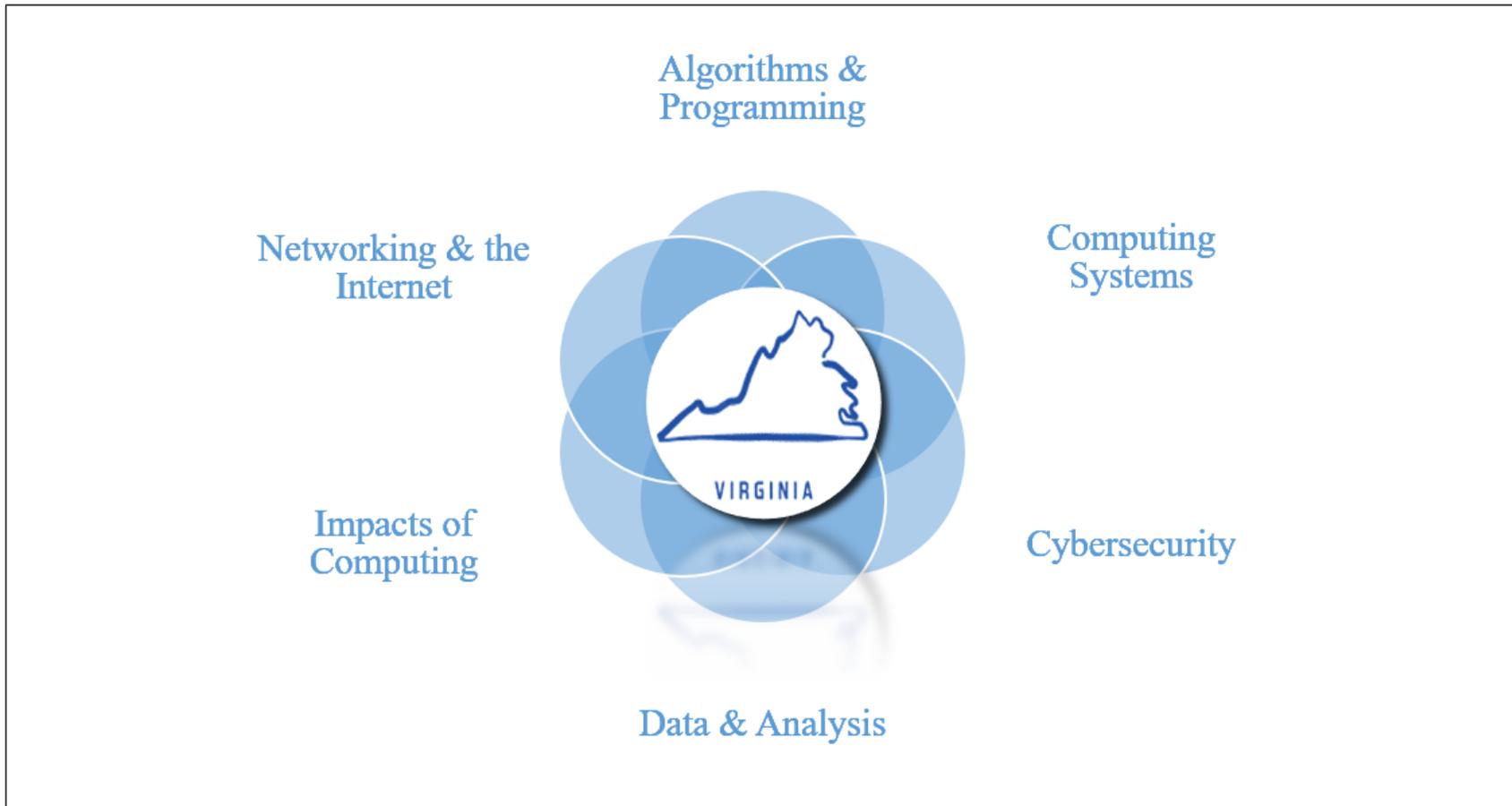


Computer Science Standards of Learning Curriculum Framework



Board of Education
Commonwealth of Virginia

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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 Six

The sixth-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 sixth grade begin to understand the means of storing data as representations of real world phenomena. 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

- 6.1 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,
- combining control structures such as if-statements and loops; and
 - 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 elementary school, students begin their study of programming through a focus on algorithms. They work both collaboratively and individually to develop algorithms to reflect tasks in daily life; these algorithms become more complex as they recognize and use

Context of the Standard

loops and events in the algorithms they construct. Although the use of plugged and unplugged activities is encouraged in early elementary, the expectation is that students use of block- and text-based programming as they progress in elementary years. Middle school continues to build on these skills as students use algorithms to build programs.

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none">• Create programs which specify the order (sequence) in which instructions are executed within a block-based and/or text-based program.• Appropriately name and apply variables in programs to meet desired outcomes.• Combine and nest if-statements and loops to create more complex programs.• Work with a partner or group to create a program.	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none">• What is meant by flow of control when developing programs?• What is the role of variables in program construction?• What kinds of data can be represented by variables?• What different types of data can be represented using variables?• What roles can different types of variables serve in program construction?• How does combining control structures increase efficiency in the construction of programs?	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none">• If statement• Loop• Control structure• Flow of control

6.2 The student will trace programs to predict outcomes and debug (correct and improve) for correctness.

Context of the Standard
<p>During the program review stage, the design and implementation are checked for adherence to program requirements, correctness, and usability. This review could lead to changes in implementation and possibly design, which demonstrates the iterative nature of the process. If the program does not work as intended, the students should determine what changes could be made to the program in order to complete the task. These changes may include adding, deleting, rearranging, or changing a step in order to obtain the intended outcome. The process of revising a program so that it works as intended is called debugging.</p> <p>One important skill students need is tracing code. Tracing means reading through commands using paper and pencil and predicting what the code will do. Students practice these skills by reviewing code written by themselves and others. This can be code the teacher creates, or through peer review.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Test and debug their own programs. • Test and debug programs written by others. • Predict the outcome or output of a program by examining the written code. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • Why is there a need to debug programs? • How does program tracing help with the debugging process? • How can you predict the outcome of a program without running it? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Bug • Debug • Program tracing

6.3 The student will seek and incorporate feedback from team members and users to refine a program that meets user needs.

Context of the Standard
<p>In middle school, students continue to develop effective group work habits across disciplines to help create products on a timetable that reflect all the group members. Programming is frequently done in a group setting. The practice of peer code review in computer science fosters effective communication, and allows students to see a variety of coding styles. The peer review process also allows students to identify common mistakes made by groupmates.</p> <p>A consideration of the peer review process is determining whether the outcome of the program meets the needs of the end-user. Considerations of the end-user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Work collaboratively with peers to review programs and adjust to meet intended outcomes. • Incorporate feedback into a program or the design of a computational artifact. • Analyze refined program to determine if it meets the intended outcomes as well as the end-user needs. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • What are the advantages of working in a group setting? • What are strategies that help in doing collaborative work? • Why is it important to analyze feedback? • What end-user considerations must be taken into consideration when determining an outcome? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • End-user

6.4 The student will incorporate existing code, media, and libraries into original programs, and give attribution.

Context of the Standard
<p>When developing programs, students are able to use algorithms, code, and other media created by others. The inclusion of existing code or portions of a program into a new program allows students to speed up the development process since they don't have to create as much from scratch. The scale of imported code can range from small sections of code to large libraries containing entire functionalities. Incorporating and editing the work of others enables students to learn different approaches to writing programs and create more powerful programs. For example, when creating a game, students may incorporate portions of code that create a realistic jump movement from another person's game, and they may also import Creative Commons-licensed images to use in the background. Creative Commons is a set of intellectual property laws that govern the use of media created by others.</p> <p>It is very important that, when using other peoples' creation, to give attribution to the original author. Students need to cite sources and give credit to the creators for all content they incorporate into their work.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Integrate portions of code, algorithms, and/or digital media from other sources in their own programs and websites. • Give attribution to the original creators to acknowledge their contributions. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • What is a Creative Commons license? • Why is important to give attribution to the original creators to acknowledge their contributions? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Creative Commons • Plagiarism • Source • Cite

Computing Systems

6.5 The student will design projects that combine hardware and software components to collect and exchange data.

Context of the Standard

When designing programs or completing projects, students should consider what types of data might be used as input, how the data is to be stored and processed, and the output that meets the specific needs of the user. The collection and exchanging of data is used throughout the programming process. The collection and exchange of data involves input, output, storage, and processing; both software and hardware components are critical to the collection and exchange of data. Student code must be written in a specific way to handle the data's input and manipulation. These data may be simple text or numbers typed in through the keyboard. There are also data such as motion or sound that may be difficult to enter without specific sensors.

Components to collect and exchange data are constantly being developed to meet societal needs. Examples of current components include GPS, car sensors, probeware, smartwatches, and more.

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Plan or sketch ideas combining hardware and software components that collect and exchange data. • Select the hardware and software components for project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • Why is important to know what kind of data you want to collect before you begin to design a project? • What are the different kinds of data you can collect using hardware and software? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Sensors

Cybersecurity

6.6 The student will identify physical and digital security measures used to protect electronic information.

Context of the Standard

Students use passwords to protect access to personal data. The use of passwords and common rules for the construction of passwords was introduced in elementary school. In sixth grade, students extend their knowledge of using passwords to protect data by learning about different types of security measures. They will identify and compare physical and digital security measures and explore the reasons for protecting electronic information. Physical security measures, as the term suggests, include locks on laptops, locked server rooms, etc. Digital security measures include firewalls, encryption, and biometric tests like thumbprint readers or retinal scans, etc.

Data protection is also a significant concern when storing and transferring personal and professional data. The concept of data protection extends into a variety of security measures. These security techniques can be hardware or software based.

At the middle school level, students are encouraged to use passwords. These passwords may not be as complex as those used by adults in protecting information. Suggestions for creating strong passwords for students include:

- Use uppercase and lowercase letters.
- Use numbers.
- Use symbols.
- Use at least 8 characters.
- Don't use words from a dictionary.
- Don't use the same password twice.
- Don't use personal information.

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Identify physical and digital security measures used to protect electronic information. • Compare advantages and disadvantages of a variety of security measures. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • Why is there a need for strong passwords? • What are the requirements of a strong password? • What are some examples of physical security measures? • What are some examples of digital security measures? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Password • Firewall • Biometrics

Data and Analysis

6.7 The student will explain how binary sequences are used to represent digital data. *Exclusion: Conversions between binary and base-ten numbers are beyond the scope of these standards.*

Context of the Standard
<p>Similar to humans, computers need a format in which to receive, interpret, and manipulate information. Computers use numeric values to store information and perform operations. Information inputted into the computer from various components must be converted into a binary sequence for processing. This conversion allows the computer to use the information and perform functions. Once all the functions and manipulation are complete, the binary sequence is translated back into a form of output that the user can understand, such as words, images, or sounds.</p> <p>Binary uses a sequence of 1's and 0's to represent data; each binary digit is referred to as a bit. All electronic data is binary information.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Identify examples of binary information. • Describe the characteristics and uses for a binary sequence. • Consider the possibilities and limitations that arise when sending binary messages. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • What is a binary sequence? • What are some examples of binary information? • What is the significance of binary sequences in computing? • How, in basic terms, does a computer convert information from binary into a form that an end user can understand? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Binary

6.8 The student will use computational tools to collect, organize, and clean data to make it more useful and reliable.

Context of the Standard
<p>In order to manipulate data, create representations, and draw conclusions, data must be organized in a consistent fashion. When collecting it is likely that there will be irrelevant and/or erroneous data points in a data set which can distort the results of any analysis. Data scientists spend up to 80% of their time cleaning these irrelevant or erroneous data points. Data cleaning is the process of detecting and correcting (or removing) corrupt or inaccurate records from a record set, table, or database and refers to identifying incomplete, incorrect, inaccurate or irrelevant parts of the data and then replacing, modifying, or deleting the dirty or coarse data.</p> <p>In elementary school students learn that data can be collected and stored in a variety of ways. Students will extend their data collection experience to include computational tools (e.g., surveys, spreadsheets). They will collect data electronically or convert data to an electronic format. The data will be organized and displayed through a graphical representation to make it easy to read and interpret. Removing irrelevant and/or erroneous data points is a new component to data analysis in middle school.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Collect data using a computational tool. • Organize data to make it easier to understand and use. • Transform (clean) data (remove and correct errors, unify response format, and eliminating blanks and duplicates) to process. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • How can we collect data electronically? • What does it mean to clean data and why is it necessary? • How does data type affect how it should be organized and displayed? • What are our goals and expectations for data cleaning? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Data • Data cleaning

6.9 The student will explain the insight and knowledge gained from digitally processed data by using appropriate visualizations.

Context of the Standard
<p>Data visualization is a general term that describes any effort to help people understand the significance of data by placing it in a visual context. Data visualization can allow for insight that would be more difficult than by looking at the raw data. Patterns, trends and correlations that might go undetected in text-based data can be exposed and recognized easier with data visualization models. Visualization model may include: circle graphs, bar graph, line plots, pictographs, Venn Diagram, etc. Software applications can also be used to assist in visualizing data.</p> <p>In sixth grade, students will evaluate visual representations of data to draw conclusions and determine the best visualization for various types of data. This is an opportunity to explore ways that data and graphical representations can be intentionally or unintentionally misleading.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Identify different types of visual representations of data. • Compare various visual representations and identify when each should be used. • Use data to create a visual artifact that answers a research question and communicates results and conclusions. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • What are some ways we can visually represent data? • How can visualizations be used to make data easier to interpret and answer questions? • How can we select the best graph for a data set? 	<p>Students should <i>apply</i> these terms in context:</p>

6.10 The student will use models and simulations to formulate, refine, and test hypotheses.

Context of the Standard
<p>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.</p> <p>Models are also constructed to test hypotheses. The data generated from the model are used to evaluate whether these models are accurate, make adjustments, and make conclusions. Models and simulations need to be tested for accuracy and refined as necessary.</p> <p>Students entering sixth grade have interpreted and constructed models to explain concepts in both computer science and science. In sixth grade, students will use models to represent systems and simulations to represent processes and to support hypotheses.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Create a hypothesis and test it using a computational model or simulation. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • What are some systems or situations that can be modeled or simulated? • What is the difference between a model and a simulation? • How can we use data to improve a model or simulation? 	<p>Students should <i>apply</i> these terms in context:</p> <ul style="list-style-type: none"> • Model • Simulation

Impacts of Computing

6.11 The student will explain how computing has impacted innovations in other fields.

Context of the Standard
<p>Almost every industry has been affected by computing technology. Manufacturing, retail, finance, healthcare, and transportation are examples of fields that have been drastically changed by the incorporation of computers. Technologies that have influenced innovation include, but are not limited to: sensors, GPS, digital forensics, cryptocurrency, cybersecurity, databases, the cloud, the Internet, Virtual Reality, 3D printing, self-driving vehicles, etc.</p> <p>Computing has also impacted innovation. Examples of innovation that have affected different career fields include: providing the opportunity for faster production, accessing large quantities of data and information, advancing our ability in communication and collaboration, and self-publishing.</p> <p>In sixth grade, students begin to understand the impact of computer science in multiple career fields. Computer science has provided opportunities for these fields to grow and evolve.</p>

Essential Skills	Essential Questions	Essential Vocabulary
Students should <i>demonstrate</i> these skills: <ul style="list-style-type: none"> • Explain how computing impacts innovation. 	Students should <i>investigate</i> these concepts: <ul style="list-style-type: none"> • How does computing impact innovation in non-computing oriented fields? 	Students should <i>apply</i> these terms in context:

6.12 The student will explore careers related to data.

Context of the Standard
<p>There are many options for careers that utilize data collection and analysis. In sixth grade, students will explore various aspects of careers such as work expectations, pay rate, and required education. 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. Examples of data-related careers include data analyst, data scientist, data engineer, data architect.</p> <p>Current information on education, pay, and employment projections can be found through the U.S.Bureau of Labor Statistics (https://www.bls.gov/emp/).</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Research careers in computing and non-computing fields. 	<p>Explore a <i>career field</i> to answer the following questions:</p> <ul style="list-style-type: none"> • What are potential career pathways related to data? • What are the pros and cons to the field? • 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? 	<p>Students should <i>apply</i> these terms in context:</p>

Networking and the Internet

6.13 The student will explain why the speed of data transmission across the Internet can vary depending on the type of data being transmitted.

Context of the Standard
<p>Speed of data transmission is how fast data can be sent from one device to another. There are a variety of factors to consider when evaluating transmission speed, including the size of the file or artifact, available bandwidth (maximum rate of data transfer), and concurrent uploading or downloading activity taking place on a given network. Examples of different types of data: jpeg, pdf, Word document, Google Doc, and video.</p>

Essential Skills	Essential Questions	Essential Vocabulary
<p>Students should <i>demonstrate</i> these skills:</p> <ul style="list-style-type: none"> • Explain different types of data and their speed when going from one device to another. • Describe factors that may affect the speed of data transmission. 	<p>Students should <i>investigate</i> these concepts:</p> <ul style="list-style-type: none"> • Why is important to know different types of data and their rates of speed? • Besides the size of the data type, what else can affect the speed of transmission? 	<p>Students should <i>apply</i> these terms in context:</p>

Grade 6

Term	Definition
Binary	The number system used by computers to represent all messages and commands
Biometrics	The use of physical human characteristics to facilitate security authentication
Bug	An error or flaw in a program that causes it to give the wrong answer or crash
Cite	To mention the author of a piece of text or media
Control structure	A block of programming that analyses variables and chooses a direction in which to go based on given parameters
Creative Commons	A set of intellectual property laws that defines how a piece of text or media can be used by others
Data	Facts and statistics collected together for reference or analysis
Data cleaning	Detecting and correcting corrupt and inaccurate records from a set of data
Debug	Find and fix problems in a program
End-user	The person who uses a particular program
Firewall	A part of a computer system or network which is designed to block unauthorized access while permitting outward communication
Flow of control	The order function calls, instructions, and statements are executed or evaluated when a program is running.
If statement	A programming conditional statement that, if proved true, performs a function or displays information
Incomplete data	A data set that has values or sections missing that could make analysis difficult

Term	Definition
Loop	A control structure that repeats a section of code until a condition is met
Model	Creating a representation of an idea, object, or a process
Password	A secret word or phrase that must be used to gain admission to something
Plagiarism	The act of passing off someone else's work or ideas as one's own
Program tracing	Reading a program and predicting how variables change and what will be output
Sensors	Hardware components that collect environmental data such as temperature or sound
Simulation	The use of a model to replicate or imitate a situation or phenomenon
Source	The original text or media from which content is used and cited