Colorado
Academic Standards

Computer Science

Adopted 2024

COLORADO
Department of Education

ALL STUDENTS • ALL STANDARDS

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Note: The above listing reflects the people and roles in 2024 when these standards were adopted.

Purpose of Computer Science

"We want students to understand what a computer can do, what a human can do, and why that's different." - Mark Guzdial, Professor of Computing, Georgia Tech

Colorado's economic vitality would greatly benefit from the implementation of comprehensive K-12 computer science education. There are literally thousands of computer science jobs in Colorado and only hundreds of Colorado college graduates to fill those positions. Additionally, Frey and Osborne (2013) estimate that 47% of current employment in all sectors of the economy will be replaced by technology in 10 to 20 years. Professionals in all disciplines will be more successful with knowledge and skills in computer science. Citizens will make more informed choices with foundational understanding of computer science. Students have been learning how to use computers for many years (digital literacy), computer science is a discipline in which students explore foundational concepts related to creating hardware, software, programming, and user interfaces. We owe it to students to prepare them adequately for future employment.

The creation of high school computer science standards in response to House Bill 16-1198 began in April 2017. After listening to focus groups around the state of Colorado and examining a professional review of national computer science standards, a volunteer citizen committee made up of professional computer science teachers, higher education professors, and private sector professionals designed the voluntary Colorado high school computer science standards. The committee used national standards from the Computer Science Teachers Association, the K12 Computer Science Framework, and other state computer science standards as references.

As practicing computer science educators, the committee sought to minimize the bulk of standards by concentrating them into three major areas. Colorado Essential Skills, replacing the 21st Century Skills, were used to augment and concentrate the computer science standards. Collaboration and communication are essential in the computer science classroom and in the private sector. However, the committee was careful to write standards that guided content and not instruction.

Even though technology presents educators with a rapidly changing landscape, long-lasting themes in computer science education have persisted and provide a robust foundation of learning. Computational thinking, computing systems and networks, and computer programming provide the bulk of content knowledge in computer science. Additional topics, providing students with opportunities to examine the impact technology has on privacy, communication, and society and exploring creative innovation are embedded in the standards.

The Association for Computing Machinery, or ACM, the premier computer science educational professional organization in the United States, details an entire code of ethics for computer science professionals. The committee has embedded computer science ethics into the three primary grade level expectations. While other national and state standards specifically name impacts on society as a standard, the committee decided that ethical considerations could be applied to curriculum in every standard.

Creativity is an area of human endeavor that is difficult to define, instruct, and assess. The committee recognized that computer science requires aspects of creativity but was reticent to specifically add creativity as a standard. AP Computer Science Principles lists creativity as one of its seven big ideas. It is the committee's opinion that the inclusion of teaching the design process, among other aspects of computer science instruction, inherently fosters creativity.

Carefully crafted with responsive inclusion from public feedback, the committee presents Colorado's first Computer Science high school standards.

Statute

House Bill 16-1198 requires the State Board of Education to adopt secondary computer science standards that identify the knowledge and skills secondary students should acquire related to computer science, including computer coding, in one or more courses that qualify as a graduation requirement in either mathematics or science. Local education providers may choose to implement the standards adopted. The voluntary nature of the computer science standards is different from all other academic standards that are required to be implemented.

Prepared Graduates in Computer Science

1. Develop, utilize, and evaluate algorithms to model and solve problems.
2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.
3. Represent, analyze and visualize data in order to generate new knowledge and capability.
4. Use systems thinking to describe networks and common software and hardware components.
5. Develop systems solutions from a set of specifications to complete a design process.
6. Recognize and apply security methodologies to ensure the prevention of exploitation, data protection, and recovery of computing systems following interruption of service.
7. Design and create programs, individually and collaboratively, for a variety of disciplines.
8. Create computational artifacts that consider security from tampering, malicious or otherwise.
9. Create a security risk profile that recognizes and analyzes security concepts.
10. Use AI tools to analyze and understand the world and to create and inspire ideas.
11. Evaluate the uses of AI.
12. Explain how AI tools work and how they are built.
13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Standards in Computer Science

The Colorado academic standards in computer science are organized into six content area strands. The six strands of computer science are:

1. Computational Thinking
Computational thinking Includes concepts related to the use of algorithms and data in different ways to generate new knowledge and articulate solutions to real world problems.

2. Computing Systems and Networks
Computing systems and networks includes concepts related to the development and communication between software and hardware, and systems thinking around data protection and recovery.

3. Computer Programming
Computer programming includes concepts related to designing algorithms, creating computer programs and applications, understanding programming structure, testing and debugging, working collaboratively to engage in stakeholder-based problem solving, and computational thinking skills.

4. Cybersecurity
Cybersecurity includes concepts related to protecting personal information, creating strong passwords, recognizing online threats, identifying vulnerabilities, implementing protective measures, detecting threats, responding to incidents, and recovering from breaches to safeguard digital systems, data, and privacy while maintaining the integrity and availability of computing resources in an increasingly interconnected world.

5. Artificial Intelligence (AI)
Artificial intelligence (AI) includes concepts related to how computers can be trained to recognize patters, make decisions, solve problems, and learn from data through the use of algorithms and models, allowing students to understand how AI can be applied to address real-world challenges that affect people's lives while considering both its capabilities and limitations.

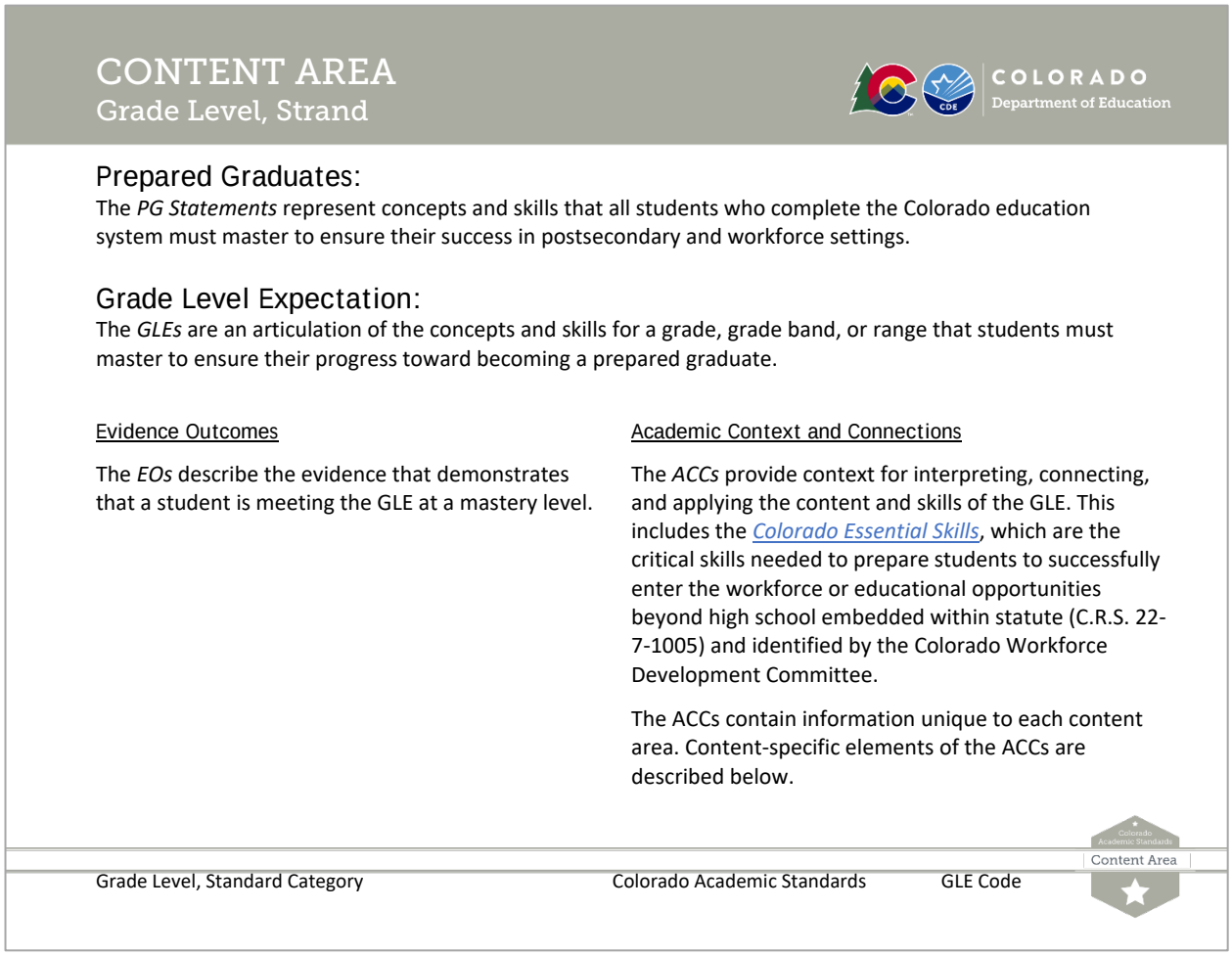
6. Digital Citizenship
Digital citizenship includes concepts related to using technology responsibly, protecting personal information, understanding digital footprints, practicing ethical online behavior, recognizing personal rights and responsibilities, and engaging respectfully in virtual communities.

The Revision Process

The Colorado Academic Standards for computer science, adopted in 2018, did not include standards for grades Kindergarten through 8th. In March 2023, the computer science standards were up for review and revision. In the summer of 2023, the Colorado State Board of Education commissioned McREL to conduct a benchmarking report of the standards. McREL used national and state standards to compare current Colorado Academic Standards in computer science. In August 2023, the State Board reviewed the benchmarking report and instructed the Colorado Department of Education to organize and facilitate a committee to review and revise the current Colorado Academic Standards for computer science to include cybersecurity and artificial intelligence (AI). Committee work began in September 2023. In November 2023, the committee chair, Bobbie Bastian, presented the Colorado State Board of Education with the draft of recommended revisions for high school computer science standards. Upon review, the Board asked the committee to draft K-8 standards to align with the current revisions to the 9-12 standards. In February 2024, Bobbie Bastian presented the Colorado State Board of Education with the draft of recommended revisions for high school computer science standards. The revisions and K-8 draft were both released for public comment. Public comment was available for all Colorado residents from February 14 through March 14, 2024. CDE also hosted an educator focus group meeting, inviting computer science educators from around the state to provide feedback. During the months of March and April of 2024, the committee reconvened for final sessions to consider public feedback for all K-12 standards. The committee carefully analyzed and incorporated public feedback, vertically aligned K-12 standards and finalized drafts for the State Board of Education. In April 2024 Bobbie Bastian presented the Colorado State Board of Education with the draft of recommended revisions for K-12 computer science standards.

On May 9, 2024, the Colorado State Board of Education adopted the newly revised K-12 computer science standards. The newly adopted K-12 Computer Science standards include revisions to the 9-12 standards, as well as new standards for K-8, including AI (artificial intelligence), cybersecurity, and digital citizenship. It is understood that the 2026-27 school year is the first year of implementation of the standards that were revised in 2024.

How to Read the Colorado Academic Standards



Academic Context and Connections in Computer Science

Colorado Essential Skills: These statements describe how the learning of the content and skills described by the GLE and EOs connects to and supports the development of the Colorado Essential Skills named in the parentheses.

Elaboration on the GLE: These statements provide greater context for the GLE through a description of the understanding about the core ideas that should be developed by students.

Computer Science Practices: These statements are adopted from the *2016 K-12 Computer Science Framework*, which says, "The seven core practices of computer science describe the behaviors and ways of thinking that computationally literate students use to fully engage in today's data-rich and interconnected world" (p. 67).

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. An algorithm is a set of step-by-step instructions to complete a task.

Evidence Outcomes:

Students Can:

a. Follow algorithms (step by step instructions) to complete tasks.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Demonstrate a willingness to follow an algorithm. (Entrepreneurial Skills / Informed Risk Taking)

Computer Science Practices:

1. Developing and Using Abstractions

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

2. Data contains patterns.

Evidence Outcomes:

Students Can:

a. Define data as stored information.
b. Identify patterns in data.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Recognize patterns in everyday experiences. (Entrepreneurial Skills / Inquiry/Analysis)

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

1. Passwords protect devices and information from inappropriate access.

Evidence Outcomes:

Students Can:

a. Practice entering passwords to gain access to content and give a simple explanation about why passwords are necessary.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for using passwords appropriately and understand the difference between weak and strong passwords. (Personal Skills/Personal Responsibility)

Computer Science Practices:

1. Communicating About Computing

Prepared Graduates:

9. Create a security risk profile that recognizes and analyzes security concepts.

Grade Level Expectation:

1. Some information is private and should be protected from access by users who do not have permission.

Evidence Outcomes:

Students Can:

a. Keep login information private and log off devices appropriately.
b. Distinguish between private vs. public information.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for keeping login information private and logging off devices. (Personal Skills/Personal Responsibility)

Computer Science Practices:

1. Communicating About Computing.

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Personal information must be protected in person, on digital devices and online.

Evidence Outcomes:

Students Can:

a. Describe appropriate and inappropriate uses of digital devices.
b. Work respectfully and responsibly with others.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for using digital technology in appropriate ways. (Personal Skills, Personal Responsibility, Self-Awareness)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. An algorithm is a set of steps for a specific purpose and can be modified.

Evidence Outcomes:

Students Can:

a. Create and follow algorithms (sets of step-by-step instructions) to complete tasks.
b. Debug (identify and fix) errors in an algorithm or program that includes sequences and simple loops.
c. Using correct terminology, describe steps taken, and choices made during the process of program development and revision.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Engage in novel approaches, moves, directions, ideas, and/or perspectives to create and debug algorithms. (Entrepreneurial Skills: Creativity/Innovation)

Computer Science Practices:

1. Creating Computational Artifacts
2. Testing and Refining Computational Artifacts
3. Practice and Develop Using Abstractions

Prepared Graduates:

2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.

Grade Level Expectation:

2. Complex problems can be broken into smaller parts to facilitate solving the problem.

Evidence Outcomes:

Students Can:

a. Decompose (break down) the steps needed to solve a problem into a precise sequence of instructions.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Exhibit persistence when breaking down problems into smaller parts. (Personal Skills: Perseverance/Resilience)

Computer Science Practices:

1. Developing and Using Abstractions

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

3. Data is information that can be collected, stored, and represented in a variety of ways.

Evidence Outcomes:

Students Can:

a. Find, add, change, and delete information using a computing device and define the information stored as data.
b. Collect and present the same data in various visual formats.
c. Describe patterns in data using visual representations such as charts or graphs, to make predictions.
d. Use numbers or other symbols to represent information and describe that this is similar to how computer programs represent information.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Make predictions and design data/information collection and analysis strategies (Entrepreneurial Skills: Inquiry/Analysis)

Computer Science Practices:

1. Recognizing and Defining Computational Problems

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

1. Computing systems rely on both hardware and software, that can be local or accessed remotely.

Evidence Outcomes:

Students Can:

a. Describe basic hardware and software problems using accurate terminology.
b. Describe the difference between online and local use of computing devices.
c. Recognize that equipment is needed to access a network.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use appropriate terminology and consider purpose and audience when describing computing systems. (Civic/Interpersonal Skills, Communication)

Computer Science Practices:

1. Communicating About Computing

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

1. A computer program is a sequence of steps that is expressed in a computer programming language so that a computer can follow and perform the steps.

Evidence Outcomes:

Students Can:

a. Use appropriate software to perform a variety of tasks.
b. Develop programs with sequences to express ideas or address a problem.
c. Cite sources when using the ideas and creations of others while developing programs.

Academic Contexts and Connections:

Colorado Essential Skills:

1. When collaborating on the design of a computer program, recognize how personal actions have had a positive or negative impact on the process. (Civic/Interpersonal Skills, Collaboration/Teamwork)

Computer Science Practices:

1. Creating Computational Artifacts

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Digital citizenship plays a role in our everyday lives both in person and online.

Evidence Outcomes:

Students Can:

a. Explain that there are rules for interacting online that are intended to keep people safe.
b. Differentiate between appropriate and inappropriate online behavior.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for using digital technology in appropriate ways. (Personal Skills, Personal Responsibility, Self-Awareness)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

5. Develop systems solutions from a set of specifications to complete a design process.

Grade Level Expectation:

1. When developing a plan or solution, the designer must follow specifications designated for the program.

Evidence Outcomes:

Students Can:

a. Develop plans that describe a program's sequence of events, goals, and expected outcomes.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Articulate task requirements for a solution based on stakeholder input. (Professional Skills, Task/Time Management)

Computer Science Practices:

1. Communicating about Computing
2. Creating Computational Artifacts

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

1. A computer program is a sequence of steps expressed in a computer programming language so that a computer can follow and perform the steps.

Evidence Outcomes:

Students Can:

a. Select and use appropriate software to perform a variety of tasks and recognize that users have different needs and preferences for the technology they use.
b. Develop programs with sequences and simple loops, to express ideas or address a problem.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Civic/Interpersonal Skills, Collaboration/Teamwork

Computer Science Practices:

1. Creating Computational Artifacts

Prepared Graduates:

10. Use AI tools to analyze and understand the world and to create and inspire ideas.

Grade Level Expectation:

1. AI tools can perform intelligent tasks, such as recognition of patterns, decision-making, and classification of information, that help users understand the world.

Evidence Outcomes:

Students Can:

a. Demonstrate how to train a computer to recognize something.
b. Describe and provide examples of how people learn and how computers learn.
c. Describe the kinds of tasks an intelligent assistant can and cannot perform.
d. Describe some jobs that no longer exist due to advances in technology.
e. Identify devices in daily life that use AI technologies.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Ask questions and learn about careers, including how those careers might be impacted by advances in technology (Professional Skills, Career Awareness).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Developing and Using Abstractions
3. Collaborating about Computing

Prepared Graduates:

11. Evaluate the uses of AI.

Grade Level Expectation:

2. AI tools can be designed for a variety of purposes and can impact people differently based on how they are designed.

Evidence Outcomes:

Students Can:

a. Examine a labeled dataset and identify problems in the data that could lead a computer to make incorrect predictions.
b. Identify current uses of AI and how they have impacted people.
c. Describe how AI can be used to solve problems that affect people.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Identify and reflect upon personal connections to AI and how it impacts society. (Global/Cultural Awareness, Civic Engagement)

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing
3. Fostering an Inclusive Computing Culture

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Digital citizenship involves being responsible for one's own behavior and being aware of laws that protect the rights of others.

Evidence Outcomes:

Students Can:

a. Discuss examples of cyberbullying and model age-appropriate responses to cyberbullying.
b. Discuss the concept of copyright.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for using digital technology in appropriate ways. (Personal Skills, Personal Responsibility, Self-Awareness)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. Algorithms can be improved.

Evidence Outcomes:

Students Can:

a. Refine multiple algorithms (step by step instructions) for the same task.

Academic Contexts and Connections:

Computer Science Practices:

1. Testing and Refining Computational Artifacts

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

1. Steps can be taken to protect private information when connecting devices or engaging in cloud computing.

Evidence Outcomes:

Students Can:

a. Discuss real-world cybersecurity problems and how personal information can be protected.
b. Demonstrate safe cloud computing practices.
c. Explain the vulnerabilities of connecting devices.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Explain and model positive behaviors for others when using digital devices. (Professional Skills, Leadership)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture
2. Communicating about Computing

Prepared Graduates:

9. Create a security risk profile that recognizes and analyzes security concepts.

Grade Level Expectation:

1. Personally identifiable information (PII) is any information that allows the identity of the person to whom that information belongs to be inferred.

Evidence Outcomes:

Students Can:

a. Define personally identifiable information (PII).

Academic Contexts and Connections:

Colorado Essential Skills:

1. Educate and inspire others to protect PII. (Professional Skills, Leadership)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture.
2. Communicating around Computing.

Prepared Graduates:

11. Evaluate the uses of AI.

Grade Level Expectation:

1. AI tools have the potential to affect society in a number of ways, and their design should take into account the varying needs of users to ensure usability across populations.

Evidence Outcomes:

Students Can:

a. Describe how AI-powered services are used in daily life.
b. Identify changes in how sectors of society operate due to the introduction of AI.
c. Describe how a job will change due to the introduction of AI or robotic technologies.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Identify and explain multiple perspectives when evaluating how AI can impact people differently. (Civic/Interpersonal Skills, Global / Cultural Awareness)
2. Analyze how deep fake media messages are constructed. (Professional Skills (Information Literacy)

Computer Science Practices:

1. Develop and Using Abstractions
2. Communicating about Computing
3. Fostering an Inclusive Computing Culture

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Using digital technologies comes with responsibilities and can have consequences the user needs to consider.

Evidence Outcomes:

Students Can:

a. Discuss and provide examples of cyberbullying and methods of age-appropriate 3 intervention.
b. Describe the concept of a digital footprint.
c. Recognize the different motivations that influence appropriate and inappropriate online behaviors.
d. Discuss examples of cyber-attacks.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Apply ethical perspectives/ concepts to behavior in an online environment.(Civic/Interpersonal Skills, Character)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture
2. Communicating about Computing

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

1. Data can be analyzed and presented in ways that reveal predictable patterns and relationships between features.

Evidence Outcomes:

Students Can:

a. Organize and present collected data visually to highlight relationships and support a claim.
b. Use data to highlight or propose cause-and-effect relationships, predict outcomes, or communicate an idea.
c. Give examples of how data can be analyzed to demonstrate relationships between features.
d. Explain how images are represented digitally in a computer.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Recognize and describe cause-and-effect relationships to predict outcomes. (Entrepreneurial Skills, Inquiry / Analysis)

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Developing and Using Abstractions
3. Communicating about Computing
4. Creating Computational Artifacts

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

1. Hardware and software work together as a system to complete tasks and often communicate via networks to share information.

Evidence Outcomes:

Students Can:

a. Use appropriate terminology in identifying and describing the function of common physical components of computing systems.
b. Describe how internal and external parts of computing devices function to form a system.
c. 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.
d. Describe network communications.
e. Identify specific network components.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Consider purpose and audience when modeling computing systems. (Civic/Interpersonal Skills, Communication)

Computer Science Practices:

1. Communicating about Computing
2. Creating Computational Artifacts

Prepared Graduates:

8. Create computational artifacts that consider security from tampering, malicious or otherwise.

Grade Level Expectation:

1. Creators of computer programs and other digital artifacts must consider multiple factors when designing content, including accessibility and intellectual property rights.

Evidence Outcomes:

Students Can:

a. Observe intellectual property rights and give appropriate attribution when creating or remixing programs.
b. Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.
c. Brainstorm ways to improve the accessibility and usability of technology products for the diverse needs and wants of users.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Apply ethical perspectives/ concepts to designing content in ways that are accessible and take intellectual property into account. (Civic/Interpersonal Skills, Character)

Computer Science Practices:

1. Communicating about Computing
2. Creating Computational Artifacts
3. Recognizing and Defining Computational Problems
4. Fostering an Inclusive Computing Culture

Prepared Graduates:

10. Use AI tools to analyze and understand the world and to create and inspire ideas.

Grade Level Expectation:

1. AI tools solve problems through the use of computing technologies.

Evidence Outcomes:

Students Can:

a. Design a solution to a societal problem that makes use of AI technology.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Plan and evaluate complex solutions to societal challenges that make use of AI technology. (Civic/Interpersonal Skills, Global/Cultural Awareness)

Computer Science Practices:

1. Communicating about Computing
2. Creating Computational Artifacts
3. Recognizing and Defining Computational Problems
4. Testing and Refining Computational Artifacts

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. A digital footprint is a record of what we do online, including the websites and digital spaces we visit, platforms and apps we use, the things we post and the things that others post, like pictures and videos, or comments of us and about us.

Evidence Outcomes:

Students Can:

a. Define the term "digital footprint" and identify the online activities that contribute to it.
b. Identify ways users are and are not in control of their digital footprint.
c. Understand what responsibilities they have for the digital footprints of themselves and others.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Take responsibility for the impact of actions on one's own and others' digital footprints in a digital environment (Personal Skills, Personal Responsibility)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. Algorithms can be created, tested, and improved.

Evidence Outcomes:

Students Can:

a. Determine potential solutions to solve simple hardware and software problems using common troubleshooting strategies.
b. Compare multiple algorithms for the same task and determine which is the most appropriate.
c. Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Test algorithms with planned process for getting feedback (Entrepreneurial Skills, Inquiry analysis)
2. Resist distractions, maintain attention, and continue testing and debugging a program or algorithm through frustration or challenges (Personal Skills, Perseverance/ Resilience)

Computer Science Practices:

1. Testing and Refining Computational Artifacts

Prepared Graduates:

2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.

Grade Level Expectation:

2. Complex problems can be broken into smaller parts to facilitate the program development process.

Evidence Outcomes:

Students Can:

a. Decompose (breakdown) problems into smaller, manageable subproblems to facilitate the program development process.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Recognize that problems can be identified, and possible solutions can be created. (Entrepreneurship Skills, Critical Thinking/Problem Solving)

Computer Science Practices:

1. Recognizing and Defining Computational Problems

Prepared Graduates:

5. Develop systems solutions from a set of specifications to complete a design process.

Grade Level Expectation:

1. When designing or improving computational artifacts, the designer should consider various perspectives.

Evidence Outcomes:

Students Can:

a. Seek diverse perspectives for the purpose of improving computational artifacts.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Identify and explain multiple perspectives when designing or improving computational artifacts. (Civic/Interpersonal Skills, Global/Cultural Awareness)

Computer Science Practices:

1. Creating Computational Artifacts
2. Fostering an Inclusive Computing Culture

Prepared Graduates:

Grade Level Expectation:

1. Computer programs can include a variety of components that can be created and revised collaboratively over time to improve and expand the function of the program.

Evidence Outcomes:

Students Can:

a. Create programs that use variables to store and modify data.
b. Create programs that include sequences, events, loops, and conditionals.
c. Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
d. Use an iterative process to plan the development of a program by including others' perspectives and considering diverse viewpoints.
e. Take on varying roles, with teacher guidance, when collaborating with peers during the design, implementation, and review stages of program development.
f. Describe choices made during program development using code comments, presentations, and demonstrations.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use interpersonal skills to learn and work with individuals from diverse backgrounds while creating and revising programs (Civic/Interpersonal Skills, Collaboration/Teamwork)

Computer Science Practices:

1. Creating Computational Artifacts
2. Recognizing and Defining Computational Problems

Prepared Graduates:

12. Explain how AI tools work and how they are built.

Grade Level Expectation:

1. AI systems can express information through a variety of ways and can perform tasks they were not explicitly programmed to perform through machine learning.

Evidence Outcomes:

Students Can:

a. Give examples of intelligent vs. non intelligent machines and discuss what makes a machine intelligent.
b. Identify problems as either classification problems or search problems.
c. Identify patterns in labeled data and determine the features that predict labels.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Articulate thoughts and ideas effectively when creating a labeled dataset. (Civic/Interpersonal Skills, Communication)
2. Make connections between information gathered and personal experiences to apply and/or test solutions about AI. Entrepreneurial (problem solving/critical thinking, inquiry thinking and analysis)

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Developing and Using Abstractions
3. Communicating about Computing

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Cyberbullying is the use of digital devices, sites, and apps to intimidate, harm, and/or upset someone.

Evidence Outcomes:

Students Can:

a. Recognize similarities and differences between in-person bullying, cyberbullying, and being mean.
b. Identify strategies for dealing with cyberbullying and ways they can be an upstander for those being bullied.
c. Explain how certain policies and laws are created to guide online interactions.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Connect ethical principles to actions regarding cyber-bullying. (Civic/Interpersonal, Civic Engagement)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. Complex problems can be broken into smaller parts to facilitate program implementation and review processes.

Evidence Outcomes:

Students Can:

a. Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Break down problems into smaller problems when implementing and reviewing processes. (Personal Skills: Self-awareness; Initiative/self-direction)

Computer Science Practices:

1. Recognizing and Defining Computational Problems

Prepared Graduates:

2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.

Grade Level Expectation:

2. Data can be collected, transformed and analyzed to develop computational models.

Evidence Outcomes:

Students Can:

a. Collect data using computational tools and transform the data to make it more useful and reliable.
b. Illustrate translation of a structure such as a game board, road map, or mind map into a labeled graph and explain the contributions of the components.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use technologies to create computational models, flowcharts, pseudocode, and other computational artifacts. (Professional Skills: Use Information and Communications Technologies)
2. Make predictions and design data/information collection and analysis strategies. (Entrepreneurial Skills: Inquiry/ Analysis)

Elaboration on the GLE:

1. In order to be able to transform data or create a model in the computer you must use abstraction.

Computer Science Practices:

1. Developing and Using Abstractions
2. Testing and Refining Computational Artifacts

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

1. Computer networks are composed of multiple, connected components and can be arranged logically in a variety of ways.

Evidence Outcomes:

Students Can:

a. Model the role of protocols in transmitting data across the Internet.
b. Design projects that combine hardware and software components to collect and exchange data.
c. Systematically identify and fix problems with computing devices and their components.
d. Compare and contrast network topologies.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Make connections between information gathered and experience with hardware and software components to design and fix computer networks. (Entrepreneurial Skills: Critical Thinking/Problem Solving)

Computer Science Practices:

1. Creating Computational Artifacts
2. Testing and Refining Computational Artifacts

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

2. The way that users interact with devices can provide useful information for improving the design.

Evidence Outcomes:

Students Can:

a. Recommend improvements to the design of computing devices, based on an analysis of how users interact with the devices.
b. Identify the role of connected network components.
c. Discuss issues of bias and accessibility in the design of existing technologies.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Prototype a digital solution and apply a process for user feedback to inform improvement of the design. (Entrepreneurial Skills: Inquiry/Analysis)

Computer Science Practices:

1. Creating Computational Artifacts
2. Testing and Refining Computational Artifacts

Prepared Graduates:

5. Develop systems solutions from a set of specifications to complete a design process.

Grade Level Expectation:

3. Cybersecurity threats can arise from a variety of sources.

Evidence Outcomes:

Students Can:

a. Describe various types of threat actors.
b. Develop strategies to raise awareness of hardware vulnerabilities.
c. Evaluate the risks and benefits of Internet of Things devices.
d. Distinguish between responsible and malicious hacking.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Evaluate complex solutions such as various cloud computing models, hardware vulnerabilities, and Internet of Things devices. (Civic/Interpersonal Skills, Global/Cultural Awareness)

Computer Science Practices:

1. Communicating About Artifacts

Prepared Graduates:

Grade Level Expectation:

1. Collaborative development of computational artifacts can be made more efficient by employing strategies for project management, crowdsourcing, and feedback.

Evidence Outcomes:

Students Can:

a. Represent data using multiple encoding schemes.
b. Document programs in order to make them easier to follow, test, and debug.
c. Seek and incorporate feedback from team members and users to refine a solution that meets user needs.
d. Distribute tasks and maintain a project timeline when collaboratively developing computational artifacts.
e. Collaborate with many contributors through strategies such as crowdsourcing or surveys when creating a computational artifact.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use interpersonal skills to work with individuals from diverse backgrounds to develop computational artifacts. (Civic/Interpersonal Skills, Collaboration/Teamwork)

Computer Science Practices:

1. Collaborating Around Computing
2. Fostering an Inclusive Computing Culture
3. Creating Computational Artifacts

Prepared Graduates:

Grade Level Expectation:

2. Computational artifacts can be designed in ways that reduce the risk of data loss or tampering.

Evidence Outcomes:

Students Can:

a. Explain the role and importance of backups.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Articulate the role and importance of backups by effectively using oral and written communication skills. (Civic/Interpersonal Skills, Communication)

Computer Science Practices:

1. Communicating About Computing

Prepared Graduates:

Grade Level Expectation:

3. Programs can combine control structures, including nested loops and compound conditionals to solve complex problems.

Evidence Outcomes:

Students Can:

a. Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals.
b. Use flowcharts and/or pseudocode to address complex problems as algorithms.
c. Systematically test and refine programs using a range of test cases.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Apply the design process needed to change a program over several iterations. (Entrepreneurial Skills: Critical thinking/problem solving; Inquiry/analysis)

Computer Science Practices:

1. Computational Artifacts

Prepared Graduates:

9. Create a security risk profile that recognizes and analyzes security concepts.

Grade Level Expectation:

1. Sharing information creates potential risks that the information could be used inappropriately, but these risks can be partially mitigated.

Evidence Outcomes:

Students Can:

a. Explain how physical and digital security measures protect electronic information.
b. Apply multiple methods of encryption to model the secure transmission of information.
c. Describe tradeoffs between allowing information to be public and keeping information private and secure.
d. Discuss the risks and benefits of sharing PII.
e. Explain techniques to detect, correct, and prevent disclosure of PII.
f. Analyze specific federal, state, and local laws as they relate to cybersecurity and privacy.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Interpret security measures to protect information and discuss consequences of unprotected information. (Entrepreneurial Skills, Critical Thinking/Problem Solving)

Computer Science Practices:

1. Communicating About Computing.

Prepared Graduates:

10. Use AI tools to analyze and understand the world and to create and inspire ideas.

Grade Level Expectation:

1. AI tools can be combined and adapted to solve a vast variety of problems and have the capacity to drive major changes in society.

Evidence Outcomes:

Students Can:

a. Examine an aspect of daily life that is predicted to change due to the introduction of AI technologies.
b. Compare the changes AI is bringing to society with those of previous industrial revolutions.
c. Predict a new type of job that might arise, or how an existing type of job might change or go away, as a result of the adoption of AI technologies.
d. Create a novel application using some of the AI extensions or plugins available in the programming framework of your choice.
e. Research a societal problem and describe how AI technologies can be used to address that problem.
f. Create a dataset for training a decision tree classifier or predictor and explore the impact that different feature encodings have on the decision tree.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Examine changing AI and propose novel approaches and ideas to societal problems. (Entrepreneurial Skills, Creativity/Innovation)

Computer Science Practices:

1. Communicating About Computing
2. Developing and Using Abstractions
3. Creating Computational Artifacts

Prepared Graduates:

11. Evaluate the uses of AI.

Grade Level Expectation:

2. The behavior of AI systems reflects both the goals of the designers and the data used to train the system.

Evidence Outcomes:

Students Can:

a. Describe how a vision system might exhibit cultural bias if it lacked knowledge of objects not found in the culture of the people who created it (For example: road signs in different countries)
b. Train and evaluate a classification or prediction model using machine learning on a dataset.
c. Evaluate the ways various stakeholders' goals and values influence the design of AI systems.
d. Explain how the choice of training data shapes the behavior of the classifier, and how bias can be introduced if the training set is not properly balanced to represent the full range and distribution of items being classified.
e. Define criteria for consciousness and evaluate AI systems or fictional AI characters according to those criteria.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Explain how data sets in AI must include multiple perspectives (cultural, global) when using AI. (Civic/Interpersonal Skills, Global / Cultural Awareness)

Computer Science Practices:

1. Developing and Using Abstractions
2. Communicating About Computing

Prepared Graduates:

12. Explain how AI tools work and how they are built.

Grade Level Expectation:

3. AI systems combine intelligent agents, reasoning models, and machine learning to perform sophisticated functions such as solving physics problems or identifying human emotional states.

Evidence Outcomes:

Students Can:

a. Give examples of how intelligent agents combine information from multiple sensors.
b. Give examples of different types of computer perception that can extract meaning from sensory signals.
c. Illustrate how sequences of words can be recognized as phrases, even if some of the words are unclear, by looking at how the words fit together.
d. Show how a game board (e.g., tic-tac-toe, Chutes and Ladders, Monopoly, chess) can be represented by a description in plain language.
e. Evaluate how an AI system meets the design criteria of accountability and respect for privacy.
f. Contrast the unique characteristics of human learning with the ways machine learning systems operate.
g. Model how unsupervised learning finds patterns in unlabeled data.
h. Explain the difference between training and using a reasoning model.
i. Compare how a decision tree learning algorithm works vs. how a neural network learning algorithm works.
j. Explain the differences between supervised learning and reinforcement learning.
k. Illustrate the structure of a neural network and describe how its parts form a set of functions that compute an output.
l. Illustrate how a computer can solve a maze, find a route on a map, or reason about concepts in a knowledge graph by drawing a search tree.
m. Model the process of solving a graph search problem using breadth-first search to draw a search tree.
n. Categorize problems as classification, prediction, combinatorial search, or sequential decision problems.
o. Illustrate how word embeddings can be used to reason about the meaning of words.
p. Describe some NLP (Natural Language Processing) tasks computers can perform and explain how they work.
q. Explain the knowledge a computer would need to solve a naive physics reasoning problem.
r. Describe how computers use different types of cues to recognize human emotional states.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Recognize and describe how cause-and-effect relationships and patterns are used by AI. (Entrepreneurial Skills, Inquiry/Analysis)
2. Articulate how AI works by effectively using oral and written communication skills. (Civic/Interpersonal Skills, Communication (using information and communications technologies)

Computer Science Practices:

1. Communicating about Computing

Prepared Graduates:

13. Digital Citizenship: Practice responsible, ethical, and safe use of computing technology and the internet.

Grade Level Expectation:

1. Users can employ specific strategies to mitigate the risks associated with online interactions.

Evidence Outcomes:

Students Can:

a. Develop strategies to raise awareness of the effects of, and methods to identify and prevent, cyberbullying.
b. Recognize the many sources of data that make up a digital footprint.
c. Recognize the permanence of a digital footprint.
d. Explain how intellectual property and copyright relate to fair use.
e. Identify the role of social media in their lives.
f. Reflect on the positive and negative effects social media use has on their relationships.
g. Think about how to develop healthy habits when using digital media.
h. Explain why information about them and their behaviors is valuable to companies and consider potential strategies to limit access to information by third parties.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Connect ethical principles to decisions about the use of digital technology (Civic/Interpersonal, Civic Engagement)
2. Examine how individuals interpret digital footprints and cyberbullying differently (Professional Skills, Information Literacy)
3. Regulate one's thoughts and emotions in a digital environment (Personal Skills, Personal Responsibility)

Computer Science Practices:

1. Fostering an Inclusive Computing Culture

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

1. Computational thinking is used to create algorithmic solutions to real-world problems.

Evidence Outcomes:

Students Can:

a. Identify and create different types of algorithms (sort, search, etc.).
b. Predict the outcome of different types of algorithms.
c. Create or adapt algorithms to solve problems for multiple purposes (e.g., personal interests, stakeholder needs).
d. Use an algorithm that involves mathematical operations and functions to solve problems.
e. Use an iterative approach to utilizing and/or developing an algorithm.
f. Recognize problems that cannot be solved computationally.
g. Identify and describe algorithms that exist within their personal lives.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Evaluate attempts to create a working algorithm. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
2. Identify how algorithms can be used to solve social problems. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
3. Compare and contrast solvable and unsolvable computational problems. (Professional Skills: Information Literacy; Use Information and Communications Technologies; Personal Skills: Perseverance/Resilience)

Elaboration on the GLE:

1. Examine ways computers could make human activities easier and more efficient. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis)
2. Central to computational thinking are the processes of generalization and decomposition, with an eye toward the technology that will be used to solve the problem. This planning and abstraction process should also include students decomposing complex problems into manageable sub-problems that could potentially be solved with programs or procedures that already exist. As students develop algorithms, they should identify procedures and/or functions that are used multiple times within a program to repeat groups of instructions (CSTA 3A-AP-17 & 2-AP-14).

Computer Science Practices:

1. Fostering an Inclusive Computing Culture
2. Recognizing and Defining Computational Problems
3. Creating Computational Artifacts

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

2. Algorithms can be represented and used in different ways (e.g., languages, diagrams, pseudocode).

Evidence Outcomes:

Students Can:

a. Illustrate the flow of execution of an iterative algorithm (e.g., recursion).
b. Explain the value of heuristic algorithms to model ways to solve problems.
c. Adapt algorithms used in one problem to solve a related or different problem.
d. Use multiple methods to represent an algorithm (e.g., diagram, programming language, unplugged).

Academic Contexts and Connections:

Colorado Essential Skills:

1. Create an algorithm to solve a stakeholder's needs. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis)
2. Use pseudocode to represent an algorithm. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
3. Collaboratively develop an algorithm that could solve a social communication problem. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
4. Present an algorithmic solution using multiple methods. (Professional Skills: Information Literacy; Use Information and Communications Technologies; Leadership)

Elaboration on the GLE:

1. Students should use pseudocode, diagrams and/or flowcharts to organize and sequence an algorithm that addresses a problem. Representing algorithms in alternative forms supports the planning phase of the design process and helps students see various ways to structure an algorithm (CSTA 2-AP-10).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing

Prepared Graduates:

1. Develop, utilize and evaluate algorithms to model and solve problems.

Grade Level Expectation:

3. Algorithm development and use is an ongoing process that involves adapting, critiquing and troubleshooting programs and/or processes.

Evidence Outcomes:

Students Can:

a. Describe pros and cons of the performance of algorithms for the same task.
b. Use an iterative approach to developing an algorithm.
c. Test and troubleshoot so that algorithms produce reasonable results.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use stakeholder feedback to develop an initial algorithm. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis)
2. Develop a plan for using stakeholder feedback to improve an algorithm. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
3. Produce a progress report detailing algorithm development. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
4. Demonstrate debugging an algorithm. (Personal Skills: Perseverance/Resilience)

Elaboration on the GLE:

1. Testing and refinement is the deliberate and iterative process of improving a computational artifact. This process includes debugging (identifying and fixing errors) and comparing actual outcomes to intended outcomes. Students should respond to the changing needs and expectations of end users and improve the performance, reliability, usability and accessibility of artifacts. For example, students could incorporate feedback from a variety of end users to help guide the size and placement of menus and buttons in a user interface (CSTA 3A-AP-21).

Computer Science Practices:

1. Testing and Refining Computational Artifacts
2. Creating Computational Artifacts
3. Recognizing and Defining Computational Problems

Prepared Graduates:

2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.

Grade Level Expectation:

4. Large, complex problems can be broken down into smaller, more manageable components.

Evidence Outcomes:

Students Can:

a. Demonstrate how the process of decomposition is iterative and used to solve problems.
b. Formulate possible solutions based on the decomposition of a problem.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Break down problems into smaller problems identifying patterns in each level. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
2. Propose a logical sequence to fix the problem. (Professional Skills: Information Literacy; Use Information and Communications Technologies; Leadership; Personal Skills: Perseverance/Resilience)

Elaboration on the GLE:

1. At this level, students should decompose complex problems into manageable sub-problems that could potentially be solved with programs or procedures that already exist. For example, students could create an app to solve a community problem by connecting to an online database through an application programming interface (API) (CSTA 3A-AP-17).

Computer Science Practices:

1. Communicating about Computing
2. Recognizing and Defining Computational Problems

Prepared Graduates:

2. Systematically analyze a problem using decomposition and abstraction to formulate a solution.

Grade Level Expectation:

5. Abstraction is used to reduce complexity of larger problems by focusing on main ideas.

Evidence Outcomes:

Students Can:

a. Describe how abstraction is central to computational thinking.
b. Identify and prioritize the most relevant parts of a problem while filtering out extraneous details.
c. Demonstrate different ways to represent key problem components.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Design a game with efficient use of code. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis)
2. Develop a work plan and match essential activities with goals. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
3. Sort data using keywords and look for patterns to represent the essential nature of the data. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
4. Describe a model of a cat that has all the essential features of a cat without using the word cat to see if another student can guess the description. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. Abstraction is a necessary part of modeling, problem solving and computational thinking; it requires the identification of key aspects of a given context to formulate and solve a problem of interest. Students might select an embedded device such as a car stereo, identify the types of data (radio station presets, volume level) and procedures (increase volume, store/recall saved station, mute) it includes, and explain how the implementation details are hidden from the user (CSTA 3A-CS-01).

Computer Science Practices:

1. Developing and Using Abstractions
2. Communicating about Computing
3. Testing and Refining Computational Artifacts

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

6. Data can be represented in different ways for storage and exchange.

Evidence Outcomes:

Students Can:

a. Identify different types of data that are exchanged and produced by computers (e.g., protocols).
b. Evaluate the trade-offs for how data elements are organized and where data are stored (e.g., PNG/GIF, structured/unstructured).
c. Compare and contrast various data structures/techniques for storing and processing data (e.g., arrays, lists, tables).

Academic Contexts and Connections:

Colorado Essential Skills:

1. Propose an app that utilizes a database. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis)
2. Compare and contrast text or visual data coding schemes for student lockers. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
3. Examine data types in Thorn Spotlight software that helps fight human trafficking. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
4. Contribute to a group outcome regarding data storage for a project. (Professional Skills: Leadership)

Elaboration on the GLE:

1. People make choices about how data elements are organized and where data is stored (e.g., convert hexadecimal color codes to decimal percentages, ASCII/Unicode representation, and logic gates (CSTA 3A-DA-09)). These choices affect cost, speed, reliability, accessibility, privacy and integrity. Students should evaluate whether a chosen solution is most appropriate for a particular problem. Students might consider the cost, speed, reliability, accessibility, privacy and integrity tradeoffs between storing photo data on a mobile device versus in the cloud (CSTA 3A-DA-10).

Computer Science Practices:

1. Communicating about Computing
2. Creating Computational Artifacts
3. Testing and Refining Computational Artifacts

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

7. Many problems appropriate for solving with a computer are organized around patterns.

Evidence Outcomes:

Students Can:

a. Provide multiple versions of data visualization in order to deepen problem analysis.
b. Interpret and analyze data to make informed decisions.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Analyze social media platforms for popular program patterns. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis)
2. Represent personal grades in Tableau and SQL. (Personal Skills: Self-Awareness; Initiative/Self-Direction)
3. Evaluate crime rates in Colorado from a variety of data sources. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness)
4. Provide suggestions for reducing crime based on the data evaluation and give a formal presentation or report. (Professional Skills: Information Literacy; Use Information and Communications Technologies; Leadership; Personal Skills: Perseverance/Resilience)

Elaboration on the GLE:

1. One of the most powerful features of computational thinking is using technological tools to make sense of natural and social phenomena. Coding and analytic techniques can be used to identify and visualize patterns in complex data. For example, students could be asked to identify trends in a data set representing social media interactions, movie reviews or shopping patterns (CSTA 3B-DA-05).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Testing and Refining Computational Artifacts

Prepared Graduates:

3. Represent and analyze data in order to generate new knowledge and capability.

Grade Level Expectation:

8. Data from a computer program can be visually presented to better understand and articulate solutions to a problem.

Evidence Outcomes:

Students Can:

a. Analyze computer output in different forms (e.g., plain text, CSV, graphs, images).
b. Design visualizations using the appropriate tool(s) with the end user in mind.
c. Provide multiple versions of data visualization in order to deepen problem analysis.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use organization and visualization tools and techniques to identify patterns in data. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Creativity/Innovation; Inquiry/Analysis; Informed Risk Taking)
2. Pose questions that can be explored with a given data set. (Personal Skills: Initiative/Self-Direction)
3. Discuss how the intended audience for output might influence how to represent data. (Civic/Interpersonal Skills: Global/Cultural Awareness)
4. Create appropriate visual representations to identify patterns and relationships in data. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. People transform, generalize, simplify and present large data sets in different ways to influence how other people interpret and understand the underlying information. Examples include visualization, aggregation, rearrangement and application of mathematical operations. People use software tools or programming to create powerful, interactive data visualizations and perform a range of mathematical operations to transform and analyze data. Students should model phenomena as systems, with rules governing the interactions within the system and evaluate these models against real-world observations. For example, flocking behaviors, queueing or life cycles (CSTA 3A-DA-11).

Computer Science Practices:

1. Recognizing and Defining Computation Problems
2. Creating Computational Artifacts
3. Fostering an Inclusive Computing Culture

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

1. Communication between computers (and over the internet) can be configured in many different ways and consist of several hardware and software components.

Evidence Outcomes:

Students Can:

a. Describe key protocols and underlying processes of internet-based services, (e.g., https) and discuss impact of technology change on communication protocols.
b. Illustrate and describe the basic components and various network types and topologies (e.g., personal, local, metropolitan and wide).
c. Explain the difference between decimal, hexadecimal, octal and binary number formats and how they are used in computing environments.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Using note cards, demonstrate how a message can be sent and received using UDP, and then using TCP. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Draw the star and bus topologies and explain the difference between the two. (Civic/Interpersonal Skills: Communication)
3. Use hexadecimal numbering to determine the color of paint on a wall in a picture on a website. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. Computing is at its most powerful when devices are connected via a network. Networks are comprised of various hardware and software components that have specific functions within the network. For example, individual devices are assigned an address that uniquely identifies it on the network; routers function by comparing IP addresses to determine the pathways packets should take to reach their destination; and switches function by comparing MAC addresses to determine which computers or network segments will receive frames (CSTA, 3A-NI-04). Each device is assigned an address that uniquely identifies it on the network. Routers function by comparing IP addresses to determine the pathways packets should take to reach their destination. Switches function by comparing MAC addresses to determine which computers or network segments will receive frames. Students could use online network simulators to experiment with these factors (CSTA 3A-NI-04).

Computer Science Practices:

1. Developing and Using Abstractions

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

2. Computer hardware, the lowest level of a computer system, consists of many different parts, each providing a specialized function.

Evidence Outcomes:

Students Can:

a. Explain the difference between memory and disk storage, internal and external storage, Random Access Memory (RAM), flash, cloud.
b. Explain how to maintain safety when working on PCs (e.g., electromagnetic precautions).
c. Describe how computing devices are engineered for fault tolerance and reliability, and identify potential sources of weakness (e.g., redundant power supplies, RAID, SAN/NAS connections).

Academic Contexts and Connections:

Colorado Essential Skills:

1. Evaluate your computer for possible sources of failure. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Develop a poster describing personal safety when working with computers. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Brainstorm ways to improve the performance of an older computer using hardware upgrades. (Civic/Interpersonal Skills: Communication)
4. Research professional certifications and identify one that could be completed over the summer. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. At its most basic level, a computer is composed of physical hardware and electrical impulses. A computing system is composed of components such as the central processor (executes commands), memory (for temporary storage of data), hard disk (stores data), mainboard (provides communication between components and peripherals), network interface (communicates with other devices) and power supply (CSTA 3A-CS-02).

Computer Science Practices:

1. Developing and Using Abstractions

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

3. Computer software is written for specific purposes.

Evidence Outcomes:

Students Can:

a. Identify and differentiate between different kinds of software (e.g., operating systems vs. applications) and their purposes.
b. Explain what an operating system is, and why it is important for a computer or computing device (e.g., Linux, Windows, iOS).
c. Describe how software interacts with hardware to complete tasks.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Compare and contrast Linux, Macintosh, and Microsoft operating systems through a cost-benefit analysis. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry Analysis; Informed Risk Taking)
2. Compare and contrast user interfaces based on user beliefs and expectations. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Discuss the pros and cons for society of open source versus proprietary commercial software. (Civic/Interpersonal Skills: Communication)
4. Write a business plan for promoting open source or commercial software. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. System software manages a computing device's resources (CSTA 3A-CS-02). Students should recognize that there is a variety of software user interfaces and that different software exists for different purposes (e.g., operating system vs. application).

Computer Science Practices:

1. Communicating about Computing

Prepared Graduates:

4. Use systems thinking to describe networks and common software and hardware components.

Grade Level Expectation:

4. Systems thinking is a way of holistically examining the various components and use cases that go into a given design.

Evidence Outcomes:

Students Can:

a. Explain the integration of hardware, software and network communications components to create a networked system.
b. Summarize security approaches using a systems approach perspective.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Using Raspberry Pis, create a network system that will display a software, hardware and network-integrated system. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Create a video demonstrating 10 basic network security habits. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Present and suggest the minimum network every household and business should have. (Civic/Interpersonal Skills: Communication)
4. Create a website that teaches other students how to practice helpful security habits for a computer system when using the internet. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. By itself, a computer is just a dumb piece of hardware. It is not until an operating system is loaded on to it that the computer becomes useful. The OS handles the operation of the hardware in conjunction with the software applications a user has loaded. System software manages a computing device's resources so that software can interact with hardware (CSTA 3A-CS-02). Systems thinking utilizes concepts and tools that helps people to understand the makeup of large systems, like computer networks, to meet user needs/requirements, and to make sure computer systems are secure.

Computer Science Practices:

1. Developing and Using Abstractions.
2. Recognizing and Defining Computational Problems
3. Communicating about Computing

Prepared Graduates:

5. Develop systems solutions from a set of specifications to complete a design process.

Grade Level Expectation:

5. Stakeholder considerations drive system design.

Evidence Outcomes:

Students Can:

a. Identify stakeholder's problems/needs.
b. Articulate design requirements back to the stakeholder.
c. Illustrate options for considerations and develop conceptual model.
d. Perform system analysis based on stakeholder considerations.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Interview a computer science project manager to devise an approach to interviewing prospective stakeholders utilizing the diverse efforts of each student in class. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Create a Gantt chart or other schedule for computing project completion. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience; Initiative/Self-Direction)
3. Evaluate group progress on a computing project and provide constructive criticism. (Civic/Interpersonal Skills: Communication)
4. Evaluate any piece of software that you think might be ending its software development life cycle (SDLC) and suggest changes. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. Software engineers plan and develop programs for broad audiences using a software life cycle process (CSTA 3B-AP-17). Similarly, systems architects use, plan and develop networks to meet specific stakeholder needs.

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing
3. Creating Computational Artifacts
4. Testing and Refining Computational Artifacts

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

6. Robust computing systems require multiple methods of recovery.

Evidence Outcomes:

Students Can:

a. Describe elements of an effective backup system.
b. Compare backup systems for computer users or a network.
c. List the various backup methodologies (e.g., full, differential) and why one would pick one over the other, or use all.
d. Explain the ways an organization would continue to operate in light of a systems failure.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Analyze the possible sources of a hypothetical system crash. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Evaluate your personal data backup sources. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Denote data privacy measures citizens in Colorado can adopt. (Civic/Interpersonal Skills: Communication)
4. Explain how to prevent your devices from being hacked and offer advice about how to restore data if they have been hacked. (Professional Skills: Information Literacy; Use Information and Communications Technologies)

Elaboration on the GLE:

1. The timely and reliable access to data and information services by authorized users, referred to as availability, is ensured through adequate bandwidth, backups and other measures (CSTA 3A-NI-06). Students should understand that an “interruption of service” can come about through disasters, hacking and other deliberate exploitations, power issues and other identifiable problems (e.g., hurricanes). The process of identifying interruptions in services is an important skill for those wanting to work in Information Technology (IT). Backing up a system means that you denote a process in which your computer copies certain data to another safe spot (e.g., another drive, the cloud). Backups are also used in Information Technology (IT) shops in various companies, governmental agencies and educational institutions.

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing
3. Collaborating about Computing

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

7. Robust computing systems require data protection.

Evidence Outcomes:

Students Can:

a. Identify examples of threats to systems and data.
b. Describe the process by which intruders gain entry into a production system (e.g., reconnaissance).
c. Describe and compare methods to test/validate how well systems and data are protected.
d. Investigate different career pathways relating to systems security.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Explain the importance of penetration testing, and for what purpose a company would employ a "pen tester." (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Explain "hardening" of software and data. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Describe how hackers use social engineering to gain access to a company's network. (Civic/Interpersonal Skills: Communication; Character; Global/Cultural Awareness)
4. Explain what a "SQL injection" is. (Professional Skills: Information Literacy; Use Information and Communications Technologies; Career Awareness)

Elaboration on the GLE:

1. Security measures may include physical security tokens, two-factor authentication and biometric verification. Potential security problems, such as denial-of-service attacks, ransomware, viruses, worms, spyware and phishing, exemplify why sensitive data should be securely stored and transmitted. Students should systematically evaluate the feasibility of using computational tools to solve given problems or sub-problems, such as long, complex passwords (CSTA 3A-NI-06. See also CSTA 3B-NI-04 and 3B-AP-18). There are numerous, high-paying jobs in the area of system security. For students interested in pursuing such a career, they should understand that there is a high degree of technical understanding required to be successful.

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating about Computing
3. Collaborating about Computing

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

1. The creation of a computer program requires a design process.

Evidence Outcomes:

Students Can:

a. Analyze and apply a design methodology to identify constraints and requirements of an identified problem.
b. Utilize tools and resources such as pseudocode, flowcharts, wireframes, etc., as part of the design process.
c. Determine and use graphical or text-based languages.
d. Understand and apply core programming concepts.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Apply the design process needed to change a computational artifact over several versions. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis)
2. Choose from tools and resources to implement the design process. (Personal Skills: Adaptability/Flexibility)
3. Use pseudocode and flowcharts to communicate design options with a stakeholder. (Civic/Interpersonal Skills: Communication)
4. Use design resource to effectively manage tasks and be productive. (Professional Skills: Task/Time Management; Use Information and Communications Technologies)

Elaboration on the GLE:

1. Computer programming requires selection of a design methodology (e.g., engineering, software, human-centered) to identify user needs and requirements. Methodologies provide tools for making important design decisions and help programmers manage the iterative process of software design (CSTA 3A-AP-13).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Developing and Using Abstractions
3. Creating Computational Artifacts
4. Communicating about Computing

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

2. The process of programming involves solving computational problems.

Evidence Outcomes:

Students Can:

a. Write code per selected design.
b. Create code comments to communicate to other developers and ensure documentation of code.
c. Use various troubleshooting and debugging techniques to improve code.
d. Create appropriate variables to store and retrieve data.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Create original code that meets specified design requirements. (Entrepreneurial Skills: Creativity/Innovation; Inquiry/Analysis)
2. Fix code that is not operational. (Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
3. Collaborate with others through pair programming, commenting code, etc. (no specific language). (Civic/Interpersonal Skills: Communication)

Elaboration on the GLE:

1. Software design is a universal approach that can be used irrespective of programming tools (such as a specific language). Effective design utilizes practices such as commenting to record rationale for specific design decisions (CSTA 3A-AP-21).

Computer Science Practices:

1. Developing and Using Abstractions
2. Creating Computational Artifacts
3. Testing and Refining Computational Artifacts
4. Communicating about Computing

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

3. Collaborative tools, methods and strategies can be used to design, develop and update computational artifacts.

Evidence Outcomes:

Students Can:

a. Integrate collaborative strategies to improve programming outputs.
b. Identify and analyze a variety of collaborative tools (e.g., commenting, development repositories) in order to determine the appropriateness for intended use.
c. Identify strategies such as peer reviews to test and refine artifacts in development.
d. Determine when to use standard software tools like APIs, libraries, version control repositories, etc.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Work on a team (product manager, scrum master, analyst, developer, etc.) to improve a computational artifact. (Entrepreneurial Skills: Creativity/Innovation; Inquiry/Analysis; Personal Skills: Adaptability/Flexibility; Perseverance/Resilience)
2. Suggest an app for your town/city government that would make your town/neighborhood a nicer place to live. (Civic/Interpersonal Skills: Collaboration/Teamwork; Communication; Global/Cultural Awareness)
3. Use positive constructive feedback to help improve a peer's program. (Professional Skills: Task/Time Management; Use Information and Communications Technologies)

Elaboration on the GLE:

1. Collaborative strategies such as peer programming and feedback protocols have students optimally revise computational artifacts (e.g., graphical interfaces, program performance, errors) and help foster an inclusive computing culture which produces artifacts that meet the needs of a broad audience (CSTA 3A-AP-22).

Computer Science Practices:

1. Creating Computational Artifacts
2. Fostering an Inclusive Computing Culture
3. Testing and Refining Computational Artifacts
4. Collaborating around Computing
5. Communicating around Computing

Prepared Graduates:

7. Design and create programs, individually and collaboratively, for a variety of disciplines.

Grade Level Expectation:

4. Stakeholder-based design requirements and feedback are essential to a quality computational product or service.

Evidence Outcomes:

Students Can:

a. Understand and apply principles of stakeholder-based design.
b. Guide/advise stakeholders on strategies and solutions best suited for their problem (i.e., type of platform).
c. Construct effective methods for gathering feedback from stakeholders.
d. Respond to feedback from stakeholders to improve computing solutions.
e. Create and share product support documentation for potential users.
f. Articulate lessons learned as a result of the design and creation process.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Provide examples of computational artifacts that exemplify stakeholder-based and non stakeholder-based design. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Ask a friend to give you feedback on your communication skills. Be sure to identify specific ways to improve your communication for your friend. (Personal Skills: Initiative/Self-Direction; Personal Responsibility; Adaptability/Flexibility)
3. Document technical information about the software you have produced. (Civic/Interpersonal Skills: Communication; Global/Cultural Awareness; Character)
4. Produce a computational artifact in accordance with a stakeholder's timeline. (Professional Skills: Task/Time Management; Career Awareness; Use Information and Communication Technologies; Leadership)

Elaboration on the GLE:

1. By allowing students the opportunity to develop programs at the request of a stakeholder or identified real-world situation, students are able to have a more authentic learning experience. Students will pursue learning opportunities that are very similar in nature to experiences they will have in a future computer science career. It is important that students follow protocols and frameworks that they would see in the modern workplace to identify problems, develop a programming solution and bring their artifact to life for review by outside stakeholders (CSTA 3A-AP-19 & 3A-IC-27).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Develop and Using Abstractions
3. Testing and Refining Computational Artifacts
4. Communicating about Computing
5. Collaborating about Computing

Prepared Graduates:

8. Create computational artifacts that consider security from tampering, malicious or otherwise.

Grade Level Expectation:

5. Computing solutions can have impacts (personal, ethical, social, economic and cultural) based on their use.

Evidence Outcomes:

Students Can:

a. Investigate and understand privacy, security and protection laws.
b. Articulate the importance of securing personal data information on encrypted storage systems.
c. Identify and analyze current events to ensure the safety, security and well-being of all potential stakeholders and end users.
d. Identify influential computing innovations, and identify the beneficial and harmful effects they have had, or could have, on society, economy and culture.
e. Discuss and explain how diversity of design and issues of accessibility impact a wide-range of users.
f. Demonstrate ways to improve the accessibility of computational technologies and artifacts.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Incorporate security protocols when developing a computational artifact. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Suggest ways that social media such as Instagram could be made ADA compliant. (Personal Skills: Self-Awareness; Adaptability/Flexibility; Initiative/Self-Direction; Personal Responsibility; Perseverance/Resilience)
3. Consider how personal data is vulnerable in both storage and transmission. (Civic/Interpersonal Skills: Collaboration; Communication; Global/Cultural Awareness; Civic Engagement; Character)

Elaboration on the GLE:

1. As students engage in computer programming, it is important for them to be highly aware of the many aspects of cyber and information security. Students need to be aware not only of security loopholes that open their programs up to hacking but also to accidental programming errors or choices that can lead to other security issues as well. Students should do their best to be proactive in their programming but be aware they will need to update code and patch as needed when security vulnerabilities arise. Students should understand the importance of keeping their devices and programs up to date through additional updates and patches but that those as well can lead to other problems. Students want to ensure security is included in their feedback cycle for developed solutions (CSTA 3A-NI-06).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Testing and Refining Computational Artifacts
3. Communicating about Computing

Prepared Graduates:

8. Create computational artifacts that consider security from tampering, malicious or otherwise.

Grade Level Expectation:

6. Security and software licensing can present constraints and restrictions in computational design and development.

Evidence Outcomes:

Students Can:

a. Describe how software licensing influences program development.
b. Investigate and develop solutions that discourage online software piracy.
c. Explore and integrate security measures such as encryption, authentication and verification strategies to secure developed computer programs.
d. Research and abide by intellectual property laws and patents.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Learn about the steps required for protecting intellectual property rights of your computational artifact. (Entrepreneurial Skills: Critical Thinking/Problem Solving; Inquiry/Analysis; Informed Risk Taking)
2. Analyze licensing agreements from a software vendor. (Civic/Interpersonal Skills: Collaboration/Teamwork; Communication; Global/Cultural Awareness; Civic Engagement; Character)
3. Evaluate the benefits of open source and proprietary software to the developer. (Professional Skills: Career Awareness; Information Literacy; Use Information and Communications Technologies; Self-Advocacy)

Elaboration on the GLE:

1. After finishing a computer program, students should consider how they would potentially distribute their product. Whether they determine to sell it at a price on an app store or distribute it for free, a license of some sort is required and a process for which consumers can access the program. Alternatively, students need to be mindful that pirating occurs and should think about ways they can secure their programs to not be unlawfully distributed such as licensing codes, attachment to connected services, methods of software distribution, etc. Students need to be aware of laws and patents that govern/protect intellectual property (CSTA 3A-AP-20 & 3A-IC-28).

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Testing and Refining a Computational Artifact
3. Communicating about Computing

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

1. Confidentiality, integrity, and availability (CIA) are core principles of cybersecurity.

Evidence Outcomes:

Students Can:

a. Define confidentiality, integrity and availability in the context of cybersecurity, and share a basic example of each.
b. Analyze real-life scenarios to identify which of the core principles are at risk or have been compromised and explain why.
c. Critically analyze case studies of cyber security incidents and identify where breaches in CIA have occurred.
d. Research real-world examples of cyber security breaches and share their findings, focusing on how CIA principles were impacted.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Make connections between CIA triad and personal experiences (Critical 3 Thinking/Problem Solving)
2. Connect knowledge of the CIA triad to understandings of civic implications and activities (Civic Engagement)
3. Examine how individuals interpret security features differently, how values and points of view are included or excluded, and how the CIA triad influences cybersecurity beliefs and behaviors (Information Literacy)

Elaboration on the GLE:

1. Confidentiality, integrity, and availability (CIA) are three core aspects of cybersecurity and form what is commonly called the CIA Triad. Confidentiality addresses keeping secret data secret. Integrity addresses ensuring data comes from the sender and was not modified in transit. Availability ensures the system is actually functional and available for use. Students could explain the difference between these concepts and articulate how any cybersecurity problem can be classified as one (or more) of these three concepts.

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Communicating About Computing

Prepared Graduates:

6. Recognize and analyze security concepts.

Grade Level Expectation:

2. Encryption is fundamental to data security and privacy and is important in cybersecurity.

Evidence Outcomes:

Students Can:

a. Compare and contrast applications based on their privacy policies and permissions, evaluating the impact on individuals and society.
b. Synthesize understanding of privacy practices to inform peers on healthy vs harmful practices.
c. Explain the individual risks of a data breach to an organization housing personal data. (Department of Homeland Security (DHS) through CISA Grant given to Cyber.org, 2021)
d. Compare and contrast the harms and benefits between ensuring privacy and enabling convenience and usability (Dark, Daugherty, Emry, Massey, & Peyrot, 2021).
e. Compare and contrast situations where one would want to be anonymous vs. identifiable and provide an example where one party desires anonymity but the other party desires clear identification.
f. Discuss and/or give an example of how privacy decisions made today may have negative implications in the future.
g. Describe one or more systems used on a regular basis which reveals information about a user's pattern of life.
h. Explain why trying every possible combination (a brute force attack) will always break encryption if given enough time.
i. Describe ways encryption is used today.
j. Evaluate strengths and weaknesses of an encryption method in context.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Communicate appropriately in different online/social media situations in response to information sharing and privacy (Personal Responsibility)
2. Apply a fundamental understanding of ethical/legal cybersecurity issues in the context of privacy and encryption including the access and use of personal information. (Character).

Elaboration on the GLE:

1. Privacy is a foundational principle in social interactions, ensuring that personal information and experiences are protected from unauthorized access or exposure. In Cybersecurity, privacy is paramount because cyber threats can compromise sensitive data. Encryption acts as a vital tool in upholding and protecting individual privacy, encoding information in a way that only authorized parties can access and interpret it. Students can give examples of the role privacy plays in their online interactions, understand how encryption can provide technical means to secure access to information, and how to make appropriate trade-offs to protect their own privacy and the privacy of systems that impact them.

Computer Science Practices:

1. Collaborating Around Computing
2. Communicating About Computing
3. Recognizing and Defining Computational Problems

Prepared Graduates:

9. Create a security risk profile that recognizes and analyzes security concepts.

Grade Level Expectation:

3. Anticipate, identify and understand cyber security threats from the prospective adversary (attacker) and incorporate this into a security risk profile that takes into consideration the potential damage of a compromise vs the cost and inconvenience of implementing security.

Evidence Outcomes:

Students Can:

a. Build a list of common threats students face and explain how an adversary may try to exploit those threats (adversarial thinking).
b. Analyze real-life scenarios to identify which of the core principles are at risk or have been compromised and explain why. (This covers "Demonstrate adversarial thinking for a given problem. example: attack trees")
c. Explain how social behaviors and human factors can impact the cybersecurity of a system design. (Dark, Daugherty, Emry, Massey, & Peyrot, 2021).
d. Evaluate digital habits and practices to identify potential risks and predict how an adversary might seek to exploit vulnerabilities.
e. Analyze the motives of threat actors (Dark, Daugherty, Emry, Massey, & Peyrot, 2021).
f. Explain the variety of ways in which a security vulnerability could be created and exploited (for example: system error, social engineering, or input by an adversary).
g. Explain the difference between protecting against a random failure versus protecting against an intentional attack.
h. Give an example of a system where the risk of a potential incident requires a high degree of security and an example where the risk of a potential compromise requires only a minor degree of security.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Innovate from security failures, connect learning across domains, and recognize new security risks and potential solutions (Risk Taking).
2. Develop, plan, and organize personal behavior that considers cybersecurity risks and takes appropriate measures to mitigate those risks (Personal Responsibility).
3. Apply knowledge and skills to implement sophisticated, appropriate, and workable solutions to address complex cybersecurity problems using interdisciplinary perspectives including both social engineering and technical requirements (Global/Cultural Awareness).

Elaboration on the GLE:

1. Cybersecurity involves anticipating the actions of adversaries and designing solutions that defend against someone intentionally trying to disrupt the system. This requires anticipating potential adversarial actions, identifying how and why the adversary may take those actions, and understanding the resulting cyber security threats. Cybersecurity introduces the idea of a security risk profile. A risk profile takes into consideration the potential damage of a compromise and considers the cost of implementing security to limit the potential damage. Students can demonstrate how to think as an adversary, propose measures to counter the actions they think an adversary might take, and finally consider whether the cost of taking the counter measures is justified given the potential damage.

Computer Science Practices:

1. Collaborating Around Computing
2. Communicating About Computing
3. Developing and Using Abstractions
4. Recognizing and Defining Computational Problems

Prepared Graduates:

10. Use AI tools to analyze and understand the world and to create and inspire ideas.

Grade Level Expectation:

1. AI tools are used for solving real-world problems.

Evidence Outcomes:

Students Can:

a. Explain the evolution of AI, the scope and limitations of current AI and the future of AI.
b. Describe the purpose of different AI tools.
c. Explain the potential ethical dilemmas and biases in developing, training, and using AI tools.
d. Distinguish between AI and general computer programming.
e. Describe real-world applications of AI, such as personal assistants, recommendation systems, advertising systems, and autonomous vehicles.
f. Examine the differences between narrow AI and general AI, and their implications.
g. Discuss the use of the term "learning" with respect to specific AI tools and techniques.
h. Evaluate the kinds of data that can be used for AI problems and how they are used to train AI models.
i. Evaluate, select and use appropriate AI technology to solve a problem.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Articulate which AI tool should be used to access the information needed for a specific purpose (Professional Skills: Information Literacy)
2. Use AI to generate information. (Professional Skills: Use Information and Communications Technologies)
3. Apply a fundamental understanding of ethical dilemmas and biases in using AI tools. (Civic/Interpersonal Skills: Character)
4. Evaluate real-world applications of AI to solve complex global challenges (Civic/Interpersonal Skills: Global/Cultural Awareness)

Elaboration on the GLE:

1. Central to understanding artificial intelligence is an ability to evaluate how AI is used, what kinds of objectives it should be applied to, and how to use AI to achieve those objectives. Not all objectives are good candidates for AI to address, in part due to the resources required to build and design AIs. When using specific AI tools, such as large- language models or image recognizers, students should be able to explore and analyze how an AI can be used to solve problems or create novel artifacts in their domain.

Using AI to help understand the world can involve the use of real-world training data. When using specific AI tools, such as large-language models or image generators, students should be able to explore and analyze how an AI can be used to understand the world by solving problems or creating novel artifacts.

AI has many subfields, such as machine learning, deep learning, natural language processing, computer vision, robotics, and reinforcement learning and it's helpful for students to understand that different areas exist to understand AI in general.

Computer Science Practices:

1. Developing and Using Abstractions
2. Recognizing and Defining Computational Problems
3. Communicating about Computing
4. Creating Computational Artifacts

Prepared Graduates:

10. Use AI tools to analyze and understand the world and to create and inspire ideas.

Grade Level Expectation:

2. AI tools can be applied to produce novel creations and inspire creativity.

Evidence Outcomes:

Students Can:

a. Develop and evaluate an AI-based solution to address a real-world objective.
b. Describe how AI can create novel outcomes by identifying patterns in data from the domain of interest.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Use AI to identify patterns in data. (Entrepreneurial Skills: Critical thinking/problem solving; Inquiry and analysis).
2. Use AI to generate novel outcomes. (Professional Skills: Use Information and Communications Technologies)

Elaboration on the GLE:

1. AI can be used to generate novel computational artifacts, analyze existing artifacts in the world, and inspire human creativity. When using specific AI tools, such as large-language models or image recognizers, students should be able to explore and analyze how an AI can be used to create novel artifacts in a domain of personal interest.

Computer Science Practices:

1. Developing and Using Abstractions
2. Recognizing and Defining Computational Problems
3. Communicating about Computing
4. Creating Computational Artifacts

Prepared Graduates:

11. Evaluate the uses of AI.

Grade Level Expectation:

3. Using AI tools requires evaluation of their results and assessment of their appropriateness for specific applications.

Evidence Outcomes:

Students Can:

a. Explain the potential limitations of AI; for example, insufficient or inaccurate data inputs, inability of the system to recognize its own errors, and flaws in the underlying algorithms.
b. Evaluate the results produced by an AI tool before using it.
c. Discuss challenges and considerations of AI with respect to personal privacy.
d. Evaluate the implications of AI on job markets and its role in automation and productivity.
e. Recognize the importance and challenges of human oversight in AI decision-making.
f. Recognize the purpose and suitability of AI tools for achieving specific outcomes.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Evaluate information produced by AI and determine if it should be used or not. (Critical Thinking/Problem Solving)

Elaboration on the GLE:

1. Some kinds of objectives may not be suitable for AI-based solutions and students should be able to distinguish those and be able to use data to train such an AI system, validate that the output is meaningful, and then test the predictions based on data outside the training set.

Computer Science Practices:

1. Recognizing and Defining Computational Problems
2. Fostering an Inclusive Computing Culture

Prepared Graduates:

11. Evaluate the uses of AI.

Grade Level Expectation:

4. The development of AI systems can create ethical and legal dilemmas that will need to be resolved.

Evidence Outcomes:

Students Can:

a. Identify arguments regarding the dilemmas created by advances in artificial intelligence.
b. Explain why computational artifacts can be attributed to an AI system rather than its initial programmers.
c. Describe the "Turing Test" and its implications for distinguishing human and artificial intelligences.
d. Articulate arguments against "artificial intelligence" qualifying as "actual intelligence" and counterarguments that refute those specific arguments.

Academic Contexts and Connections:

Colorado Essential Skills:

1. Explain why AI generated computational artifacts are attributed to the AI tool instead of the initial programmer. (Civic: Character)

Computer Science Practices:

1. Communicating About Computing