CS Matters

Computer Science Principles

Enduring Understandings and Learning Objectives

February 2017

Course Overview

CS Matters in Maryland (http://csmatters.org/) is an NSF-funded CS10K project focusing on the new AP Computer Science Principles (CSP) course. The objectives of the course are consistent with those defined within the AP Computer Science Principles Curriculum Framework by the College Board. This course will be taught using the curriculum developed by CS Matters.

The CS Matters CSP curriculum was developed with one key goal: to provide all students the opportunity to learn computer science within a rigorous and engaging framework. To reach, retain, and teach traditionally underrepresented groups, the curriculum is designed to foster welcoming learning environments that are respectful of the diverse strengths of all students. The theme of the CS Matters course is *data* -- where it comes from, how it is collected and made available, how it can be analyzed

and visualized, and the impact of “big data” on society.

Unit 1, *Your Virtual World*, informs and involves students in the many ways in which computing shapes their environment. Students study scalable problem solving by participating in citizen science, contributing their thoughts and recording their reactions in daily journals, investigating innovations of particular importance to them, and collaborating with partners and groups. Core lessons from Unit 1 include Impact of Innovation, A Problem Solving Process that Scales, Societal Impact, and Privacy in the Age of Big Data.

Unit 2, *Developing Programming Tools*, introduces students to software development using the Python programming language. The unit begins by focusing on the motivation for programming and then teaches the fundamentals of procedural programming, including data storage and retrieval, sequence, selection, iteration, and functions. This unit plays a pivotal role that allows subsequent units to challenge students to implement their own code to investigate their virtual world.

Unit 3, *Information and the Internet*, continues the emphasis on impact while examining the Internet, its core technologies, and its design. The unit explores how the design and technologies of the Internet affect innovation. Students take on the roles of Internet technologies by acting out the parts these technologies play. The first and third units together equip students to complete the College Board’s *Explore* Performance Task.

In the Explore Performance Task (EPT), students choose and explore a computing innovation. The EPT requires students to select and investigate a computational innovation that: has or has had the potential to have significant beneficial and harmful effects on our society, economy, or culture, consumes, produces, and/or transforms data and raises at least one data storage concern, data privacy concern, or data security concern. Students will have 8 hours (480 minutes) of class time to complete the EPT.

Unit 4, *Data Acquisition*, focuses on data, modeling, and simulations, while introducing fundamental concepts of probability and statistics. Students address the potential and limits of modeling by developing and testing hypotheses. Using computational thinking and the programming skills they learned in the prior unit, students build and test a model that leverages the power of computing to increase the accuracy of its results.

Unit 5, *Data Manipulation*, orients students to the conceptual foundations and core strategies for managing big data. Students investigate several data manipulation strategies, focusing on common algorithms and methods of evaluating them. The study of algorithms leads to small individual programming projects that acquaint students with the College Board’s *Create* performance task.

Unit 6, *Data Visualization*, serves as a bridge between the introduction to computing and the development of more substantial programming artifacts. This unit includes

several options for teachers to strengthen their students' creative programming abilities. The first lessons use EarSketch to engage students in computation through collaborative music composition. Other lessons use Bokeh from Continuum Analytics to equip students to create their own data visualizations.

In the Create Performance Task (CPT), students bring ideas to life through software development. The CPT requires students to design and iteratively develop a program. The College Board encourages but does not require students to collaborate with a partner, and once students begin the development of the CPT, they may receive help only from the collaborative partner. While not requiring it, this lesson supports a collaborative effort. Even if collaboration is used, each student must independently complete a significant level of planning, designing, and developing the program. Students will have 12 hours (720 minutes) of class time to complete the CPT.

Instruction in the Six Computational Practices and Seven Big Ideas is integrated throughout the course. The following table indicates the number of times each learning objective is addressed in each unit. Each Big Idea is taught in at least three units. Most Big Ideas are taught in every unit.

1. Your Virtual World

Unit 1 Enduring Understandings and Learning Objectives:

Big Idea	EUs and LOs in Unit 1: Your Virtual World
Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2] *To build toward EU 1.1, EU 1.2, and EU 1.3, Unit 1 focuses on students creating*

	presentations on the Internet and its impact using computing tools online, such as online collaboration tools. As students learn about how the Internet affects our daily lives, students apply this knowledge in their development of a computational artifact to illustrate or express the Internet as a positive agent of change.
Abstraction	**EU 2.1 A variety of abstractions built on binary sequences can be used to represent all digital data.** LO 2.1.1 Describe the variety of abstractions used to represent data. [P3] LO 2.1.2 Explain how binary sequences are used to represent digital data. [P5] **EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] *Concepts in Unit 1 build toward EU 2.1 and EU 2.2 by focusing on multiple ways to represent a single bit physically as fundamental building blocks of digital computing. Students learn about how bits ae stored and used to represent information, and how to convert between different forms. The unit also hones in on collections of bits for multiple purposes such as to represent numbers, for electronic books, and to control programs.*
Data	**EU 3.1 People use computer programs to process information to gain insight and knowledge.** LO 3.1.3 Explain the insight and knowledge gained from digitally processed data by using appropriate visualizations, notation and precise language. [P5] **EU 3.2 Computing facilitates exploration and the discovery of connections in information.** LO 3.2.1 Extract information from data to discover and explain connections or trends. [P1] LO 3.2.2 Determine how large data sets impact the use of computational processes to discover information and knowledge. [P3] **EU 3.3 There are trade-offs when representing information as digital data.** LO 3.3.1 Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. [P4] *Unit 1 builds toward EU 3.1, EU 3.2, and EU 3.3 by focusing on identifying data that is being used by a computing innovation(s) and analyzing how data is consumed, produced or transformed in various ways by computing innovations. The unit includes the study of various ways that data is stored and trade-offs that occur when considering the security and transmission of data.*
Internet	**EU 6.1 the Internet is a network of autonomous systems.** LO 6.1.1 Explain the abstractions in the Internet and how it functions. [P3] *The unit builds toward EU 6.1 with the study of different abstractions of the Internet and the study of technologies designed to track Internet usage. Also included is the analysis of the consequences of Internet usage on personal privacy and security.*
Global	**EU 7.1 Computing enhances communications, interaction, and cognition.**

Impact	LO 7.1.1 Explain how computing innovations affect communication, interaction, and cognition. [P4[] LO 7.1.2 Explain how people participate in a problem-solving process that scales. [P4] **EU 7.2 Computing enables innovation in nearly every field.** LO 7.2.1 Explain how computing has impacted innovations in other fields. [P1] **EU 7.3 Computing has global effects – both beneficial and harmful – on people and society.** LO 7.3.1 Analyze the beneficial and harmful effects of computing. [P4] **EU 7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.** LO 7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts. [P1] **EU 7.5 An investigative process is aided by effective organization and selection of resources. Appropriate technologies and tools facilitate the accessing of information and enable the ability to evaluate the credibility of sources.** LO 7.5.2 Evaluate online and print sources for appropriateness and credibility. [P5] *To build toward EU 7.2 and 7.4, and 7.5, Unit 1 requires students to consider how people and society are more vulnerable today because of new technology developed by advancements in computing. Unit 1 focuses on investigating the impacts of computing on society, culture and the economy, such as social media, online retail and banking, cloud data storage, and government surveillance. Unit 1 includes the study of the digital divide on national and global levels and on problem solving processes that scale. This unit also studies appropriate ways to conduct basic research on the functionality and impacts of computing innovations, analyze sources of information and a focus on technical writing.*

2. Developing Programs

Unit 2 Enduring Understandings and Learning Objectives:

Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2] *Lessons in Unit 2 build toward EU1.1, EU1.2 and EU 1.3 by introducing students to the goals and processes of programming. Students encounter programming as a service then begin creating computational artifacts with multiple levels of abstraction. Students learn to express ideas through algorithms and abstraction.*
Abstraction	**EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.1 Develop an abstraction when writing a program or creating other computational artifacts. [P2] LO 2.2.2 Use multiple levels of abstraction to write programs. [P3] LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] *Lessons in Unit 2 build student understanding of EU 2.2 by teaching students to use abstractions of variables, expressions and statements. Students refine program code that employs functional and data abstractions.*
Data	**EU 3.1 People use computer programs to process information to gain insight and knowledge.** LO 3.1.2 Collaborate when processing information to gain insight and knowledge. [P6] *The role of this unit in building toward EU 3.1 is to give students experience with collaborative review of information. Later stages of the curriculum have students build on this foundation employing computer programs to process information.*

Algorithms	**EU 4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages.** LO 4.1.1 Develop an algorithm for implementation in a program [P2] LO 4.1.2 Express an algorithm in a language [P5] *This unit builds toward EU 4.1 as students investigate and apply algorithms to develop code. Concepts and requirements of algorithms are introduced early in the unit and then applied throughout the increasing levels of abstraction in the unit.*
Programming	**EU 5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations, or society).** LO 5.1.1 Develop a program for creative expression, to satisfy personal curiosity or to create new knowledge. [P2] LO 5.1.2 Develop a correct program to solve problems. [P2] LO 5.1.3 Collaborate to develop a program. [P6] **EU 5.2 People write programs to execute algorithms.** LO 5.2.1 Explain how programs implement algorithms. [P3] **EU 5.3 Programming is facilitated by appropriate abstractions.** LO 5.3.1 Use abstraction to manage complexity in programs [P3] **EU 5.4 Programs are developed, maintained, and used by people for different purposes.** LO 5.4.1 Evaluate the correctness of programs. [P4] **EU 5.5 Programming uses mathematical and logical concepts.** LO 5.5.1 Employ appropriate mathematical and logical concepts in programming. [P1] *This is the first of two units primarily focusing on learning objectives associated with programming and building toward EU 5.1, EU 5.2, EU5.3, EU 5.4 and EU 5.5. After examining the role and programming in society students analyze and learn to manage expression of their ideas while developing programs and applying increasing levels of abstraction.*

Impact	**EU 7.1 Computing enhances communications, interaction, and cognition.** LO 7.1.1 Explain how computing innovations affect communication, interaction, and cognition. [P4] **EU 7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.** LO 7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts. [P1] *Building toward EU 7.1 and EU 7.4, are not only goals of this unit but of the entire curriculum. While detail oriented in implementing coding instruction the first focus of this unit is on coding's impact on society.*

3. Information and the Internet

Unit 3 Enduring Understandings and Learning Objectives:

Big Idea	**EUs and LOs in Unit 3: Information and Internet**
Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2] *To continue building EU 1.1, EU 1.2, and EU 1.3 in Unit 3, students work independently and in groups to create a variety of artifacts using multiple modes of expression. This unit provides multiple opportunities to practice the skills needed for the Explore Task using online sources, creative and collaborative tools.*

Abstraction	**EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] **EU 2.3 Models and Simulations use abstraction to generate new understanding and knowledge.** LO 2.3.1 Use models and simulations to represent phenomena [P3] *Concepts in Unit 3 build toward EU 2.2 and 2.3 by developing models of information flow across the Internet and layers of abstraction from the hardware that uses simple logic gates and chips to the devices, software and systems that are connected worldwide. Students act out simulations and modify the parameters to learn how data transmission and encryption work.*
Data	**EU 3.1 People use computer programs to process information to gain insight and knowledge.** LO 3.1.1 Find patterns and test hypotheses about digitally processed information to gain insight and knowledge [P4] LO 3.1.3 Explain the insight and knowledge gained from digitally processed data by using appropriate visualizations, notation and precise language. [P5] **EU 3.2 Computing facilitates exploration and the discovery of connections in information.** LO 3.2.1 Extract information from data to discover and explain connections or trends. [P1] **EU 3.3 There are trade-offs when representing information as digital data.** LO 3.3.1 Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. [P4] *Unit 3 builds EU 3.1, EU 3.2, and EU 3.3 by focusing on the data the flows on the Internet. The unit includes the study of the ways that page rank algorithms rely on many factors to predict what someone is looking for, and how search engines extract and analyze information to make predictions and increase revenues. Students also analyze the trade-offs in trying to secure data with an in depth look at many different cybersecurity techniques. By doing research and creating artifacts for the practice explore task, students gather data and analyze trends, innovations and features of the Internet that they must communicate clearly and succinctly.*
Algorithms	**EU 4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages** LO 4.1.1 Develop an algorithm for implementation in a program [P2] LO 4.1.2 Express an algorithm in a language [P5]

	Unit 3 builds on EU 4.1 by analyzing a wide range of algorithms used in Internet communication such as search engine page rank and retrieval, routing routines, and cryptography. Low level machine language algorithms are explored within the study of logic gates and students learn how the need for precision and efficiency is so significant in the large scale of the data flowing online.
Programming	**EU 5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations or society).** LO 5.1.1 Develop a program for creative expression, to satisfy personal curiosity or to create new knowledge. [P2] LO 5.1.2 Develop a correct program to solve problems. [P2] **EU 5.2 People write programs to execute algorithms.** LO 5.2.1 Explain how programs implement algorithms. [P3] **EU 5.3 Programming is facilitated by appropriate abstractions** LO 5.3.1 Use abstraction to manage complexity in programs [P3] **EU 5.4 Programs are developed, maintained, and used by people for different purposes.** LO 5.4.1 Evaluate the correctness of programs. [P4] **EU 5.5 Programming uses mathematical and logical concepts.** LO 5.5.1 Employ appropriate mathematical and logical concepts in programming. [P1] *Unit 3 continues to build on EU 5.1 – 5.5 developed in Units 1 and 2 by investigating the details of the many programs that control the flow of information, organize, secure and retrieve it and allow for collaborative interaction online. Students compare the efficiency and complexity of different algorithms used by Internet systems. This unit also continues the development of programs using the Python skills developed in Unit 2 to explore the Internet of Things and to encrypt and decrypt data.*
Internet	**EU 6.1 the Internet is a network of autonomous systems.** LO 6.1.1 Explain the abstractions in the Internet and how it functions. [P3] **EU 6.2 Characteristics of the Internet influence the systems built on it.** LO 6.2.1 Explain characteristics of the Internet and the system built on it. [P5] LO 6.2.2 Explain how the characteristics of the Internet influence the system built on it. [P4] **EU 6.3 Cybersecurity is an important concern for the Internet and the systems built on it.**

	LO 6.3.1 Identify existing cybersecurity concerns and potential options to address these issues with the Internet and the systems built on it. [P1] *Unit 3 builds EU 6.1, 6.2 and 6.3 significantly with the focus on how the Internet works at multiple levels from the hardware level of logic gates and chips to the flow of data around the world that is accomplished with layers of hardware and software working together. Students investigate the history, present state, and future of the Internet including the systems that have been built on it through activities that drill down into the details about the flow of data, routing, DNS, search engines and cybersecurity. With time set aside for individual research into the features, impact and function of the Internet to prepare for the Explore Task, students investigate areas of personal interest and share what they have learned with the class. The unit ends with a detailed investigation of a wide variety of ways to secure data.*
Global Impact	**EU 7.1 Computing enhances communications, interaction, and cognition.** LO 7.1.1 Explain how computing innovations affect communication, interaction, and cognition. [P4] **EU 7.2 Computing enables innovation in nearly every field.** LO 7.2.1 Explain how computing has impacted innovations in other fields. [P1] **EU 7.3 Computing has global effects – both beneficial and harmful – on people and society.** LO 7.3.1 Analyze the beneficial and harmful effects of computing. [P4] **EU 7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.** LO 7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts. [P1] **EU 7.5 An investigative process is aided by effective organization and selection of resources. Appropriate technologies and tools facilitate the accessing of information and enable the ability to evaluate the credibility of sources.** LO 7.5.1 Access, manage and attribute information using effective strategies [P1] LO 7.5.2 Evaluate online and print sources for appropriateness and credibility. [P5] *To build toward EU 7.1, 7.2, 7.3, 7.4, and 7.5, Unit 3 explores how the design and technologies of the Internet affect innovation. Aspects of the Internet are analyzed for their impact on our world from the bias in search engine results, to government control of access to information. This Unit includes the impact of cybersecurity concerns at a personal, corporate and global level as well as*

	the costs and developments that are part of industries that have grown around cybersecurity. In the process of doing research and creating artifacts to practice for the Explore Task, students focus on high quality sources of current information while they evaluate and manage multiple sources of information to be used in a larger project.

4. Data Acquisition

Unit 4 Enduring Understandings and Learning Objectives:

Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2]
	This unit builds toward EU 1.1 - EU 1.3 as students create several model and simulation computational artifacts. Students experience deriving conclusions from the models and examine both their power and limitations to solve problems.
Abstraction	**EU 2.1 A variety of abstractions built on binary sequences can be used to represent all digital data.** LO 2.1.1 Describe the variety of abstractions used to represent data. [P3] **EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] **EU 2.3 Models and Simulations use abstraction to generate new understanding and knowledge.**

	LO 2.3.1 Use models and simulations to represent phenomena [P3] LO 2.3.2 Use models and simulations to formulate, refine and test hypothesis. [P3]
	Lessons in this unit build toward EU 2.1 by focusing students on the power and limitations of data to describe phenomena. EU 2.2 and EU 2.3 are developed by students as they examine simulations and modify them to address changes in hypothesis and to support the development of new findings.
Data	**EU 3.1 People use computer programs to process information to gain insight and knowledge.** LO 3.1.1 Find patterns and test hypotheses about digitally processed information to gain insight and knowledge [P4] LO 3.1.2 Collaborate when processing information to gain insight and knowledge. [P6] LO 3.1.3 Explain the insight and knowledge gained from digitally processed data by using appropriate visualizations, notation and precise language. [P5] **EU 3.2 Computing facilitates exploration and the discovery of connections in information.** LO 3.2.1 Extract information from data to discover and explain connections or trends. [P1] **EU 3.3 There are trade-offs when representing information as digital data.** LO 3.3.1 Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. [P4] LO 3.2.2 Use large data sets to explore and discover information and knowledge. [P3] *Unit 4 builds toward EU 3.1 throughout this unit beginning with an examination of the quantity of large data sets and the roles of data scientists in their analysis. The emphasis moves to the generation of data from simulations. The unit builds toward EU 3.2 and 3.3 as students use simulations they develop to draw inferences and are introduced to issues impacting the reliability of the conclusions.*
Algorithms	**EU 4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages** LO 4.1.1 Develop an algorithm for implementation in a program [P2] LO 4.1.2 Express an algorithm in a language [P5
	Unit 4 builds towards EU 4.1 as students are led to implement algorithms to simulate rolling dice and throwing darts. The programs students develop are then used to collect data and to support inferences.
Programming	**EU 5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations or society).**

	LO 5.1.1 Develop a program for creative expression, to satisfy personal curiosity or to create new knowledge. [P2] LO 5.1.2 Develop a correct program to solve problems. [P2] LO 5.1.3 Collaborate to develop a program. [P6] **EU 5.2 People write programs to execute algorithms.** LO 5.2.1 Explain how programs implement algorithms. [P3] **EU 5.3 Programming is facilitated by appropriate abstractions** LO 5.3.1 Use abstraction to manage complexity in programs [P3] **EU 5.4 Programs are developed, maintained, and used by people for different purposes.** LO 5.4.1 Evaluate the correctness of programs. [P4] **EU 5.5 Programming uses mathematical and logical concepts.** LO 5.5.1 Employ appropriate mathematical and logical concepts in programming. [P1]
	This unit builds toward EU 5.1 by designing tools to answer questions based on data to create new knowledge and solve problems. Student understanding of EU 5.2, EU 5.4 and 5.5 are developed as students are guided through exercises that implement two algorithms that rely on mathematical and logical expressions for their result. EU 5.3 is developed by students as they consider the adequacy of chosen data models used in simulations.
Impact	**EU 7.1 Computing enhances communications, interaction, and cognition.** LO 7.1.1 Explain how computing innovations affect communication, interaction, and cognition. [P4] **EU 7.3 Computing has global effects – both beneficial and harmful – on people and society.** LO 7.3.1 Analyze the beneficial and harmful effects of computing. [P4] **EU 7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.** LO 7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts. [P1]
	The availability of public data is used in this unit to build toward EU 7.1. The impact of computational analysis of data develops student understanding of EU 7.3. EU 7.4 is developed by student study of the world wide availability of data .

5. Data Manipulation

Unit 5 Enduring Understandings and Learning Objectives:

Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2] *Unit 5 continues building EU 1.1, EU 1.2, and EU 1.3 to create a synthesis of algorithms, programming, and data. This unit's focus on data manipulation provides many ways to apply the creative skills that have been developed in Units 1-4 to implement common and unique algorithms. Students collaborate on creative development to modify and create artifacts while working on the partial practice for the Create Performance task.*
Abstraction	**EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.1 Develop an abstraction when writing a program or creating other computational artifacts. [P2] LO 2.2.2 Use multiple levels of abstraction to write programs. [P3] LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] **EU 2.3 Models and Simulations use abstraction to generate new understanding and knowledge.** LO 2.3.1 Use models and simulations to represent phenomena [P3] LO 2.3.2 Use models and simulations to formulate, refine and test hypothesis. [P3] *The focus on EU 2.2 and 2.3 in Unit 5 provides an in depth look at how models and simulations are used to represent real-life situations. This builds on the concepts and activities in Units 1-4 that introduced models and simulations to explain the function of the Internet, and program execution.*

Data	**EU 3.1 People use computer programs to process information to gain insight and knowledge.** LO 3.1.1 Find patterns and test hypotheses about digitally processed information to gain insight and knowledge [P4] LO 3.1.2 Collaborate when processing information to gain insight and knowledge. [P6] LO 3.1.3 Explain the insight and knowledge gained from digitally processed data by using appropriate visualizations, notation and precise language. [P5] **EU 3.2 Computing facilitates exploration and the discovery of connections in information.** LO 3.2.1 Extract information from data to discover and explain connections or trends. [P1] LO 3.2.2 Use large data sets to explore and discover information and knowledge. [P3] **EU 3.3 There are trade-offs when representing information as digital data.** LO 3.3.1 Analyze how data representation, storage, security, and transmission of data involve computational manipulation of information. [P4] *EU 3.1, 3.2 and 3.3 are developed in Unit 5 using activities that analyze and implement algorithms. Python lists will be used to work with a large set of data using searching, sorting, and other ways to manipulate data. Results are analyzed to discover trends and connections that are uncovered in the data.*
Algorithms	**EU 4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages** LO 4.1.1 Develop an algorithm for implementation in a program [P2] LO 4.1.2 Express an algorithm in a language [P5] **EU 4.2 Algorithms can solve many, but not all, computational problems.** LO 4.2.1 Explain the difference between algorithms that run in a reasonable time and those that do not run in a reasonable time. [P1] LO 4.2.2 Explain the difference between solvable and unsolvable problems in computer science. [P1] LO 4.2.3 Explain the existence of undecidable problems in computer science. [P1] LO 4.2.4 Evaluate algorithms analytically and empirically for efficiency, correctness and clarity. [P4] *Unit 5 develops EU 4.1 and 4.2 using activities that analyze and implement algorithms. Python lists are used to work with large sets of data using searching, sorting, and other ways to manipulate data. Algorithms are compared for their effectiveness as well as their readability.*

Programming	**EU 5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations or society).** LO 5.1.1 Develop a program for creative expression, to satisfy personal curiosity or to create new knowledge. [P2] LO 5.1.2 Develop a correct program to solve problems. [P2] LO 5.1.3 Collaborate to develop a program. [P6] **EU 5.2 People write programs to execute algorithms.** LO 5.2.1 Explain how programs implement algorithms. [P3] **EU 5.3 Programming is facilitated by appropriate abstractions** LO 5.3.1 Use abstraction to manage complexity in programs [P3] **EU 5.4 Programs are developed, maintained, and used by people for different purposes.** LO 5.4.1 Evaluate the correctness of programs. [P4] **EU 5.5 Programming uses mathematical and logical concepts.** LO 5.5.1 Employ appropriate mathematical and logical concepts in programming. [P1] *In Unit 5, EU 5.1, 5.2, 5.3, 5.4 and 5.5 are strengthened by repeated opportunities to design, implement and evaluate programs. Python lists will be used to work with large sets of data using searching, sorting, and other ways to manipulate data. Students will investigate, program and modify models and simulations that represent real-life situations.*
Internet	**EU 6.1 the Internet is a network of autonomous systems.** LO 6.1.1 Explain the abstractions in the Internet and how it functions. [P3] *Lessons in Unit 5 support EU 6.1 by investigating the way that the systems on the Internet address the problems of cybersecurity on multiple levels including hardware and software solutions.*
Impact	**EU 7.1 Computing enhances communications, interaction, and cognition.** LO 7.1.2 Explain how people participate in a problem-solving process that scales. [P4] *In Unit 5, EU 7.1 is developed as students investigate the impact of large scale data collection and analysis as well as the pervasive effects of computation on communication and productivity.*

6. Data Visualization

Unit 6 Enduring Understandings and Learning Objectives:

Creativity	**EU 1.1 Creative development can be an essential process for creating computational artifacts.** LO 1.1.1 Apply a creative development process when creating computational artifacts. [P2] **EU 1.2 Computing enables people to use creative development processes to create computational artifacts for creative expressions or to solve a problem.** LO 1.2.1 Create a computational artifact for creative expression. [P2] LO 1.2.2 Create a computational artifact using computing tools and techniques to solve a problem. [P2] LO 1.2.3 Create a new computational artifact by combining or modifying existing artifacts. [P2] LO 1.2.4 Collaborate in the creation of computational artifacts. [P6] LO 1.2.5 Analyze the correctness, usability, functionality, and suitability of computational artifacts. [P4] **EU 1.3 Computing can extend traditional forms of human expression and experience.** LO 1.3.1 Use computing tools and techniques for creative expression. [P2] *Unit 6 builds on the skills developed in units 1 - 5 as students master the ability to use a variety of computing tools and techniques in a creative process to develop programs for creative expression. EarSketch provides a platform where students programmatically generate music using Python, not only producing a creative result, but also employing a creative process in the development of their software.*
Abstraction	**EU 2.1 A variety of abstractions built on binary sequences can be used to represent all digital data.** LO 2.1.1 Describe the variety of abstractions used to represent data. [P3] **EU 2.2 Multiple levels of abstraction are used to write programs or create other computational artifacts.** LO 2.2.1 Develop an abstraction when writing a program or creating other computational artifacts. [P2] LO 2.2.2 Use multiple levels of abstraction to write programs. [P3] LO 2.2.3 Identify multiple levels of abstractions used when writing programs. [P3] *Unit 6 supports student learning EU 2.1 and EU 2.2 as students use a variety of data abstractions including variables, files and lists in Python to express numeric, String values and musical structures. Students learn to use multiple level functional and data abstractions to organize program development. Multiple level functional abstract support repeated use of lower level functions. Students learn to use list structures that themselves use abstractions for the music students are mixing.*

Algorithms	**EU 4.1 Algorithms are precise sequences of instructions for processes that can be executed by a computer and are implemented using programming languages** LO 4.1.1 Develop an algorithm for implementation in a program [P2] LO 4.1.2 Express an algorithm in a language [P5] *Unit 6 builds toward EU 4.1 by communicating algorithms to define criteria for student developed programs. By first studying, then implementing these algorithms in Python, students recognize the need for precision both in algorithm definition and implementation.*
Programming	**EU 5.1 Programs can be developed for creative expression, to satisfy personal curiosity, to create new knowledge, or to solve problems (to help people, organizations or society).** LO 5.1.1 Develop a program for creative expression, to satisfy personal curiosity or to create new knowledge. [P2] LO 5.1.2 Develop a correct program to solve problems. [P2] LO 5.1.3 Collaborate to develop a program. [P6] **EU 5.2 People write programs to execute algorithms.** LO 5.2.1 Explain how programs implement algorithms. [P3] **EU 5.3 Programming is facilitated by appropriate abstractions** LO 5.3.1 Use abstraction to manage complexity in programs [P3] **EU 5.4 Programs are developed, maintained, and used by people for different purposes.** LO 5.4.1 Evaluate the correctness of programs. [P4] **EU 5.5 Programming uses mathematical and logical concepts.** LO 5.5.1 Employ appropriate mathematical and logical concepts in programming. [P1] *This unit builds toward EU 5.1 as students develop music mixes to meet their tastes and towards EU 5.2 and EU 5.3 as they develop algorithms and their implementations to meet the standards expressed as algorithms. Students identify several abstractions used by Python to manage complexity. Students build toward EU 5.4 throughout this unit students develop programs that must comply with their own goals. The curriculum builds toward EU 5.5 as student use mathematical concepts in their programs to manage data collections and logical expressions to make decisions.*

Impact	**EU 7.2 Computing enables innovation in nearly every field.** LO 7.2.1 Explain how computing has impacted innovations in other fields. [P1] **EU 7.4 Computing innovations influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.** LO 7.4.1 Explain the connections between computing and real-world contexts, including economic, social, and cultural contexts. [P1] *Unit 6 builds toward EU 7.4 by studying issues of digital ownership and copyright law. It also illustrates the impact of cultural context showing how audio from a variety of musical genre can be mixed utilizing the same computing skills.*