • Model a process of breaking a message into packets and message reassembly.	Students should *investigate* these concepts: • How is information sent from one computer to another over the Internet? • What happens if a message is too large to carry all at once?	Students should *apply* these terms in context: • Data integrity • Data efficiency • Computer network • Constraints • Network

Grade 7

Term	Definition
Automation	The use of largely automatic equipment in a system of manufacturing or other production process
Career Pathway	A series of connected education programs and courses that prepare students for a particular career
Command	An instruction telling a computer program to do something
Compound conditionals	The use of multiple conditions joined by AND or OR in a control structure
Computational thinking	A set of problem-solving methods that express problems and their solutions in a way that a computer could execute
Computer network	A series of interconnected computers and devices that share resources and exchange data with each other
Constraints	A limit or restriction on a program or situation
Culture	The customs, arts, social institutions, and achievements of a particular nation, people, or other social group
Cybersecurity	The study and practice of protecting computers and programs from unwanted access and theft of data
Data	Facts and statistics collected together for reference or analysis
Data efficiency	The speed and resource usage involved in collecting, manipulating, and analyzing data

Term	Definition
Data integrity	The preservation of accuracy and consistency of a data set over the course of its analysis
Data transmission	The process of transferring data between two or more digital devices
Debugging	Systematically finding the cause of an error in a program and fixing it
Decompose	System of program design that involves breaking problem down into smaller tasks
Documentation	Written text or illustrations that describe a program to its users or other programmers
Firewall	A part of a computer system or network which is designed to block unauthorized access while permitting outward communication
Funnel marketing	The process of directing consumers from becoming aware of a product to the eventual sale
Global economy	The international exchange of goods and services
Goods and services	The products and actions exchanged for money in an economy
Identity Theft	The deliberate use of someone's personal data for financial gain or to harm their reputation
If statements	A programming conditional statement that, if proved true, performs a function or displays information
Input	Data that is fed into a program to be processed

Term	Definition
Internet	A global computer network consisting of multiple interconnected networks
Internet speed	The rate at which data is communicated from the Internet to a computer and vice versa
IP address	A numerical label assigned to each computing device on a network
Model	Creating a representation of an idea, object, or a process
Network	A group of interconnected computers and other devices
Occupational Outlook Handbook	A publication of the US Department of Labor's statistics about various aspects of work in the United States
Output	Data that is produced by a program for the user or by another program
Parameter	A special value that is used to further define the action of a function
Password	A secret word or phrase that must be used to gain admission to something
Pay rate	The amount of money workers are paid by hour, week, etc.
Protocol	The official procedure of a particular computing process
Reliability	The ability of computers and the Internet to consistently perform to the expectations of their designed function

Term	Definition
Salary	The amount of money works are paid as described by an employment contract
Simulation	The use of a model to replicate or imitate a situation or phenomenon
Subprogram	A section of code designed to complete a task that is used multiple times within a program
Technology	Computing devices and skills used in production or investigation
Variable	Programming element that can hold a numeric or non-numeric value
Workplace readiness skill	The basic academic, critical thinking and personal skills necessary to maintain employment