Computer Science

Tennessee K-12 Computer Science State Standards

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Introduction

Tennessee students have various 21st century needs that their K-12 education should address to enable them to engage and thrive in a connected, digital world. The Tennessee K-12 Computer Science Standards are designed to be used within and across all content areas to enhance learning and to ultimately inspire students to take ownership of their own academic success.

Computer science is one of the **fastest growing industries** and computer programmers are needed within every field, including healthcare, transportation, and banking.[1] Although not every Tennessee student will enter a STEM field, all students will benefit from learning computer science concepts and practices allowing them to better understanding the world around them, improve their logical reasoning and problem-solving skills, and increase their creativity and collaboration.

ACT results over the past two years in Tennessee indicate that **close to half (48 percent)** of the state's graduates have an interest in pursuing a STEM field, but **only 21 percent meet the ACT STEM benchmarks**. While the number of students meeting the STEM benchmark has improved by a few percentage points since 2013, Tennessee continues to see gaps between interest and aptitude for STEM. Additionally, STEM interest has declined since 2013, with minority and female interest particularly low. One way to shrink this gap is to explicitly focus on how STEM content is applied in the classroom. Because computer science is an applied science it encourages students to understand and engage in the "why" of science, technology, engineering and math, so they can begin to see connections to careers. This can serve as a needed inspiration as students learn science and math.

In addition to the benefits for students, investing in computer science will directly benefit Tennessee's economy. **Tennessee, like many other states, has seen a steady increase in the number of jobs in the computer science and technology** fields. From 2013 to 2015, Tennessee's advanced **industry jobs increased by an average of 4.6 percent** annually, outpacing the national average, and the Nashville metropolitan region **ranked No. one** among the 100 largest metro areas in the U.S. **for advanced industry job growth**.[2] Specifically, IT employment throughout the state grew 13.7 percent from 2010-2015.

For Tennessee to continue its economic growth, it must take advantage of the growing number of high wage technology jobs available by ensuring that a skilled workforce is available and ready to meet the demand. Currently, Tennessee **employment in the IT field is 39 percent below the national average**, and during 2015, there were **89,686 unique job postings for IT jobs in the state but only 32,052 hires**.

The instructional focus in elementary school will be introducing students to computer systems and helping them develop an awareness of safe and responsible device practices, such as protecting private information and best practices for creating and using passwords. Students will also develop an

[1] *K-12 Computer Science Framework*. (n.d.) k12.cs.org. https://k12cs.org.

[2] *Tennessee is Top State in US for Advanced Industry Job Growth, Brookings Institution Report Finds.* (n.d.). www.tn.gov. Retrieved September 14, 2022, from https://www.tn.gov/ecd/news/2016/8/5/tennessee-is-top-state-in-us-for-advanced-industry-job-growth-brookings-ins.html

understanding of how multi-step solutions are executed within computer programs. They will do this in the organic intersections of content when teachers can infuse computer science vocabulary and make students metacognitive about the task they are performing as they work and study any topic area.

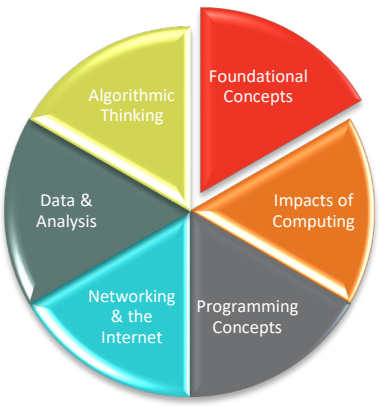
The instructional focus in middle school will extend digital citizenship discussions to include safely interacting with people and content online, including socio-emotional health issues around bullying. Students will engage in activities to introduce computational thinking and information-processing skills to be utilized in creating programs. They will be introduced to the idea of computer programming as a study of languages, using pseudo-code instead of an emphasis on specific programming languages at this stage of development. Students will explore connections between computer science skills and career opportunities; including how almost every occupation today requires computer literacy.

At the high-school level, students have the option of taking a basic level introductory course to computer science or exploring languages, app development, and hardware associated with computers through elective academic coursework (i.e., AP Computer Science Principles or AP Computer Science A) or enrolling in a technology-focused career and technical education program of study which includes the opportunity for students to gain multiple industry-recognized certifications. These high school courses are focused on developing industry specific skills through the application of technical skills to real world problems.

The standards are divided into six major strands (Core Concepts), with each strand developing from one grade level to the next and extending into a student's high-school course work. The five strands excluding Programming Concepts are not meant to be taught in isolation, rather they should be integrated within grade-level content areas with a goal of cultivating empowered learners throughout their academic career. The Programming Concepts strand should be addressed through explicit computer science instruction. The Tennessee K-12 Computer Science Standards lay a foundation that enables students to be workforce and post-secondary ready in a continuously evolving technological world.

The six core concepts of K-12 Computer Science are represented in the graphic below. They are similarly sized because they each support the other. One cannot remove one without causing the integrity of the structure to collapse; therefore, by the time a student has completed high school in Tennessee, he/she should have had opportunities to explore, experience and demonstrate mastery in each of the six core concept areas and to develop the skills and practices each represents.

Figure 1. Six Core Concepts of Tennessee's CS K12 Standards



Vision of the Tennessee K-12 Computer Science Standards

Drawing from a purpose for computer science standards embraced by the national K-12 Computer Science Framework[3] which discusses the overlap of concepts from the fields of educational technology, digital citizenship, and information technology with computer science. It states that tomorrow's workforce and innovators need to understand why computer technologies work and how to create and improve upon those technologies.

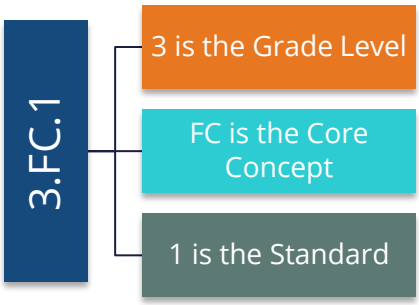
Building on that idea, the Tennessee K-12 Computer Science Standards are written to capture those skills and knowledge that any citizen in the modern era needs to function as a contributing part of society. The driving thought behind these standards is that *Computer Science should become a foundational part of Tennessee K-12 education, accessible by all, rather than a vocational part of education only for those headed to technology-based employment.*

To achieve this vision, the Standards are created in themes and terms so as to be seamlessly integrated into instruction and cognitive tasks in every grade level and subject area so students can see how the logical problem solving allows for enhancement of any topic.

Structure of the Standards

The organization and structure of this standards document includes:

- **Grade Level/Course Overview:** An overview that describes that specific content and themes for each grade level or high school course.
- **Core Concept:** The six overarching ideas/skills inherent to Computer Science.
- **Standard:** Statements of what students can do to demonstrate knowledge of the conceptual understanding.



[3] *K-12 Computer Science Framework. (n.d.) K12cs.org. https://k12cs.org/*

Grade Level Progression

The structure of the progression of ideas is built heavily upon the practices captured in the national CS K-12 Framework. In each grade band overview, there is a visual showing the six core concepts and practices that build from kindergarten through 12th grade listed under each. In each grade progression the practices highlighted are those included in the standards for that band. This makes it easy to see the spiral nature of knowledge and skills throughout a student's career and teachers to see that the call for integration is not an overwhelming number of new concepts or skills. Here is the progression shown at high school level, where all practices are revisited in the direct instruction format of the high school computer science course:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)
Investigable questions/problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
			Communicating data for decision making or problem solving		

Computer Science Standards Creation

Applications were solicited in winter 2022 for interested K-12 teachers to work on the creation committee. The committee was selected to represent diversity in grade level, primary subject area, school setting (urban, rural, suburban) and socio-economic status in addition to gender and ethnicity. The 26-person selected team met in person on May 10, 2022, in Nashville for an orientation to the task and training on standards writing. At the meeting, teachers were grouped into grade bands based on their job role and

stated preference. There were four working groups appointed, one for K-2, 3-5, 6-8, and 9-12. Out of the 26 teachers there were 12 different Tennessee counties represented, five from the eastern grand division of the state, four from the middle or central division, and three from the western grand division. A complete list of the standards writing team members can be found in Appendix A.

The writing process itself extended from May through July 2022. The first draft of the standards was then vetted by industry professionals from a variety of tech-based companies and higher education institutions across Tennessee by invitation from the Tennessee STEM Innovation Network. Names, job titles and organizational affiliations of those who provided input in the first round will be found in Appendix B. Their first round of feedback is included in the first draft being submitted to the Tennessee State Board of Education for consideration of first reading at the scheduled October 28, 2022 meeting.

Grades K-2 Overview

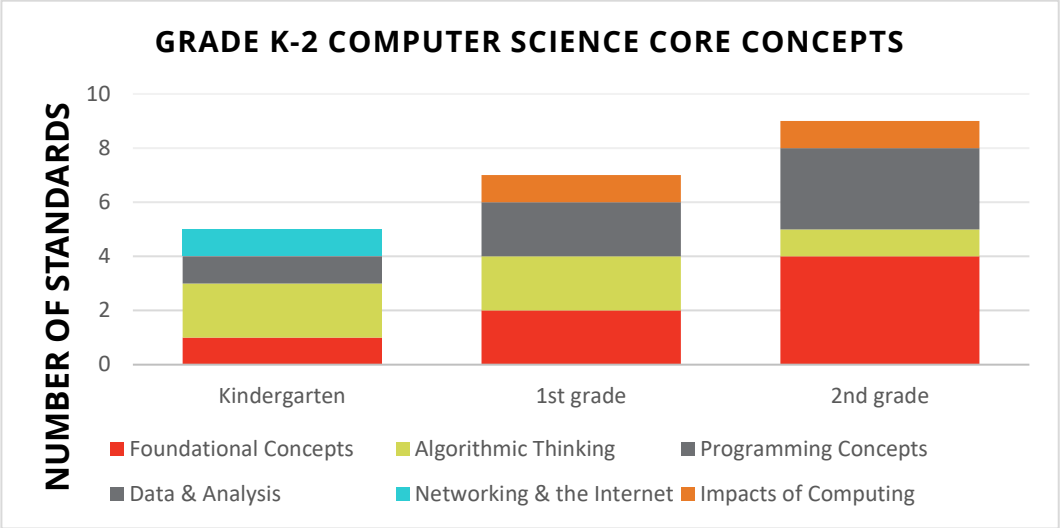
The overarching goal of primary grades progression is to harness the novelty of interactions this age group will have begun to experience just by existing in this digitally ubiquitous world. A study published in 2014 in the online *Journal of the American Medical Association Pediatrics* found that on average children in the United States aged three – five years old were logging 2 hours, 28 minutes a day of screen time.[4] This means that before they even get to formal schooling, they have been exposed to thousands of hours of computer logic and its outputs for entertainment and early learning. The academic standards for Computer Science in grades K-2 are built to emphasize the intention that Computer Science concepts are not delivered via direct instruction in a class with its own curriculum for this age. Following recognition in the *National K-12 Computer Science Framework* that computer science supports play-based pedagogy and extends what educators are already doing in their classrooms; these standards are designed to be integrated into regular content instruction in other academic areas already required in Tennessee K-2 grade standards.[5]

The standards in grades K-2 are about beginning the practices that will eventually become habits which help students recognize that Computer Science is the body of problem-solving practices that allow computers to do what their brains do, just faster. Emphasis on application of concepts in the learning process will help students understand these are habits that will help them no matter the content studied and even into their future workplace.

The Tennessee Writing Committee identified Core Concepts (domains) of critical ideas in Computer Science. Each Core Concept has large ideas/habits embedded and the progression of standards through primary grades K-2 look like this:

[4] Chen W, Adler JL. *Assessment of Screen Exposure in Young Children, 1997 to 2014.* JAMA Pediatric. *2019;173(4):391–393. doi:10.1001/jamapediatrics.2018.5546*

[5] *Computer Science in Early Childhood Education.* (n.d.). K12cs.org. https://k12cs.org/pre-k/



Kindergarten: Overview

The academic standards for kindergarten establish the foundation to create habits of problem solving and playing that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in kindergarten are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of kindergarten. Core concepts and skills for kindergarten include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)
Computational thinking	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Kindergarten: Computer Science Standards

K.FC: Foundational Concepts

1) Locate letters and numbers on the keyboard.
2) Ask questions to conduct investigations, solve problems, and test solutions.

K.AT: Algorithmic Thinking

1) Construct sequential events step-by-step in a logical order.

K.DA: Data Analysis

1) Collect and organize data.

K.NI: Networking and the Internet

1) Demonstrate age-appropriate methods for keeping personal information private.

First Grade: Overview

The academic standards for first grade establish the foundation to create habits of problem solving and playing that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in first grade are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of first grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for first grade include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)

Computational thinking	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

First Grade: Computer Science Standards

1.FC: Foundational Concepts

1) Navigate to applications and documents by using desktop icons, windows, and menus (e.g., open and close the browser window, find/use bookmark to store the website, recognize and use app on tablet).
2) Demonstrate use of input devices (e.g., mouse, keyboard).

1.AT: Algorithmic Thinking

1) Identify and revise problem-solving strategies to solve a simple problem.
2) Classify and sort information into logical order with and/or without a computer.
3) Utilize digital tools to illustrate potential solutions to a problem.

1.DA: Data Analysis

1) Interpret data displayed in a chart.
2) Organize data using similarities and differences.

1.NI: Networking and the Internet

1) Advocate, demonstrate, and routinely practice safe, legal, and responsible use of information and technology.

Second Grade: Overview

The academic standards for second grade establish the foundation to create habits of problem solving and playing that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in second grade are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of second grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for second grade include:

Foundational Concepts	Algorithmic Thinking	Programming Concepts	Data and Analysis	Networking & the Internet	Impacts of Computing
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)
Investigable questions/problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/ personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Second Grade: Computer Science Standards

2.FC: Foundational Concepts

1) Use the menu and tool bar to navigate editing functions.
2) Use a variety of digital tools collaboratively to connect with other learners.
3) Ask questions to conduct investigations, solve problems, and test solutions.
4) Select technology or tools to solve a problem or design a solution.

2.AT: Algorithmic Thinking

1) Plan and create a design document to illustrate thoughts, ideas, and stories in a sequential (step-by-step) manner (e.g., story map, storyboard, sequential graphic organizer).
2) Compare and evaluate multiple ways to get a solution.
3) Categorize a group of items based on the attributes of actions of each item, with or without a computing device.

2.DA: Data Analysis

1) Use data to make decisions, identify solutions, or determine relationships.

2) Use if/then reasoning to understand relationships with data.
3) Collect, create, and organize data in a digital chart or graph.

2.NI: Networking and the Internet

1) Identify appropriate and inappropriate behaviors for communicating in a digital environment.
2) Cite media and/or owners of digital content.
3) Create a research-based product using online digital tools.

2.IC: Impacts of Computing

1) Recognize and describe the potential risks and dangers associated with various forms of online communications (e.g., cell phones, social media, digital photos).

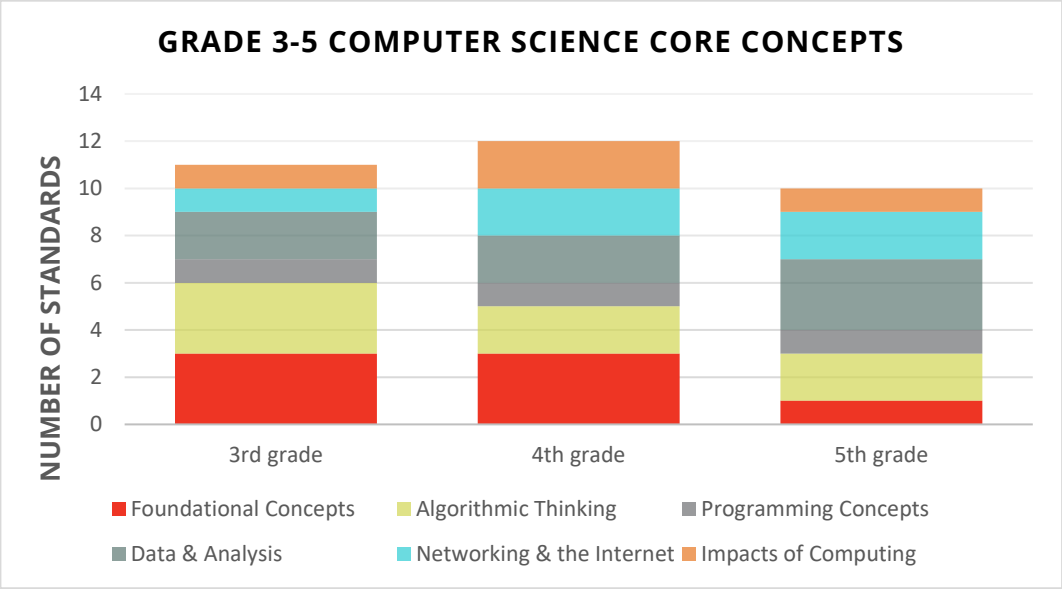
Grades 3-5 Overview

The early accountability grades are the perfect time for districts to allow a focus on equity, inclusion and diversity in all aspects of computer science education to provide context for the literacy and numeracy that students are gaining simultaneously. Allowing students to engage in project-based work furthers internalization of all academic learning targets by providing engaging and fun work that introduces vocabulary, structured problem solving, and tasks that support the structured nature of computational thinking and allows them a glimpse into why computers do what we tell them to do. Concepts and language are able to be introduced at natural intersections with tested academic content in early grade levels and elaborated on over multiple years to allow habits to form and schema to develop. Following guidance in the *National K-12 Computer Science Framework;* these standards are designed to be integrated into regular content instruction in other academic areas already required in Tennessee 3-5 grade standards.[6]

The standards in grades 3–5 are about extending understanding of concepts introduced in grades K-2 in computational thinking and offering opportunities to apply new computer science vocabulary and processes while deepening levels of comprehension of core content standards. Emphasis on application of concepts in the learning process will help students understand these habits of problem solving and tools of computer science that will help them no matter the content studied and even into their future workplace.

The Tennessee Writing Committee identified six Core Concepts (domains) of critical ideas in Computer Science. Each Core Concept has large ideas/habits embedded and the progression of standards through intermediate grades 3–5, they look like this:

[6] *Computer Science in Early Childhood Education*. (n.d.). K12cs.org. https://k12cs.org/pre-k/



Third Grade: Overview

The academic standards for third grade continue development of vocabulary and introduce simple computing concepts that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in third grade are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of third grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for third grade include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)

Investigable questions/problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/ personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Third Grade: Computer Science Standards

3.FC: Foundational Concepts

1) Locate and use appropriate online tools and resources to explore, research, and collect data on specific topics (e.g., applications, web browsers, and online tutorials).
2) Communicate key ideas and details collaboratively in a way that informs, persuades, and/or entertains, using digital tools.
3) Use basic features of digital tools to communicate key ideas and details in a way that informs and/or persuades.

3.AT: Algorithmic Thinking

1) Discuss the design process and use digital tools to illustrate potential solutions.
2) Create an algorithm to solve a problem as a collaborative team.
3) Identify problems to solve and generate questions for investigations.

3.DA: Data Analysis

1) Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea.
2) Describe examples of data sets or databases from everyday life.

3.NI: Networking and the Internet

1) Advocate, demonstrate, and routinely practice safe, legal, and responsible use of information and technology.
2) Conduct basic keyword searches to produce valid, appropriate results, and evaluate results for accuracy, relevance, and appropriateness.

3.PC: Programming Concepts

1) Analyze a given list of sub-problems while addressing a larger problem.
2) Define a problem or task, decompose it into smaller sub-problems.
3) Use numbers or letters to represent information in another form.

Fourth Grade: Overview

The academic standards for fourth grade continue development of vocabulary and introduce simple computing concepts that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in fourth grade are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of fourth grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for fourth grade include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)
Investigable questions/problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Fourth Grade: Computer Science Standards

4.FC: Foundational Concepts

1) Demonstrate an appropriate level of proficiency in performing tasks using a range of digital devices.

2) Use age-appropriate online tools and resources (e.g., learning management systems, grade and assignment record, tutorial, assessment, web browser).
3) Create a simple digital model of a system and explain what the model shows and does not show.

4.AT: Algorithmic Thinking

1) Examine logical reasoning to predict outcomes of an algorithm.
2) Use flowcharts to create a plan or algorithm.
3) Construct a basic system of numbers, letters, or symbols to represent information as a cipher.

4.DA: Data Analysis

1) Collect, organize, analyze, and interpret data to identify solutions and/or make informed decisions.
2) Gather data to answer a question using a variety of computing and data visualization methods.

4.NI: Networking and the Internet

1) Identify appropriate and inappropriate uses of communication technology and discuss the permanence of actions in the digital world.
2) Conduct advanced keyword searches to produce valid, appropriate results and evaluate results for accuracy, relevance, and appropriateness.

4.PC: Programming Concepts

1) Test and debug a given program in a block-based visual programming environment using arithmetic operators, conditionals, and repetition in programs, in collaboration with others.

4.IC: Impacts of Computing

1) Identify laws and tools which help ensure that users of varying abilities can access electronic and information technology.
2) Explain how hardware and applications can enable everyone, including people with disabilities, to do things they could not do otherwise.

Fifth Grade: Overview

The academic standards for fifth grade continue development of vocabulary and introduce simple computing concepts that will prepare students for learning in all subject areas and even future jobs. These standards are the minimum a teacher should integrate across the year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science in fifth grade are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of fifth grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for fifth grade include:

Foundational Concepts	Algorithmic Thinking	Programming Concepts	Data and Analysis	Networking & the Internet	Impacts of Computing
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems (internet safety)
Investigable questions/ problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Fifth Grade: Computer Science Standards

5.FC: Foundational Concepts

1) Use advanced features of digital tools and media-rich resources to communicate key ideas and details in a way that informs, persuades, and/or entertains.

5.AT: Algorithmic Thinking

1) Analyze and improve an algorithm that includes sequencing and simple patterns with or without a computing device.
2) Create an algorithm to solve a problem while detecting and debugging logical errors within the algorithm.
3) Develop and recommend solutions to a given problem and explain the process to an audience.

5.DA: Data Analysis

1) Manipulate data to answer a question using a variety of computing methods and tools to collect, organize, graph, analyze, and publish the resulting information.
2) Connect data from a simulation to real-life events.

5.NI: Networking and the Internet

1) Explain responsible uses of technology and digital information; describe possible consequences of inappropriate use such as copyright infringement and piracy.
2) Apply copyright principles to real life scenarios.

5.PC: Programming Concepts

1) Create simple animated stories or solve pre-existing problems using a precise sequence of instructions and simple loops, collaboratively or individually.
2) Identify bugs (errors) in basic programming.

5.IC: Impacts of Computing

1) Analyze the impact of social media on individuals, families, and society.

Middle School: Overview

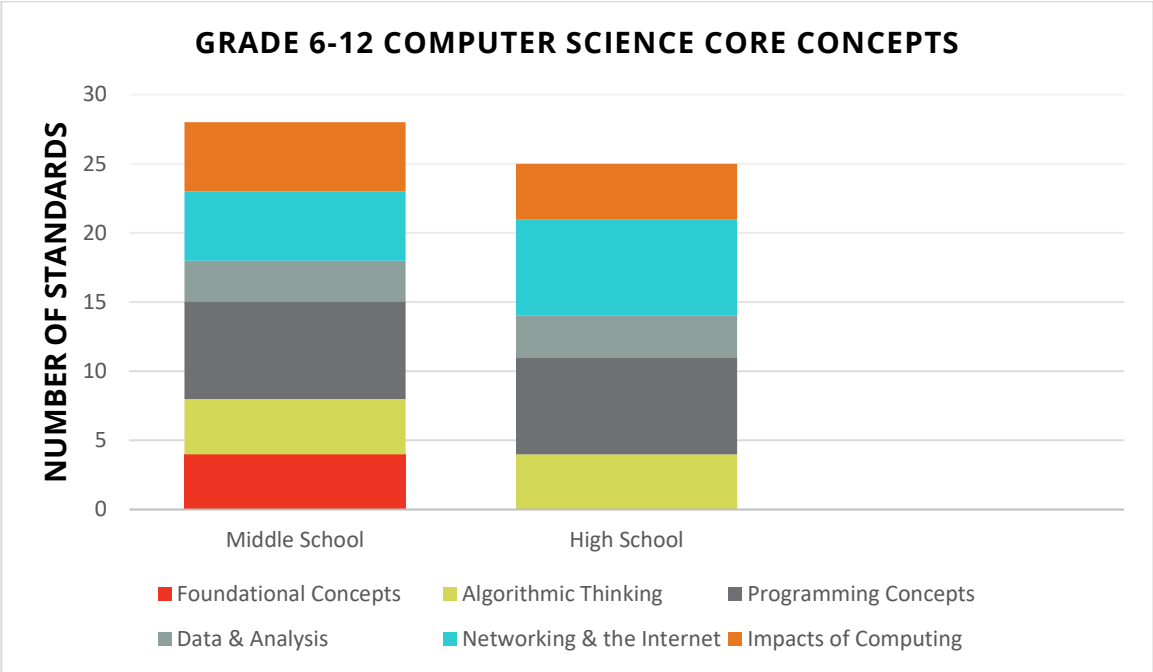
While Chapter 979 calls for direct instruction during middle school, there is a recognition that if computer science really is a body of habits of mind, then the habits must be consistently practiced for the entirety of a students' middle school experience. While direct instruction allows teachers with computer language training to set up learning experiences specific to some programs, the intention of the Computer Science Standards Writing Committee is that all teachers will offer opportunities for students to practice the vocabulary and thinking skills of Computer science in every subject area. As teachers are encouraged to offer student agency and creativity in creating work products to demonstrate learning in all academic and related areas, computer science skills and concepts will enhance the rigor and authenticity by their incorporation into any subject or grade level in addition to direct instruction to build programming skills. Following guidance in the *National K-12 Computer Science Framework.*[7] These standards are designed to be integrated into regular content instruction in other academic areas already required in Tennessee 6-8 grade standards-based instruction.

Inclusion of computer science concepts and skills regularly and across content areas will offer students more opportunities for exposure to potential career fields which employ tasks and skills they find success and enjoyment in while learning content. Consistent and ubiquitous inclusion of opportunities to increase skills that are part of 21st century life, including digital citizenship and etiquette, also allow support for development of beneficial social-emotional health habits in this critical age of self-identity formation in the middle school years. Emphasis on application of concepts in the learning process will help students understand these habits of problem solving and tools of computer science that will help them no matter the content studied and even into their future workplace.

Because the requirement allows flexibility on the part of schools to meet the instructional time requirement, the standards for grades 6 – 8 are written as a grade band. They should be read as "by the time a student completes eighth grade, he/she should be able to . . . " with the understanding that true "ability" entails multiple exposure and scaffolded experiences consistently throughout the middle school career. These standards will not be adequately built for success in high school if students are only exposed to instruction in one direct instruction experience lasting one part of one year of their time in middle school. Please see the "Tennessee Computer Science Resources" document for suggested grade-level activities and break down of the standards.

[7] *Computer Science in Early Childhood Education.* (n.d.). K12cs.org. https://k12cs.org/pre-k/

The Tennessee Writing Committee identified six Core Concepts (domains) of critical ideas in Computer Science. Each Core Concept has large ideas/habits embedded and the progression of standards through middle school grades 6 – 8, they look like this:



The academic standards for middle school are intended to be reinforced in classrooms of every subject area and grade level in middle school except for specific programming language in the Core Concept of Programming Concepts, which is recommended to be included in the direct instruction curriculum. These standards are the minimum a teacher should integrate across any year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science for middle school are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of eighth grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for middle school include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down	Developing code to solve a problem	Cleaning or transforming data to	Data is transferred using	Benefits and risks to users and

	problems into parts		discover useful information	protocols or rules	developers due to computational systems (internet safety)
Investigable questions/ problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

Middle School: Computer Science Standards

MS.FC: Foundational Concepts

1) Analyze the advantages and limitations of existing computing devices to improve user experience.
2) Demonstrate skills in identifying and solving hardware and software problems that can occur during regular usage.
3) Apply computational thinking to a variety of problems across multiple disciplines.
4) Understand how collaboration is essential to computer science and apply collaborative skills to develop computational solutions.

MS.AT: Algorithmic Thinking

1) Use clearly named variables of various data types to create generalized algorithms.
2) Create algorithms which include methods of controlling the flow of computation using "if…then… else" type conditional statements to perform different operations depending on the values of inputs.
3) Identify algorithms that make use of sequencing, selection, or iteration.
4) Describe how algorithmic processes and automation increase efficiency.

MS.DA: Data Analysis

1) Represent data using multiple encoding schemes, such as decimal, binary, Unicode, Morse code, Shorthand, student-created codes.
2) Refine computational models based on the data they have generated.
3) Collect, analyze, transform, and refine computational data to make it more useful and reliable.

MS.NI: Networking and the Internet

1) Identify and employ appropriate troubleshooting techniques used to solve computing or connectivity issues.

2) Differentiate between secure and non-secure websites and applications including how they affect and use personal data.
3) Describe the causes and effects of intellectual property as it relates to print and digital media, considering copyright, fair use, licensing, sharing, and attribution.
4) Compare and contrast common methods of securing data and cybersecurity.
5) Analyze different modes of social engineering and their effectiveness.

MS.PC: Programming Concepts

1) Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs.
2) Create procedures with parameters that hide the complexity of a task and can be reused to solve similar tasks.
3) Seek and incorporate feedback from team members and users to refine a solution that meets user needs.
4) Provide proper attribution when incorporating existing code, media, and libraries into original programs.
5) Use the iterative design process to systematically test and refine programs to improve performance and eliminate errors.
6) Document programs using comments and/or README files to make them easier to follow, test, and debug.
7) Design a function using a programming language.

MS.IC: Impacts of Computing

1) Identify and evaluate the impacts computer science innovations have had on our society.
2) Identify how computational systems are being used to collect and analyze information both public and private and understand the benefits and disadvantages of these systems for the user and developer.
3) Cite evidence of the positive and negative effects of data permanence on personal and professional digital identity.
4) Discuss digital globalization and Internet censorship.
5) Investigate a variety of education pathways and career options that utilize computational thinking and/or computer science skills across the state of Tennessee and the world.

High School: Overview

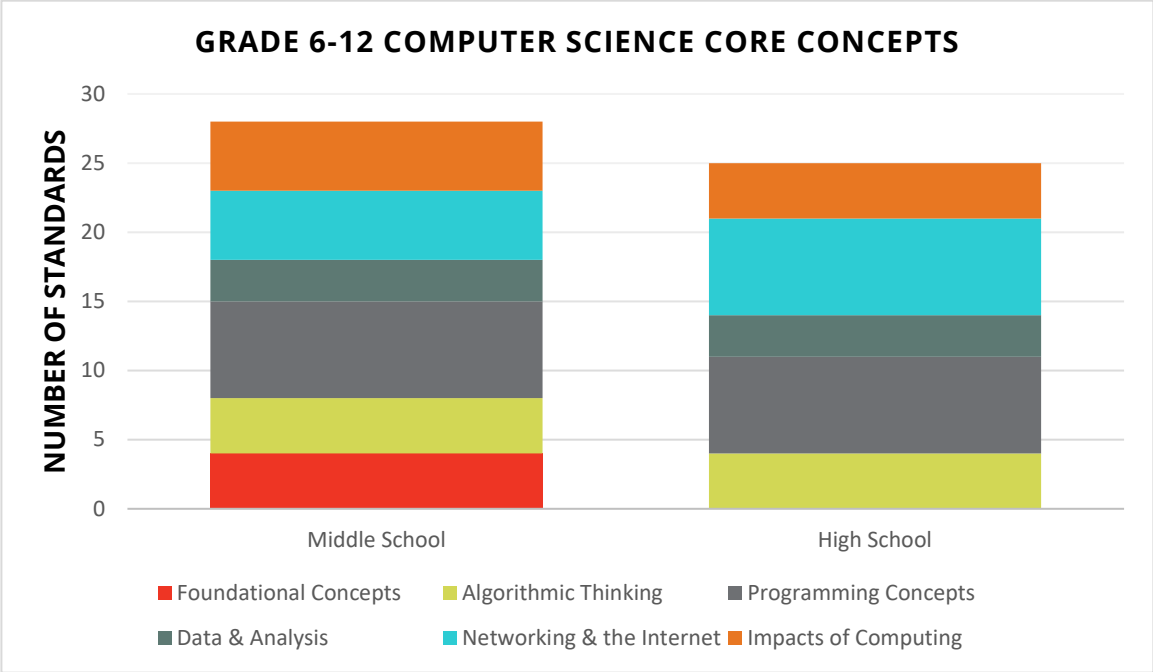
The intention of the new requirement that every Tennessee high school graduate will have at least one Computer science credit is not to make every graduate a computer programmer; the purpose of the requirement is so Tennessee will strengthen its reputation as a state with a capable workforce for new industry. With more and more aspects of daily lives being run online and using algorithms to make decisions that influence every citizen, it is imperative to prepare the next generation to understand the basics of what computers need to run and what it looks like when they are not running properly (i.e., when to not trust the data). This new requirement does not compete with existing high school pathways in CTE Information Technology or other tech-focused programs of study. Nor does it diminish or discourage

any student from AP College Board, IB, Cambridge, or dual enrollment opportunities in computer science. The new requirement is for those students who were not choosing those courses as part of their high school experience. These standards are not to be used for any of the courses referenced above, instead they are specifically for new basic level high school classes for what everyone needs to know about computers. However, to be truly computer literate, students need exposure in multiple formats using the tools of computer science as they would be in the work world – embedded in tasks utilizing every subject area. While direct instruction allows teachers with computer language training to set up learning experiences specific to the programming concepts in the standards, the intention of the Computer Science Standards Writing Committee is that all teachers will offer opportunities for students to practice the vocabulary and thinking skills of Computer science. As teachers are encouraged to offer student agency and creativity in creating work products to demonstrate learning in all academic and related areas, computer science skills and concepts will enhance the rigor and authenticity by their incorporation into any subject or grade level in addition to direct instruction to build programming skills.

Inclusion of computer science concepts and skills regularly and across content areas will offer students more opportunities for exposure to potential career fields which employ tasks and skills they find success and enjoyment in while learning content. Consistent and ubiquitous inclusion of opportunities to increase skills that are part of 21st century life, including digital citizenship and etiquette, also allow support for development of beneficial social-emotional health habits. Emphasis on application of concepts in the learning process will help students understand these habits of problem solving and tools of computer science that will help them no matter the content studied and even into their future workplace.

Because the requirement does not dictate at what grade students will earn their graduation requirement credit, standards are expressed in the high school grade band. They should be read as “by the time a student completes twelfth grade, he/she should be able to . . . “with the understanding that true “ability” entails multiple exposure and scaffolded experiences consistently throughout the high school career. These standards will not be adequately built for success in post-secondary employment or education if students are only exposed to instruction in one direct instruction experience lasting for one course over their time in high school.

The Tennessee Writing Committee identified six Core Concepts (domains) of critical ideas in Computer Science. Each Core Concept has large ideas/habits embedded and the progression of standards through secondary grades 6-12, they look like this:



The academic standards for high school are intended to be reinforced in classrooms of every subject area and grade level in high school except for specific programming language in the Core Concept of Programming Concepts, which is recommended to be included in the direct instruction curriculum of the graduation requirement course. These standards are the minimum a teacher should integrate across any year, and it is recommended they be expanded and reinforced multiple times in different ways. The academic standards for computer science for high school are based on research by the *K-12 Computer Science Framework* coalition including, but not limited to, national Computer Science Teachers Association, National Math and Science Initiative in partnership with states and districts.

These academic standards establish the core concepts and practices students need to know by the end of twelfth grade. Computer Science concepts and practices are not to be taught in isolation but within core content instruction in any academic curriculum area. Core concepts and skills for high school include:

Foundational Concepts	**Algorithmic Thinking**	**Programming Concepts**	**Data and Analysis**	**Networking & the Internet**	**Impacts of Computing**
Computing systems' hardware	Logical or sequential thinking	Using and troubleshooting existing code	Organizing, clustering or categorizing data	Connectivity and issues	Innovations due to computer science
Computing systems' software	Breaking down problems into parts	Developing code to solve a problem	Cleaning or transforming data to discover useful information	Data is transferred using protocols or rules	Benefits and risks to users and developers due to computational systems

					(internet safety)
Investigable questions/problems that can be solved by computational thinking/CS	Create step by step processes to solve problems	Concepts of programming (language exposure)	Displaying or visualizing data	Protecting data/personal information	How jobs/careers use computer science and computational thinking
Collaboration about computer science			Communicating data for decision making or problem solving		

High School: Computer Science Standards

CS.AT: Algorithmic Thinking

1) Use lists to simplify solutions, generalizing computational problems instead of repeatedly using simple variables.
2) Systematically design and develop programs for broad audiences by incorporating feedback from users.
3) Create prototypes that use algorithms to solve computational problems by leveraging prior student knowledge and personal interests.
4) Use effective communication and accurate computer science terminology to explain problem solving when completing a task.

CS.DA: Data Analysis

1) Create computational models that represent the relationships among different elements of data collected from a phenomenon or process.
2) Utilize data to answer a question using a variety of computing and data visualization methods.
3) Use data analysis tools and techniques to identify patterns in data representing complex systems.

CS.NI: Networking and the Internet

1) Explain the tradeoffs when selecting and implementing cybersecurity recommendations.
2) Identify laws regarding the use of technology and their consequences and implications.
3) Evaluate strategies to manage digital identity and reputation with awareness of the permanent impact of actions in a digital world.
4) Demonstrate how to apply techniques to mitigate effects of user tracking methods.
5) Show an understanding of the ramifications of end-user license agreements and terms of service associated with granting rights to personal data and media to other entities.
6) Recommend security measures to address various scenarios based on factors such as efficiency, feasibility, and ethical impacts.
7) Demonstrate a fundamental understanding of API (Application Programming Interface).

CS.PC: Programming Concepts

1) Choose and apply an appropriate iterative design process to systematically test and refine a program to increase performance.
2) Develop a plan to manage and assign data values of different types (strings, numeric, character, integer, and date) to a variable
3) Create and refine programs with Boolean conditionals to demonstrate the use of branches and logical operators.
4) Design and develop iterative programs that combine control structures, including nested loops and compound conditionals.
5) Create parameters to organize a program to make it easier to follow, test, and debug.
6) Incorporate existing code, media, and libraries into original programs, and give proper attribution.
7) Debug (identify and fix) errors in an algorithm or program that includes sequences and simple and complex loops following a two-step debugging process.

CS.IC: Impacts of Computing

1) Evaluate and debate the social and economic implications of computing in the context of safety, law, and ethics.
    a. Discuss the ethical ramifications of hacking and its impact on society.
    b. Explain the privacy concerns related to the collection and generation of data through automated processes that may not be evident to users (Bots, Chatbots, Spiders or Crawlers, Web Scraping, keyloggers etc.).
    c. Explain the positive and negative consequences that intellectual property laws can have on innovation.
2) Use tools and methods for collaboration on a project to increase connectivity of people in different cultures and career fields.
3) Research the impact of computing technology on possible education and career pathways.
4) Predict how computational innovations that have revolutionized aspects of our culture might evolve.

Appendix A: Standards Committee Writers

K-2	
Jessica Holloway	Hamilton County Schools
Vickie Stem	Rutherford County Schools
Ben Bruce	Sumner County Schools
Ashley McNealy	Elk Valley STEM Elementary School

3-5	
Samantha Carroll	Union Heights Elementary School
Crystal Lock	Finely Elementary School
Emily Gilbertson	Community Montessori School Jackson
Bixiao Zhao	Farragut Intermediate School
Michelle Bettis	Hamilton County Schools
Kimberly Elbakidze	Red Bank Middle School

6-8	
Chassity Burks	Rockvale Middle School
Bobbie Jo Meredith	Rocky Fork Middle School
Chad Ward	Kenwood Middle School
Jerry Lynn Recker	Memphis Academy of Science & Engineering
Kimberly Blackerby	Lincoln Heights Middle School
Debbie Jacobs	Siegel Middle School
Amy Haney	Clinton High School
Stephanie Zeiger	Harpeth Hall School
Teddy Faxon	Morristown East High School

9-12	
Missy Hayes	Hamblen County Schools
Janet Williams	Memphis Academy of Science & Engineering
Michelle Vannoy	Meadowview High School
Amy Bakaletz	L&N STEM Academy
Richard Hawkins	Morristown-Hamblen High School West
Robert Neill	Morristown-Hamblen High School East
Amanda Powers	Clinton High School

TSIN Staff	
Chelsey Guttery	Computer Science Specialist
Becky Ashe	Director of Professional Learning and Innovation

TDOE Staff	
Audra Block	Director of STEM/STEAM and Computer Science

Appendix B: Tennessee Community Members Who Vetted Standards

Name	Title	Company/Organization
Amy Harris, Ph.D.	Graduate Program Director | Associate Professor	MTSU
Christy O'Neal	Sr. Director OCIO	Dollar General
Gary Garrison	Professor, Business Systems & Analytics	Belmont University
Chad Wasserman	Vice President	HCA Healthcare
Charles Apigian	Executive Director - Belmont Data Collaborative	Belmont University
Charlie Yielding	CEO	G Squared Wireless
Amy Harris, Ph.D.	Graduate Program Director | Associate Professor	MTSU
Christy O'Neal	Sr. Director OCIO	Dollar General
Gary Garrison	Professor, Business Systems & Analytics	Belmont University
Chad Wasserman	Vice President	HCA Healthcare
Charles Apigian	Executive Director - Belmont Data Collaborative	Belmont University
Annette Littrell, Ph.D.	Deputy Chief Information Officer	Western Carolina University
Madyson Burgess	Managing Partner	Panoramic Marketing
Alex Curtis	Chief Development Officer	Greater Nashville Technology Council