2022 Computer Science and Engineering

Course Code: 000287

Direct inquiries to:

Instructional Design Specialist
Research and Curriculum Unit
P.O. Drawer DX
Mississippi State, MS 39762
662.325.2510

Program Supervisor
Office of Career and Technical Education
Mississippi Department of Education
P.O. Box 771
Jackson, MS 39205
601.359.3974

Published by:

Office of Career and Technical Education
Mississippi Department of Education
Jackson, MS 39205

Research and Curriculum Unit
Mississippi State University
Mississippi State, MS 39762

The Research and Curriculum Unit (RCU), located in Starkville, as part of Mississippi State University (MSU), was established to foster educational enhancements and innovations. In keeping with the land-grant mission of MSU, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

Table of Contents

Acknowledgments

The computer science and engineering (CSE) curriculum was presented to the Mississippi State Board of Education on February 17, 2022. The following persons were serving on the state board at the time:

Dr. Carey M. Wright, state superintendent of education
Ms. Rosemary G. Aultman, chair
Mr. Glen V. East, vice-chair
Dr. Karen J. Elam
Dr. Angela Bass
Dr. Ronnie L. McGehee
Dr. Wendi Barrett
Mr. Matt Miller
Mrs. Mary Werner
Mr. Bill Jacobs
Ms. Amy Zhang, student representative
Ms. Micah Hill, student representative

The following Mississippi Department of Education (MDE) and RCU managers and specialists assisted in the development of the CSE curriculum:

Wendy Clemons, the executive director of the MDE Office of Secondary Education, supported the RCU and teachers throughout the development of the framework and supporting materials.

Dr. Aimee Brown, the state director of the MDE Office of Career and Technical Education (CTE), supported the RCU and teachers throughout the development of the framework and supporting materials.

Shelly Hollis, the assistant director of the MSU Center for Cyber Education (CCE), RCU, researched and coauthored this framework.

Lizzie Brandon, a project manager for the RCU, researched and revised this framework.

Amanda Taylor, a project manager for the RCU, researched and revised this framework.

To reach the CCE, please email helpdesk@rcu.msstate.edu.

Special thanks are extended to the educators who contributed teaching and assessment materials that are included in the framework and supporting materials:

Denise Adair, Millsaps Career and Technical Center, Starkville
Charles Bourg, Hancock Middle School, Kiln
Mitzi Cox, R. H. Long Booneville Middle School, Booneville
Steve Goodgame, Lafayette Middle School, Oxford

Virginia Kittrell, Sand Hill Elementary School, Richton
Cheryl Malone, South Pontotoc High School, Pontotoc
Meg Stewart, Purvis Middle School, Purvis
Shelley Thoms, Newton County High School, Decatur
Amanda Richardson, Eupora High School, Eupora
Erin Campbell, Wayne County Career-Technical Center, Waynesboro
Jennifer Carwile, Water Valley High School, Water Valley
Mitzi Cox, Booneville Middle School, Booneville

Appreciation is expressed to the following professionals who provided guidance and insight throughout the development process:

Dr. Louella Mack-Webster, the program director for the MDE Office of CTE
Betsey Smith, the director of the RCU
Sam Watts, the curriculum manager for the RCU

Standards

Standards and alignment crosswalks are referenced in the appendices. Depending on the curriculum, these crosswalks should identify alignment to the standards mentioned below, as well as possible related academic topics as required in the Subject Area Testing Program in Algebra I, Biology I, English II, and U.S. History from 1877, which could be integrated into the content of the units. Mississippi's CTE CSE curriculum is aligned to the following standards:

International Society for Technology in Education Standards (ISTE)
Reprinted with permission from *ISTE Standards for Students* (2016). All rights reserved. Permission does not constitute an endorsement by ISTE.
iste.org

Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress (NAEP)
"The 2018 NAEP Technology and Engineering Framework is a statement about what should be expected of students in terms of their knowledge and skills with technology, written to be the basis for an assessment of technology and engineering literacy appropriate for all students. It opens the door to seeing what our K-12 students know about technology and engineering, in the same way that NAEP already assesses their knowledge and capabilities in reading, mathematics, science, and other subjects."
nationsreportcard.gov

2018 Mississippi College- and Career-Readiness Standards (MCCRS) for Computer Science
In an effort to closely align instruction for students who are progressing toward postsecondary study and the workforce, the 2018 MCCRS for Computer Science includes grade- and course-specific standards for K-12 computer science. Mississippi has adapted these standards from the nationally developed Computer Science Teachers Association K-12 Computer Science Standards (Revised 2017).
mdek12.org/oae/college-and-career-readiness-standards

Framework for 21st Century Learning
In defining 21st-century learning, the Partnership for 21st Century Skills has embraced key themes and skill areas that represent the essential knowledge for the 21st century: global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; environmental literacy; learning and innovation skills; information, media, and technology skills; and life and career skills. *21 Framework Definitions* (2019).
battelleforkids.org/networks/p21/frameworks-resources

Preface

Secondary CTE programs in Mississippi face many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing applied learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. This document provides information, tools, and solutions that will aid students, teachers, and schools in creating and implementing applied, interactive, and innovative lessons. Through best practices, alignment with national standards and certifications, community partnerships, and a hands-on, student-centered concept, educators will be able to truly engage students in meaningful and collaborative learning opportunities.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Strengthening Career and Technical Education for the 21st Century Act, 2019 [Perkins V]; and Every Student Succeeds Act, 2015).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers:

Curriculum, Assessment, Professional Learning

Program resources can be found at the RCU's website, rcu.msstate.edu.

Learning Management System: An Online Resource

Learning management system information can be found at the RCU's website under Professional Learning.

Should you need additional instructions, call the RCU at 662.325.2510.

Executive Summary

Pathway Description

CSE is a project-based course designed to instruct students through activities that require modeling, physical design, and coding, leading them to discover how computing and engineering work together to solve problems. This course offers students exposure to the engineering design process which introduces them to problem solving and critical thinking as well as the basics of project management and teamwork. This knowledge will assist them in making informed and meaningful decisions about high school coursework and broaden their horizons for career opportunities.

This course was combined with the STEM Applications course in 2021 to create a single course that would provide an opportunity for students to learn how computer science and engineering are connected. The competencies and objectives allow students to become familiar with two different areas of the science, technology, engineering, and math (STEM) occupations cluster giving them insight into numerous career fields.

Grade Level and Class Size Recommendations

It is recommended that students enter this course as an eighth grader. Exceptions to this are a district-level decision based on class size, enrollment numbers, and student maturity. A maximum of 24 students is recommended for this classroom-based course.

Student Prerequisites

Currently, no prerequisites are required to take this course.

Assessment

The latest assessment blueprint for the curriculum can be found at rcu.msstate.edu/curriculum/curriculumdownload.

Applied Academic Credit

The latest academic credit information can be found at mdek12.org/ese/approved-course-for-the-secondary-schools.

Teacher Licensure

The latest teacher licensure information can be found at mdek12.org/oel/apply-for-an-educator-license.

Professional Learning

If you have specific questions about the content of any training sessions provided, please contact the RCU at 662.325.2510.

Course Outlines

This curriculum consists of one 1-credit course that should be completed in the eighth grade or above.

Computer Science and Engineering—Course Code: 000287

Unit	Title	Hours
1	Orientation, Safety, and Student Organizations	10
2	Project Design	20
3	Exploring Newton's Laws	20
4	Introduction to Modeling and 3D Printing	20
5	Coding	25
6	Introduction to Electronics	20
7	Introduction to Robotics & Microcontrollers	25
Total		**140**

Career Pathway Outlook

Overview

Professionals working in computer science and engineering apply principles of science, technology, engineering, and mathematics to develop economical solutions for society. Whether it is working on scientific discoveries or commercial applications, employees in these rapidly changing fields are expected to continuously pursue further education to remain current in knowledge and skill. Licensing requirements for computer science and engineering professionals vary widely depending on the field or sector. Credentials may involve a professional degree, industry certifications, training, and/or practical work experience. The 2018-2028 occupational employment projections and wage estimates for Mississippi were used to determine where computer science and engineering employment needs would be in the population over a 10-year period.

Needs of the Future Workforce

Data for this synopsis was compiled from the Mississippi Department of Employment Security (2021). Employment opportunities in Mississippi representative of various engineering occupations are listed below.

Table 1.1: Current and Projected Occupation Report

Description	**Jobs, 2018**	**Projected Jobs, 2028**	**Change (Number)**	**Change (Percent)**	**Average Hourly Earnings, 2021**
Computer and Mathematical Occupations	13,300	14,340	1,040	7.8%	$34.48
Architecture and Engineering Occupations	14,710	15,280	570	3.9%	$37.43
Health Care Practitioners and Technical Occupations	82,360	91,270	8,910	10.8%	$32.13
Life, Physical, and Social Science Occupations	7,430	7,740	310	4.2%	$31.15
Installation, Maintenance, and Repair Occupations	54,860	56,400	1,540	2.8%	$22.02
Transportation and Material Moving Occupations	105,930	111,460	5,530	5.2%	$16.64

Source: Mississippi Department of Employment Security; mdes.ms.gov (2021).

Perkins V Requirements and Academic Infusion

The CSE curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in computer science fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for computer science careers. Additionally, this curriculum is integrated with academic college- and career-readiness standards. Lastly, it focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Transition to Postsecondary Education

The latest articulation information for secondary to postsecondary can be found at the Mississippi Community College Board website, mccb.edu.

Best Practices

Innovative Instructional Technologies

Classrooms should be equipped with tools that will teach today's digital learners through applicable and modern practices. The CSE educator's goal should be to include teaching strategies that incorporate current technology. To make use of the latest online communication tools—wikis, blogs, podcasts, and social media platforms, for example—the classroom teacher is encouraged to use a learning management system that introduces students to education in an online environment and places more of the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways, and numerous factors—students' background, emotional health, and circumstances, for example—create unique learners. By providing various teaching and assessment strategies, students with various learning preferences can have more opportunities to succeed.

CTE Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the CSE curriculum. Skills USA and Technology Student Association (TSA) are examples of student organizations for computer science. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of computer science careers and scholarship opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the CSE curriculum for group work. To function in today's workforce, students need to be able to work collaboratively with others and solve problems without excessive conflict. The CSE curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the CSE curriculum that will allow and encourage collaboration with professionals currently in the computer science field.

Work-Based Learning

Work-based learning is an extension of understanding competencies taught in the CSE classroom. This curriculum is designed in a way that necessitates active involvement by the students in the community around them and the global environment. These real-world connections and applications link all types of students to knowledge, skills, and professional dispositions. Work-based learning should encompass ongoing and increasingly more complex involvement with local companies and computer science professionals. Thus, supervised collaboration and immersion into computer science around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

For students:
SkillsUSA
skillsusa.org

Technology Student Association
tsaweb.org

For teachers:
Association of Career and Technical Education
acteonline.org

Computer Science Teachers Association
csteachers.org

International Society for Technology in Education
iste.org

Mississippi Association of Career and Technical Education
mississippiacte.com

Mississippi Business Education Association
ms-mbea.com

Mississippi Educational Computing Association
ms-meca.org

Student Competitions

Teachers are encouraged to charter one of the student organizations on the previous page and participate in a competition hosted by that organization or at least one of the following student competitions (student organization charter and competition may occur in tandem):

BEST Robotics
bestinc.org

FIRST Robotics (LEGO League or Tech Challenge)
firstinspires.org

SeaPerch National Challenge
seaperch.org/index

Transportation and Civil Engineering (TRAC™) Bridge Challenge developed by the Mississippi Department of Transportation (MDOT)
mdot.ms.gov/stemeducation/programs/trac.html

VEX Robotics Competition (I.Q. or EDR through TSA, REC, or both)
vexrobotics.com

Using This Document

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students are expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level. Teachers are welcome to teach the competencies in other ways than the listed objectives if it allows for mastery of the competencies. Teachers are also allowed to teach the units and competencies in the order that they prefer, as long as they teach necessary material allotted for that specific course or credit they are teaching at the time.

Teacher Resources

Teacher resources for this curriculum may be found in multiple places. Many program areas have teacher resource documents that accompany the curriculum and can be downloaded from the same site as the curriculum. The teacher resource document contains references, lesson ideas, websites, teaching and assessment strategies, scenarios, skills to master, and other resources divided by unit. This document could be updated periodically by RCU staff. Please check the entire document, including the entries for each unit, regularly for new information. If you have something you would like to add or have a question about the document, call or email the RCU's instructional design specialist for your program. The teacher resource document can be downloaded at rcu.msstate.edu/curriculum/curriculumdownload.aspx.

All teachers should request to be added to the "*Canvas Resource Guide for Middle School*." This is where all resources will be housed, including pacing guides and unit-by-unit activity suggestions.

To be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu. In the email, request an MDE Canvas account and to be added to the course called "Resource Guides for Middle School."

Unit 1: Orientation, Safety, and Student Organizations

Competencies and Suggested Objectives
1. Identify expectations, school policies, student organizations, and program policies related to this course. DOK1 a. Identify school rules, policies, and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards.
2. Analyze general safety in the project-based learning classroom. DOK2 a. Identify, describe, and demonstrate the importance of safety and the proper use of equipment (ongoing). b. Construct a diagram of the classroom/lab to scale, including the location of safety equipment. c. Complete a safety test exhibiting 100% mastery of safety practices and procedures.
3. Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work. DOK2 a. Identify, describe, and demonstrate the proper use of classroom management tools. b. Be familiar with the **required** Student Competency Profile form for this course.
4. Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies. DOK2 a. Describe the importance of effective communication skills. • Demonstrate verbal and nonverbal communication skills. • Apply appropriate speaking and listening skills to class- and work-related situations. b. Apply leadership skills to class- and work-related situations. • Define leadership. • Discuss the attributes of a leader. • Identify the roles a leader can assume. c. Utilize team-building skills in class- and work-related situations. • Define team building. • Discuss the attributes of a team. • Identify the roles included in a team. d. Discuss the various competitions offered through a program area student organization. • Describe each of the competitions and the skills needed to accomplish the tasks. • Perform the tasks needed to complete an assigned requirement for a competition.
5. Demonstrate proper digital citizenship concepts (ongoing). DOK2 a. Understand the ethical use of materials created by others. b. Understand how cyber bullying can impact teamwork and collaboration.

Note: Competencies marked as “ongoing” will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

Unit 2: Project Design

Competencies and Suggested Objectives
1. Analyze and become familiar with the use of basic tools and techniques to plan, organize, and manage a project. DOK3 a. Define a project timeline. b. Create and calculate a sample project budget. c. Construct communications (e.g., emails, letters, texts, etc.) to interact with others regarding design and computational thinking. d. Demonstrate the principles and practice of leadership and teamwork.
2. Demonstrate knowledge and understanding of the NASA's BEST Engineering Design Process, or a similar design process (ongoing). DOK3 a. Identify the steps of the Engineering Design Process. i. Ask • Objectives • Challenges and limitations ii. Imagine • Brainstorming iii. Plan • Sketches and/or scaled drawings • Materials list • Limitations iv. Create • Artifacts/work samples • Pictures and/or videos v. Experiment • Analytical (physical science and mathematics) calculations and data • Results vi. Improve • Reflective writing including items such as: o Trade-offs/unintended consequences o Design/product evaluation o Project reviews (e.g., peer, teacher, industry, community) vii. Improvement plan for continuation b. Apply the steps of the Engineering Design Process to a specific project. c. Explain how each step of the Engineering Design Process relates to a specific project.
3. Establish essential elements of the course portfolio. DOK 3 a. Describe the purpose of a digital portfolio. b. Create a cumulative portfolio which includes the following: • Title page • Table of contents (pages must be numbered) • Section for all included projects detailing each step of the design process for each project, including reflective writing and peer reviews • Photos documenting steps of the design process for each project

• Works cited/references, if relevant (e.g., photo credit)
4. Synthesize research to understand project needs and limitations. DOK4 a. Identify and describe engineering needs and limitations. b. Identify and describe client needs and limitations.
5. Assess client needs to understand the purposes of design. DOK3 a. Express opinions respectfully and effectively. b. Critically evaluate an object for how well its design meets a given set of needs. c. Identify empathy for the client as an important component of the design process. d. Distinguish between creator needs and client needs.
6. Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.). DOK3

Note: Competencies marked as "ongoing" will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

Unit 3: Exploring Newton's Laws

Competencies and Suggested Objectives
1. Demonstrate problem-solving and teamwork skills using the engineering design process by completing a complex challenge (Newton Project). DOK 3 a. Complete a complex challenge using the engineering design process (MDOT Bridge Challenge, balsa wood gliders, Rube Goldberg machine, catapult, or equivalent). b. Document project in student digital portfolio, emphasizing scaled drawings and materials lists. c. Demonstrate proper safety knowledge while completing project.
2. Apply appropriate physical and mathematical principles to Newton Project tasks (include in portfolio). DOK 3 a. Conduct a student-led project to include the following physical and mathematical principles: • Simple machines to include: o Wedge o Pulley o Inclined plane o Screw o Wheel and axle o Lever • Distance • Displacement (d=change in x/change in time) • Speed (s=distance/time) • Velocity (v=change in displacement/change in time) • Acceleration (a=change in velocity/change in time) • Equilibrium • Forces o Friction o Gravity o Normal o Tension o Torsion o Compression o Shear (force/area) • Newton's Laws of Motion (F=ma) • Measurement (metric and imperial) • Geometry (Pythagorean theorem, finding unknown angles or sides of triangles) • Ratios (strength to weight)

3. Engage with STEM industry and business professionals. DOK 2 a. Arrange a field trip, professional visit, or virtual interaction with a STEM professional and inquire about: • Career fields and availability (considering automation trends) • Education and training • Certifications • Average salaries • Job descriptions and daily tasks b. Complete a reflective writing exercise that includes career interests and add to the student's portfolio.

Enrichment
1. Apply the continuous improvement model of the engineering design process to improve an existing product. Include tradeoff (sustainability and efficiency) concepts frequently used in industry.

Unit 4: Introduction to Modeling and 3D Printing

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using 3D printers and associated supplies. DOK2
2. Demonstrate the use of computer-aided design (CAD) software to create 3D models. DOK2 a. Use appropriate resources to become familiar with a CAD workspace. b. Communicate CAD terms using multiple formats (e.g., verbally, textually, graphically). c. Complete online tutorials to create an object that includes the following parts: • Holes • Fillets • Lettering • Manipulation of pieces
3. Design a 3D model for rapid prototyping using a 3D printer. DOK3 a. Use CAD software to design and create multiple objects. b. Use CAD software to edit/remix a design created by someone else. (Note: If 3D printers are not available, all objectives can be met with free software and by creating models with other materials.)
4. Slice and 3D print an object created with CAD software. DOK3 a. 3D print one of the designated projects or build a project from other materials (3D print as time and resources allow, having at least one example from each class). b. Identify and demonstrate use of the following terms while using slicing software: layer height, infill, support, and adhesion.
5. Develop a cost analysis based on time and materials. DOK3
6. Investigate 3D printing industry careers and examine how those careers use this technology. DOK2

Unit 5: Coding

Competencies and Suggested Objectives
1. Examine the use of Booleans and conditionals. DOK3 a. Demonstrate proper use of *if*, *then*, and *else* statements. b. Demonstrate proper use of Boolean logic (e.g., true/false, on/off, etc.). c. Understand that all coding languages use common concepts, such as conditionals. d. Understand that conditionals are statements that are carried out when certain criteria are met. e. Evaluate a conditional statement and predict the outcome using the given input. f. Write conditional statements, defining criteria for when a program should take certain actions.
2. Apply the use of loops. DOK2 a. Understand the effective use of loops. b. Understand and predict the behavior of a loop. c. Write valid loops with proper indention. d. Describe and give an example of the conditional part of a loop. e. Explain the standard flowchart representation for loops.
3. Investigate the use of variables. DOK2 a. Identify a variable as a way to label and reference a value in a program. b. Use variables in a program to store a piece of information that is used multiple times. c. Correct common errors encountered when programming with variables.
4. Summarize the purpose of functions. DOK2 a. Explain the purpose of a function. b. Demonstrate the proper use of a function.
5. Demonstrate an understanding of debugging and identify syntax errors. DOK2
6. Investigate careers in software development and coding. DOK3

Unit 6: Introduction to Electronics

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using electronics and associated tools. DOK2
2. Identify, analyze, and create models to explore electronics and their applications. DOK3 a. Review the importance of electronics safety and the proper use of lab equipment. b. Communicate electrical terms and their units of measure using multiple formats (e.g., verbally, graphically, textually, etc.), including: • Alternating current • Direct current • Voltage • Amperage • Resistance c. Learn symbols for the following electronic components included on the Institute of Electronics and Electronics Engineers (IEEE) chart: • Resistor • Capacitor • Diode • Inductor • LED • Sensor (e.g., temperature and humidity, ultrasonic, photo resistor, etc.)
3. Create a physical or simulation model showing different configurations using the required components (e.g., battery, light-emitting diode [LED], light sensor, switch, etc.). DOK4
4. As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications. DOK 3 a. Collect, organize, and interpret data from the basic principles of energy through simulation or hands-on project to include: • Simple machines such as: o Wedge o Pulley o Inclined plane o Screw o Wheel and axle o Levers • Electrical energy • Kinetic energy ($KE=1/2mv^2$) • Potential energy (U=mgh) • Work • Work-energy theorem (W=KE) • Conservation of energy • Momentum (P=mv) • Conservation of momentum

5. Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology. DOK3

Unit 7: Introduction to Robotics & Microcontrollers

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using robots and microcontrollers. [DOK2]
2. Research current, past, and future applications of robots. [DOK2] a. Using scholarly articles or other reputable sources, research the types and applications of robots, including: • Current, past, and future applications of robots • Advantages and disadvantages of robots b. Communicate technical information found in research using multiple formats (e.g., verbally, graphically, textually, mathematically, etc.).
3. Design and build a simple, functional robotic system using the required components (e.g., motor, battery, wires, and body/case/chassis). [DOK4] a. On paper, virtually, or with hands-on components, design a robot with proper connections and functionality. b. Identify the components of a robotic system. c. Explain the purpose/function of each component.
4. Identify common microcontroller terms. [DOK1] a. Communicate microcontroller terms using multiple formats (e.g., verbally, textually, graphically). b. Identify and label the components of a hands-on or simulation microcontroller from the list below: • Power sources • Inputs • Switches • Push buttons • Sensors • Joysticks and remotes • Outputs • Buzzers • LEDs • LCD modules • Motors
5. Use programming to manipulate microcontroller inputs and outputs. [DOK2] a. Incorporate the following methods/concepts in the programming: • Different languages (e.g., Scratch, SNAP, Python, etc.) • Logic statements (e.g., *if*, *and*, *or*, *not*, etc.) • Loops (e.g., *for*, *if*, *while*, etc.)
6. Use a microcontroller for a specified purpose. [DOK2] a. Demonstrate the proper use of a microcontroller for a specified purpose. b. Explain how microcontrollers are used to manipulate a robotic system.
7. Investigate careers in robotics and examine industries that use robotics. [DOK2]

Student Competency Profile

Student's Name: ____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It should be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course. This document is required for each student and may be requested during an audit.

In the blank before each number, place the date on which the student mastered the competency.

Unit 1: Orientation, Safety, and Student Organizations		
	1.	Identify expectations, school policies, student organizations, and program policies related to this course.
	2.	Analyze general safety in the project-based learning classroom.
	3.	Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work.
	4.	Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies.
	5.	Demonstrate proper digital citizenship concepts (ongoing).
Unit 2: Project Design		
	1.	Analyze and become familiar with the basic tools and techniques to plan, organize, and manage a project.
	2.	Demonstrate knowledge and understanding of the NASA's BEST Engineering Design Process, or a similar design process (ongoing).
	3.	Establish essential elements of the course portfolio.
	4.	Synthesize research to understand project needs and limitations.
	5.	Assess client needs to understand the purposes of design.
	6.	Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.).
Unit 3: Exploring Newton's Laws		
	1	Demonstrate problem-solving and teamwork skills using the engineering design process by completing a complex challenge (Newton Project).
	2.	Apply appropriate physical and mathematical principles to Newton Project tasks (include in portfolio).
	3.	Engage with STEM industry and business professionals.
Unit 4: Introduction to Modeling and 3D Printing		
	1.	Review the importance of safety and the proper use of lab equipment when using 3D printers and associated supplies.
	2.	Demonstrate the use of computer-aided design (CAD) software to create 3D models.

	3.	Design a 3D model for rapid prototyping using a 3D printer.
	4.	Slice and 3D print an object created with CAD software.
	5.	Develop a cost analysis based on time and materials.
	6.	Investigate 3D printing industry careers and examine how those careers use this technology.
Unit 5: Coding		
	1.	Examine the use of Booleans and conditionals.
	2.	Apply the use of loops.
	3.	Investigate the use of variables.
	4.	Summarize the purpose of functions.
	5.	Demonstrate an understanding of debugging and identify syntax errors.
	6.	Investigate careers in software development and coding.
Unit 6: Introduction to Electronics		
	1.	Review the importance of safety and the proper use of lab equipment when using electronics and associated tools.
	2.	Identify, analyze, and create models to explore electronics and their applications.
	3.	Create a physical or simulation model showing different configurations using the required components.
	4.	As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications.
	5.	Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology.
Unit 7: Introduction to Robotics & Microcontrollers		
	1.	Review the importance of safety and the proper use of lab equipment when using robots and microcontrollers.
	2.	Research current, past, and future applications of robots.
	3.	Design and build a simple, functional robotic system using the required components.
	4.	Identify common microcontroller terms.
	5.	Use programming to manipulate microcontroller inputs and outputs.
	6.	Use a microcontroller for a specified purpose.
	7.	Investigate careers in robotics and examine industries that use robotics.

Appendix A: ISTE National Educational Technology Standards for Students (NETS-S)

	Unit	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Standards								
T1			X	X	X	X	X	X
T2		X	X	X	X	X	X	X
T3			X		X	X	X	X
T4			X	X	X	X	X	X
T5		X	X		X	X	X	X
T6		X	X		X	X	X	X

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

a. Apply existing knowledge to generate new ideas, products, or processes.
b. Create original works as a means of personal or group expression.
c. Use models and simulations to explore complex systems and issues.
d. Identify trends and forecast possibilities.

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

a. Plan strategies to guide inquiry.
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

a. Identify and define authentic problems and significant questions for investigation.
b. Plan and manage activities to develop a solution or complete a project.
c. Collect and analyze data to identify solutions and/or make informed decisions.
d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

a. Advocate and practice safe, legal, and responsible use of information and technology.
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. Demonstrate personal responsibility for lifelong learning.
d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

a. Understand and use technology systems.
b. Select and use applications effectively and productively.
c. Troubleshoot systems and applications.
d. Transfer current knowledge to learning of new technologies.

Appendix B: National Association of Educational Progress (NAEP) Technology and Engineering Literacy Framework

NAEP Standard	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
T.8.1							X
T.8.2							X
T.8.3							X
T.8.4							X
T.8.5							X
T.8.6							X
T.8.7							X
T.8.8		X					
T.8.9							X
T.8.10							X
T.8.11		X			X	X	X
T.8.12		X		X	X	X	X
T.8.13		X					
T.8.14		X					
T.8.15	X						
T.12.3			X				
D.8.1		X					
D.8.2		X					
D.8.3		X					X
D.8.4		X					
D.8.5		X					
D.8.6		X					
D.8.7		X		X		X	X
D.8.8		X					
D.8.9		X		X			
D.8.10		X					
D.8.11						X	X
D.8.12						X	X
D.8.13		X				X	X
D.8.14						X	X
D.8.15						X	X
D.8.16						X	
D.8.17		X				X	
D.8.18						X	
D.8.19		X					
D.12.4			X				
D.12.6			X				
D.12.7			X				
D.12.8			X				
D.12.9			X				
D.12.10			X				
D.12.11			X				
D.12.13			X				
D.12.14			X				
D.12.15			X				
D.12.17			X				
I.8.1	X	X		X	X	X	X
I.8.2		X		X	X	X	X
I.8.3		X		X	X	X	X
I.8.4	X						

I.8.5		X				X	X
I.8.6							
I.8.7		X					
I.8.8							
I.8.9						X	
I.8.10	X				X		
I.8.11	X						
I.8.12	X	X					
I.8.13		X		X	X	X	X
I.12.1			X				
I.12.2			X				
I.12.3			X				
I.12.4			X				
I.12.5			X				
I.12.6			X				
I.12.8			X				

NAEP Technology and Engineering Literacy Framework

Students know that:
T.8.1: Economic, political, social, and cultural aspects of society drive improvements in technological products, processes, and systems.
T.8.2: Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.

Students are able to:
T.8.3: Describe and analyze positive and negative impacts on society from the introduction of a new or improved technology, including both expected and unanticipated effects.
T.8.4: Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.

Students know that:
T.8.5: Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.
T.8.6: Resources such as oceans, fresh water, and air—which are essential for life and shared by everyone—are protected by regulating technologies in such areas as transportation, energy, and waste disposal.

Students are able to:
T.8.7: Compare the environmental effects of two alternative technologies devised to solve the same problem or accomplish the same goal and justify which choice is best, taking into account environmental impacts as well as other relevant factors.

Students know that:
T.8.8: Information technologies are developing rapidly so that the amount of data that can be stored and made widely accessible is growing at a faster rate each year.
T.8.9: Information technologies make it possible to analyze and interpret data—including text, images, and sound—in ways that are not possible with human senses alone. These uses may result in positive or negative impacts.
T.8.10: The large range of personal and professional information technologies and communication devices allows for remote collaboration and rapid sharing of ideas unrestricted by geographic location.

Students are able to:
T.8.11: Use appropriate information and communication technologies to collaborate with others on the creation and modification of a knowledge product that can be accessed and used by other people.

Students know that:
T.8.12: Technology by itself is neither good nor bad, but its use may affect others; therefore, decisions about products, processes, and systems must take possible consequences into account.
T.8.13: People who live in different parts of the world have different technological choices and opportunities because of such factors as differences in economic resources, location, and cultural values.

Students are able to:
T.8.14: Explain that it is important for citizens to reduce the negative impacts and increase the positive impacts of their technologies on people in another area or on future generations.
T.8.15: Explain why it is unethical to infect or damage other people's computers with viruses or "hack" into other computer systems to gather or change information.

Students are able to:
T.12.3: Choose an appropriate technology to help solve a given societal problem, and justify the selection based on an analysis of criteria and constraints, available resources, likely trade-offs, and relevant environmental and cultural concerns.

Students know that:
D.8.1: Science is the systematic investigation of the natural world. Technology is any modification of the environment to satisfy people's needs and wants. Engineering is the process of creating or modifying technologies and is constrained by physical laws and cultural norms, and economic resources.
D.8.2: Technology advances through the processes of innovation and invention. Sometimes a technology developed for one purpose is adapted to serve other purposes.
D.8.3: Tools have been improved over time to do more difficult tasks and to do simple tasks more efficiently, accurately, or safely. Tools further the reach of hands, voices, memory, and the five human senses.

Students are able to:
D.8.4: Simulate tests of various materials to determine which would be best to use for a given application.
D.8.5: Redesign an existing tool to make it easier to accomplish a task.

Students know that:
D.8.6: Engineering design is a systematic, creative, and iterative process for meeting human needs and wants. It includes stating the challenge, generating ideas, choosing the best solution, making and testing models and prototypes, and redesigning. Often there are several possible solutions.
D.8.7: Requirements for a design are made up of the criteria for success and the constraints, or limits, which may include time, money, and materials. Designing often involves making tradeoffs between competing requirements and desired design features.

Students are able to:
D.8.8: Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions.
D.8.9: Construct and test a model and gather data to see if it meets the requirements of a problem.
D.8.10: Communicate the results of a design process and articulate the reasoning behind design decisions by using verbal and visual means. Identify the benefits of a design as well as the possible unintended consequences.

Students know that:
D.8.11: Technological systems are designed to achieve goals. They incorporate various processes that transform inputs into outputs. They all use energy in some form. These processes may include feedback and control.
D.8.12: Technological systems can interact with one another to perform more complicated functions and tasks than any individual system can do by itself.

Students are able to:
D.8.13: Examine a product or process through reverse engineering by taking it apart step by step to identify its systems, subsystems, and components, describing their interactions, and tracing the flow of energy through the system.
D.8.14: Measure and compare the production efficiency of two machines, a simple machine and a complex machine, designed to accomplish the same goal.
D.8.15: Construct and use a moderately complicated system, given a goal for the system and a collection of parts, including those that may or may not be useful in the system.

Students know that:
D.8.16: Many different kinds of products must undergo regular maintenance, including lubrication and replacement of parts before they fail so as to ensure proper functioning.

Students are able to:
D.8.17: Diagnose a problem in a technological device using a logical process of troubleshooting. Develop and test various ideas for fixing it.
D.8.18: Modify a moderately complicated system so that it is less likely to fail. Predict the extent to which these modifications will affect the productivity of the system.
D.8.19: Trace the life cycle of a repairable product from inception to disposal or recycling in order to determine the product's environmental impact.
Students are able to:
D.12.4: Take into account trade-offs among several factors when selecting a material for a given application.

Students know that:
D.12.6: Engineering design is a complicated process in which creative steps are embedded in content knowledge and research on the challenge. Decisions on trade-offs involve systematic comparisons of all costs and benefits, and final steps may involve redesigning for optimization.
D.12.7: Specifications involve criteria, which may be weighted in various ways, and constraints, which can include natural laws and available technologies. Evaluation is a process for determining how well a solution meets the requirements.

Students are able to:
D.12.8: Meet a sophisticated design challenge by identifying criteria and constraints, predicting how these will affect the solution, researching and generating ideas, and using trade-offs to balance competing values in selecting the best solution.
D.12.9: Construct and test several models to see if they meet the requirements of a problem. Combine features to achieve the best solution.
D.12.10: Communicate the entire design process from problem definition to evaluation of the final design, taking into account relevant criteria and constraints, including aesthetic and ethical considerations as well as purely logical decisions.

Students know that:
D.12.11: The stability of a system depends on all of its components and how they are connected, with more complicated systems tending to require more energy and to be more vulnerable to error and failure. Negative feedback loops tend to increase the stability and efficiency of systems.

Students are able to:
D.12.13: Examine a system to predict how it will perform with a given set of inputs in each situation and how performance will change if the components or interactions of the system are changed.
D.12.14: Redesign a complex machine by modifying or rearranging its subsystems to optimize its efficiency.
D.12.15: Construct and test a manufacturing system composed of several machines to accomplish a given goal. Redesign the system to optimize its efficiency.

Students are able to:
D.12.17: Analyze a system malfunction using logical reasoning (such as a fault tree) and appropriate diagnostic tools and instruments. Devise strategies and recommend tools for fixing the problem.

Students know that:
I.8.1: Collaboration can take many forms. Pairs or teams of people can work together in the same space or at a distance, at the same time or at different times, and on creative projects or on technical tasks. Different communications technologies are used to support these different forms of collaboration.

Students are able to:
I.8.2: Provide feedback to a (virtual) collaborator on a product or presentation, taking into account the other person's goals and using constructive, rather than negative, criticism.
I.8.3: Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences.

Students know that:
I.8.4: Increases in the quantity of information available through electronic means and the ease by which knowledge can be published have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.

Students are able to:
I.8.5: Select and use appropriate digital and network tools and media resources to collect, organize, analyze, and display supporting data to answer questions and test hypotheses.
I.8.6: Search media and digital resources on a community or world issue and identify specific examples of distortion, exaggeration, or misrepresentation of information.

Students are able to:
I.8.7: Use digital tools to identify a global issue and investigate possible solutions. Select and present the most promising sustainable solution.
I.8.8: Use digital tools to gather and display data in order to test hypotheses of moderate complexity in various subject areas. Draw and report conclusions consistent with observations.
I.8.9: Use a digital model of a system to conduct a simulation. Explain how changes in the model result in different outcomes.

Students know that:
I.8.10: Style guides provide detailed examples for how to give appropriate credit to others when incorporating their ideas, text, or images in one's own work.

Students are able to:
I.8.11: Identify or provide examples of fair use practices that apply appropriate citation of sources when using information from books or digital resources.

Students know that:
I.8.12: Certain digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other kinds of tools are appropriate for creating text, visualizations, and models and for communicating with others.

Students are able to:
I.8.13: Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others.

Students know that:
I.12.1: Effective collaboration requires careful selection of team members, monitoring of progress, strategies for reaching agreement when there are opposing points of view, and iterative improvement of collaborative processes. Information and communication technologies can be used to record and share different viewpoints and to collect and tabulate the views of groups of people.

Students are able to:
I.12.2: Work through a simulation of a collaborative process. Negotiate team roles and resources, draw upon the expertise and strengths of other team members and remote experts, monitor progress toward goals, and reflect on and refine team processes for achieving goals.
I.12.3: Synthesize input from multiple sources to communicate ideas to a variety of audiences using various media, genres, and formats.

Students know that:
I.12.4: Advanced search techniques can be used with digital and network tools and media resources to locate information and to check the credibility and expertise of sources.

Students are able to:
I.12.5: Select digital and network tools and media resources to gather information and data on a practical task, and justify choices based on the tools' efficiency and effectiveness for a given purpose.
I.12.6: Search media and digital resources on a community or world issue and evaluate the timeliness and accuracy of the information as well as the credibility of the source.

Students are able to:
I.12.8: Use digital tools to collect, analyze, and display data in order to design and conduct complicated investigations in various subject areas. Explain rationale for the design and justify conclusions based on observed patterns in the data.

Appendix C: 2018 MS CCR Standards for Computer Science

	Units	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Standards								
CS.2.1								X
CS.2.2			X					
CS.2.3			X					
NI.2.1								
NI.2.2		X						
NI.2.3						X		
DA.2.1			X					
DA.2.2			X					
DA.2.3			X					
AP.2.1			X					
AP.2.2						X		X
AP.2.3						X		X
AP.2.4			X		X	X	X	X
AP.2.5						X		X
AP.2.6			X		X	X	X	X
AP.2.7			X		X	X	X	X
AP.2.8					X	X	X	X
AP.2.9			X		X	X	X	X
AP.2.10						X		X
IC.2.1		X						
IC.2.2					X	X	X	X
IC.2.3						X		X
IC.2.4		X				X		

Level 2: GRADES 6-8 - Computing Systems (CS.2)

Conceptual understanding: People interact with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) that make up a computing system communicate and process information in digital form. An understanding of hardware and software is useful when troubleshooting a computing system that does not work as intended.

CS.2.1 **Recommend improvements to the design of computing devices based on an analysis of how users interact with the devices. [DEVICES] (P3.3)**
The study of human-computer interaction (HCI) can improve the design of devices, including both hardware and software.

CS.2.1a **Students should make recommendations for existing devices (e.g., a laptop, phone, or tablet) or design their own components or interface (e.g., create their own controllers).** Teachers can guide students to consider usability through several lenses, including accessibility, ergonomics, and learnability. For example, assistive devices provide capabilities such as scanning written information and converting it to speech.

CS.2.2 **Design projects that combine hardware and software components to collect and exchange data. [HARDWARE & SOFTWARE] (P5.1)**
Collecting and exchanging data involves input, output, storage, and processing. When possible, students should select the hardware and software components for their project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics.

CS.2.2a **Students will design projects that use both hardware and software to collect and exchange data.** For example, components for a mobile app could include accelerometer, GPS, and speech recognition. The choice of a device that connects wirelessly through a Bluetooth connection versus a physical USB connection involves a tradeoff between mobility and the need for an additional power source for the wireless device.

CS.2.3 Systematically identify and fix problems with computing devices and their components. [TROUBLESHOOTING] (P6.2)

Since a computing device may interact with interconnected devices within a system, problems may not be due to the specific computing device itself but to devices connected to it.

CS.2.3a **Students will use a structured process to troubleshoot problems with computing systems and ensure that potential solutions are not overlooked.** Examples of troubleshooting strategies include following a troubleshooting flow diagram, making changes to software to see if hardware will work, checking connections and settings, and swapping in working components.

Level 2: GRADES 6-8 - Networks and the Internet (NI.2)

Conceptual Understanding: Computing devices typically do not operate in isolation. Networks connect computing devices to share information and resources and are an increasingly integral part of computing. Networks and communication systems provide greater connectivity in the computing world by providing fast, secure communication and facilitating innovation.

NI.2.1 Model the role of protocols in transmitting data across networks and the Internet. [NETWORK COMMUNICATION & ORGANIZATION] (P4.4)

Protocols are rules that define how messages between computers are sent. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to handle errors in transmission.

NI.2.1a **Students should model how data is sent using protocols to choose the fastest path, to deal with missing information, and to deliver sensitive data securely.** For example, students could devise a plan for resending lost information or for interpreting a picture that has missing pieces. The priority at this grade level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected.

NI.2.2 Explain how physical and digital security measures protect electronic information. [CYBERSECURITY] (P7.2)

Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. Examples of digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol, such as HTTPS, to ensure secure data transmission.

NI.2.2a **Students will explain how physical and digital security measures protect electronic information.**

NI.2.3 Apply multiple methods of encryption to model the secure transmission of information. [CYBERSECURITY] (P4.4)

Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet.

NI.2.3a **Students should encode and decode messages using a variety of encryption methods, and they should understand the different levels of complexity used to hide or secure information.** For example, students could secure messages using methods like Caesar cyphers or steganography (i.e., hiding messages inside a picture or other data). They can also model more complicated methods, such as public key encryption, through unplugged activities.

Level 2: GRADES 6-8 - Data and Analysis (DA.2)

Conceptual Understanding: Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

DA.2.1 **Represent data using multiple encoding schemes. [STORAGE] (P4.0)**

Data representations occur at multiple levels of abstraction, from the physical storage of bits to the arrangement of information into organized formats (e.g., tables).

DA.2.1a **Students should represent the same data in multiple ways.** For example, students could represent the same color using binary, RGB values, hex codes (low-level representations), as well as forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).

DA.2.2 **Collect data using computational tools and transform the data to make it more useful and reliable. [COLLECTION, VISUALIZATION, & TRANSFORMATION] (P6.3)**

As students continue to build on their ability to organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose.

DA.2.2a **Students should transform data to remove errors, highlight or expose relationships, and/or make it easier for computers to process.** The cleaning of data is an important transformation for ensuring consistent format and reducing noise and errors (e.g., removing irrelevant responses in a survey). An example of a transformation that highlights a relationship is representing males and females as percentages of a whole instead of as individual counts.

DA.2.3 **Refine computational models based on the data they have generated. [INFERENCE & MODELS] (P5.3, P4.4)**

A model may be a programmed simulation of events or a representation of how various data is related.

DA.2.3a **Students will refine computational models by considering which data points are relevant, how data points relate to each other, and if the data is accurate.** For example, students may make a prediction about how far a ball will travel based on a table of data related to the height and angle of a track. The students could then test and refine their model by comparing predicted versus actual results and considering whether other factors are relevant (e.g., size and mass of the ball). Additionally, students could refine game mechanics based on test outcomes in order to make the game more balanced or fair.

Level 2: GRADES 6-8 - Algorithms and Programming (AP.2)

Conceptual understanding: An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems. The development process to create meaningful and efficient programs involves choosing which information to use and how to process and store it, breaking apart large problems into smaller ones, recombining existing solutions, and analyzing different solutions.

AP.2.1 **Use flowcharts and/or pseudocode to address complex problems as algorithms. [ALGORITHMS] (P4.4, P4.1)**

Complex problems are problems that would be difficult for students to solve computationally.

AP.2.1a **Students will use pseudocode and/or flowcharts to organize and sequence an algorithm that addresses a complex problem, even though they may not actually program the solutions.** For example, students might express an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost. Testing the algorithm with a wide range of inputs and users allows students to refine their recommendation algorithm and to identify other inputs they may have initially excluded.

AP.2.2 **Create clearly named variables that represent different data types and perform operations on their values. [VARIABLES] (P5.1, P5.2)**

A variable is like a container with a name, in which the contents may change, but the name (identifier) does not.

AP.2.2a **When planning and developing programs, students should decide when and how to declare and name new variables.** Examples of operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.

AP.2.2b **Students should use naming conventions to improve program readability.**

AP.2.3 **Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals. [CONTROL] (P5.1, P5.2)**

Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another.

AP.2.3a **Students will design and develop programs that combine control structures.** For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.

AP.2.4 **Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. [MODULARITY] (P3.2)**

Decomposition facilitates aspects of program development by allowing students to focus on one piece at a time (e.g., getting input from the user, processing the data, and displaying the result to the user). Decomposition also enables different students to work on different parts at the same time.

AP.2.4a **Students should break down problems into subproblems, which can be further broken down to smaller parts.** For example, animations can be decomposed into multiple scenes, which can be developed independently.

AP.2.5 **Create procedures with parameters to organize code and make it easier to reuse. [MODULARITY] (P4.1, P4.3)**

AP.2.5a **Students will create procedures and/or functions that are used multiple times within a program to repeat groups of instructions.** These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as “drawCircle.” By adding a radius parameter, the user can easily draw circles of different sizes.

AP.2.6 **Seek and incorporate feedback from team members and users to refine a solution that meets user needs. [PROGRAM DEVELOPMENT] (P2.3, P1.1)**

Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language.

AP.2.6a **Students should begin to seek diverse perspectives throughout the design process to improve their computational artifacts.** Considerations of the end user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.

AP.2.7 **Incorporate existing code, media, and libraries into original programs and give attribution. [PROGRAM DEVELOPMENT] (P4.2, P5.2, P7.3)**

Building on the work of others enables students to produce more interesting and powerful creations.

AP.2.7a **Students should use portions of code, algorithms, and/or digital media in their own programs and websites.** At this level, they may also import libraries and connect to web application program interfaces (APIs). For example, when creating a side-scrolling games, students may incorporate portions of code that create a realistic jump movement from another person’s game, and they may also import Creative Commons-lessened images to use in the background.

AP.2.7b **Students should give attribution to the original creator’s contributions.**

AP.2.8 **Systematically test and refine programs using a range of test cases. [PROGRAM DEVELOPMENT] (P6.1)**

Test cases are created and analyzed to better meet the needs of users and to evaluate whether programs function as intended. At this level, testing should become a deliberate process that is more iterative, systematic, and proactive than at lower levels.

AP.2.8a **Students will test programs by considering potential errors, such as what will happen if a user enters invalid input (e.g., negative numbers and zero instead of positive numbers).**

AP.2.9 **Distribute tasks and maintain a project timeline when collaboratively developing computational artifacts. [PROGRAM DEVELOPMENT] (P2.2)**

Collaboration is a common and crucial practice in programming development. Often, many individuals and groups work on the interdependent parts of a project together.

AP.2.9a **Students will work collaboratively in groups.**

AP.2.9b **Students should assume predefined roles within their teams and manage the project workflow using structured timelines.** With teacher guidance, they will begin to create collective goals, expectations, and equitable workloads. For example, students may divide the design stage of a game into planning the storyboard, flowchart, and different parts of the game mechanics. They can then distribute tasks and roles among members of the team and assign deadlines.

AP.2.9c **Students should give attribution to the original creators to acknowledge their contributions.**

AP.2.10 **Document programs in order to make them easier to follow, test, and debug. [PROGRAM DEVELOPMENT] (P7.2)**

Documentation allows creators and others to more easily use and understand a program.

AP.2.10a **Students should provide documentation for end users that explains their artifacts and how they function.** For example, students could provide a project overview and clear user instructions.

AP.2.10b **Students should incorporate comments in their product (comments in the code).**

AP.2.10c **Students should communicate their process using design documents, flowcharts, and presentations.**

Level 2: GRADES 6-8 - Impacts of Computing (IC.2)

Conceptual understanding: Computing affects many aspects of the world in both positive and negative ways at local, national, and global levels. Individuals and communities influence computing through their behaviors and cultural and social interactions, and in turn, computing influences new cultural practices. An informed and responsible person should understand the social implications of the digital world, including equity and access to computing.

IC.2.1 **Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options. [CULTURE] (P7.2)**

Advancements in computer technology are neither wholly positive nor negative; however, the ways that people use computing technologies have tradeoffs.

IC.2.1a **Students should consider current events related to broad ideas, including privacy, communication, and automation.** For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will not only reduce the number of taxi and shared-ride drivers but also create more software engineering and cybersecurity jobs.

IC.2.2 **Discuss issues of bias and accessibility in the design of existing technologies. [CULTURE] (P1.2)**

IC.2.2a **Students should test and discuss the usability of various technology tools (e.g., apps, games, and devices) with the teacher's guidance.** For example, facial recognition software that works better for lighter skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population. When discussing accessibility, students may notice that allowing a user to change font sizes and colors will not only make an interface usable for people with low vision but also benefits users in various situations, such as in bright daylight or a dark room.

IC.2.3 **Collaborate with many contributors through strategies such as crowdsourcing or surveys when creating a computational artifact. [SOCIAL INTERACTIONS] (P2.4, P5.2)**

Crowdsourcing is gathering services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities, like Scratch and Minecraft).

IC.2.3a **Students should collaborate with many contributors.** For example, a group of students could combine animations to create a digital community mosaic. They could also solicit feedback from many people though use of online communities and electronic surveys.

IC.2.4 **Describe tradeoffs between allowing information to be public and keeping information private and secure. [SAFETY, LAW, & ETHICS] (P7.2)**

Sharing information online can help establish, maintain, and strengthen connections between people. For example, it allows artists and designers to display their talents and reach a broad audience; however, security attacks often start with personal information that is publicly available online. Social engineering is based on tricking people into revealing sensitive information and can be thwarted by being wary of attacks, such as phishing and spoofing.

IC.2.4a **Students should discuss and describe the benefits and dangers of allowing information to be public or kept private and secure.**