SRI Education

Deepening Learning in High School Computer Science through Practices in the NGSS

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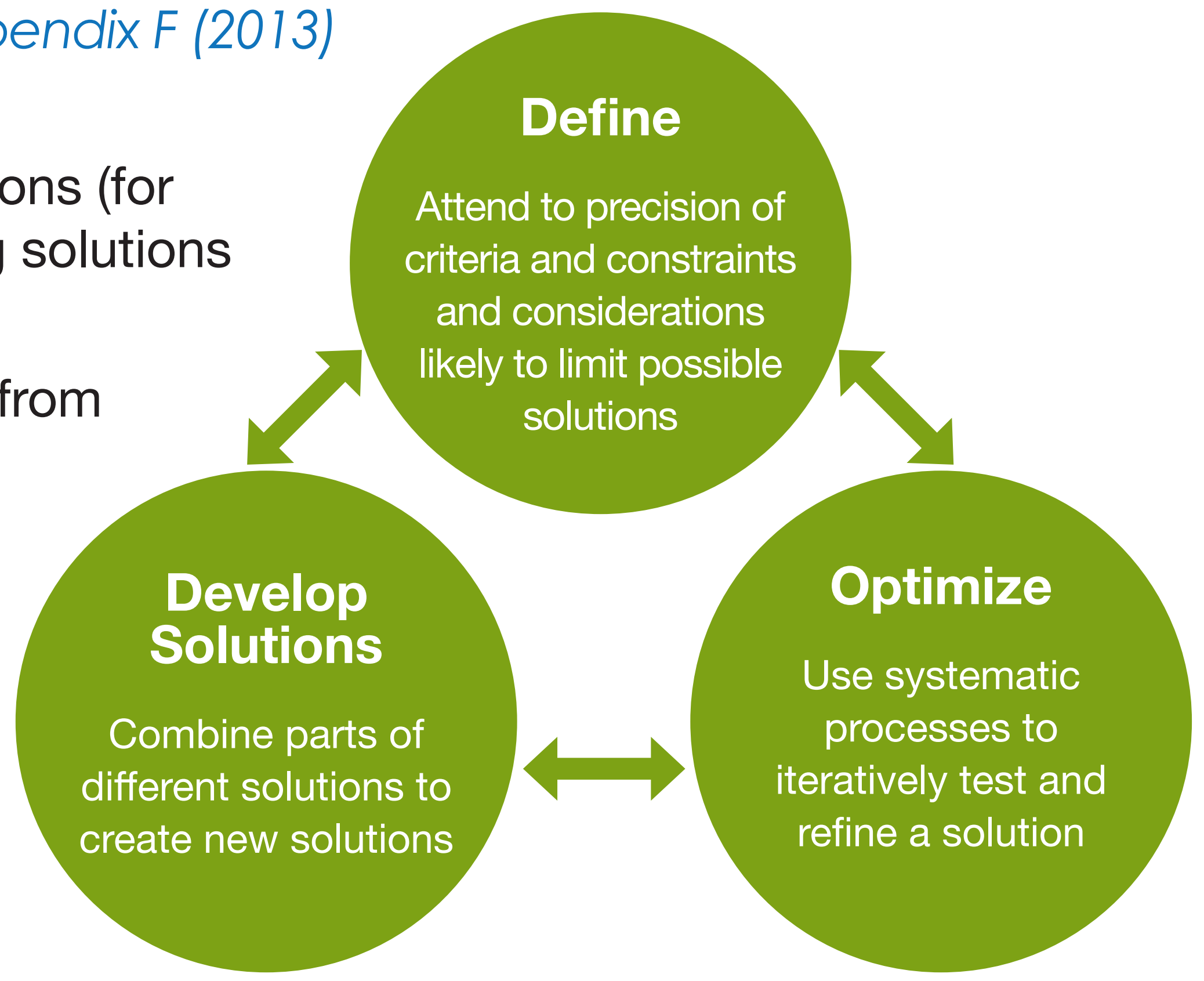
NGSS Science and Engineering Condensed Practices

Adapted from the NRC Framework (2012) and the NGSS Appendix F (2013)

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information



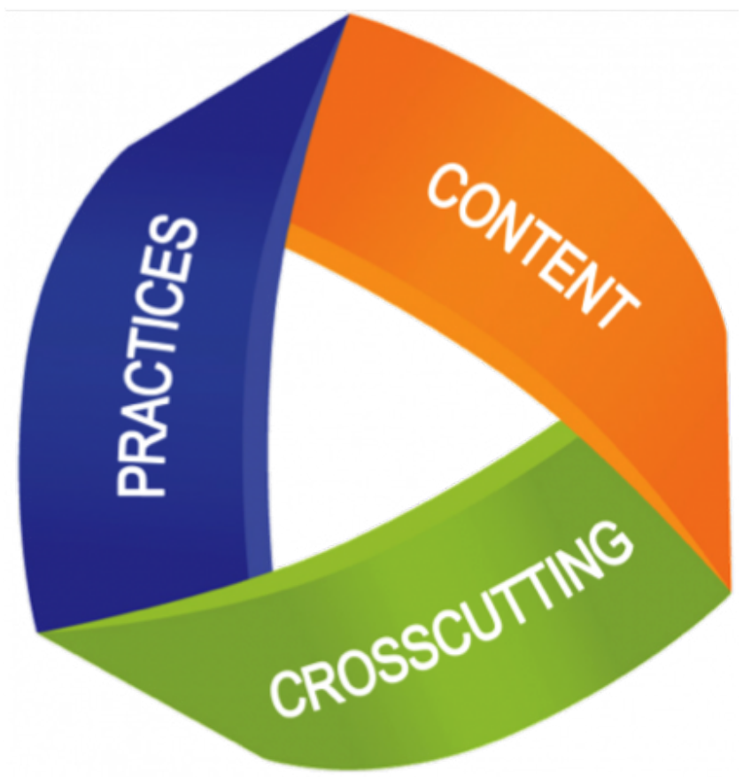
Define
Attend to precision of criteria and constraints and considerations likely to limit possible solutions

Develop Solutions
Combine parts of different solutions to create new solutions

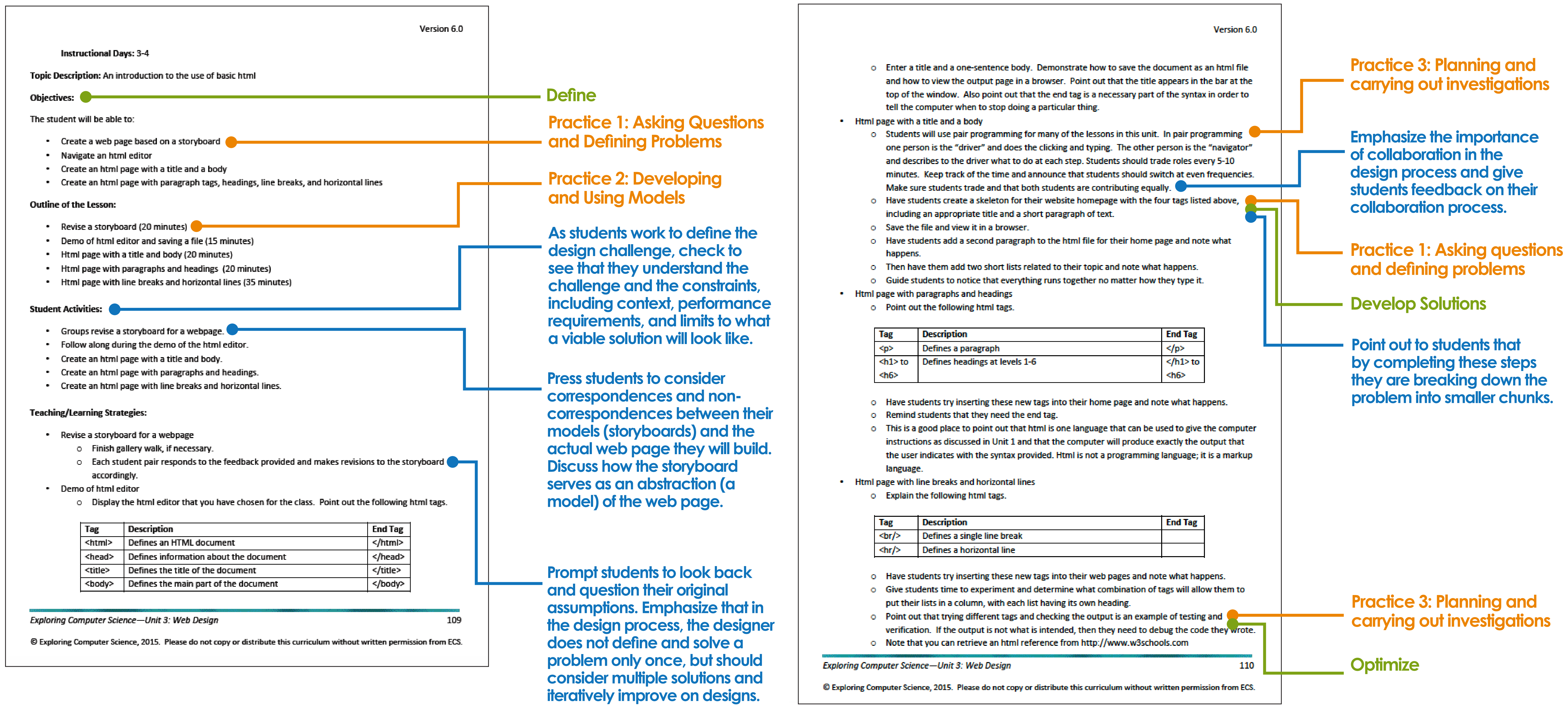
Optimize
Use systematic processes to iteratively test and refine a solution

Data Sources

- Exploring Computer Science, Versions 5 & 6
- Computational Thinking Practices: CS Principles and pact.sri.com/resources.html
- National Research Council, 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.
- Next Generation Science Standards (NGSS) released 2013.
  - Appendix F: Science and Engineering Practices in the NGSS
  - Appendix I: Engineering Design in the NGSS



ECS Sample Lesson Annotation



Version 6.0

Instructional Days: 3-4

Topic Description: An introduction to the use of basic html

Objectives:

The student will be able to:

- Create a web page based on a storyboard
- Navigate an html editor
- Create an html page with a title and a body
- Create an html page with paragraph tags, headings, line breaks, and horizontal lines

Outline of the Lesson:

- Revise a storyboard (20 minutes)
- Demo of html editor and saving a file (15 minutes)
- Html page with a title and body (20 minutes)
- Html page with paragraphs and headings (20 minutes)
- Html page with line breaks and horizontal lines (35 minutes)

Student Activities:

- Groups revise a storyboard for a webpage.
- Follow along during the demo of the html editor.
- Create an html page with a title and body.
- Create an html page with paragraphs and headings.
- Create an html page with line breaks and horizontal lines.

Teaching/Learning Strategies:

- Revise a storyboard for a webpage
  - Finish gallery walk, if necessary.
  - Each student pair responds to the feedback provided and makes revisions to the storyboard accordingly.
- Demo of html editor
  - Display the html editor that you have chosen for the class. Point out the following html tags.

Tag	Description	End Tag
<html>	Defines an HTML document	</html>
<head>	Defines information about the document	</head>
<title>	Defines the title of the document	</title>
<body>	Defines the main part of the document	</body>

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Define

Practice 1: Asking Questions and Defining Problems

Practice 2: Developing and Using Models

As students work to define the design challenge, check to see that they understand the challenge and the constraints, including context, performance requirements, and limits to what a viable solution will look like.

Press students to consider correspondences and non-correspondences between their models (storyboards) and the actual web page they will build. Discuss how the storyboard serves as an abstraction (a model) of the web page.

Prompt students to look back and question their original assumptions. Emphasize that in the design process, the designer does not define and solve a problem only once, but should consider multiple solutions and iteratively improve on designs.

Version 6.0

- Enter a title and a one-sentence body. Demonstrate how to save the document as an html file and how to view the output page in a browser. Point out that the title appears in the bar at the top of the window. Also point out that the end tag is a necessary part of the syntax in order to tell the computer when to stop doing a particular thing.
- Html page with a title and a body
  - Students will use pair programming for many of the lessons in this unit. In pair programming one person is the "driver" and does the clicking and typing. The other person is the "navigator" and describes to the driver what to do at each step. Students should trade roles every 5-10 minutes. Keep track of the time and announce that students should switch at even frequencies. Make sure students trade and that both students are contributing equally.
  - Have students create a skeleton for their website homepage with the four tags listed above, including an appropriate title and a short paragraph of text.
  - Save the file and view it in a browser.
  - Have students add a second paragraph to the html file for their home page and note what happens.
  - Then have them add two short lists related to their topic and note what happens.
  - Guide students to notice that everything runs together no matter how they type it.
- Html page with paragraphs and headings
  - Point out the following html tags.

Tag	Description	End Tag
<p>	Defines a paragraph	</p>
<h1> to <h6>	Defines headings at levels 1-6	</h1> to <h6>

  - Have students try inserting these new tags into their home page and note what happens.
  - Remind students that they need the end tag.
  - This is a good place to point out that html is one language that can be used to give the computer instructions as discussed in Unit 1 and that the computer will produce exactly the output that the user indicates with the syntax provided. Html is not a programming language; it is a markup language.
- Html page with line breaks and horizontal lines
  - Explain the following html tags.

Tag	Description	End Tag
<br/>	Defines a single line break	
<hr/>	Defines a horizontal line	

  - Have students try inserting these new tags into their web pages and note what happens.
  - Give students time to experiment and determine what combination of tags will allow them to put their lists in a column, with each list having its own heading.
  - Point out that trying different tags and checking the output is an example of testing and verification. If the output is not what is intended, then they need to debug the code they wrote.
  - Note that you can retrieve an html reference from http://www.w3schools.com

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Practice 3: Planning and carrying out investigations

Emphasize the importance of collaboration in the design process and give students feedback on their collaboration process.

Practice 1: Asking questions and defining problems

Develop Solutions

Point out to students that by completing these steps they are breaking down the problem into smaller chunks.

Practice 3: Planning and carrying out investigations

Optimize

Findings

Representative engineering practices mapped to ECS learning objectives

NGSS Practice and ECS Objective	Teaching Notes
Practice 1: Asking Questions and Defining Problems	
• Evaluate a question to determine if it is testable and relevant.	1. Conducting Internet searches requires evaluating and framing questions so they can be used as search terms. 2. Questions are evaluated to determine if they can be answered using computation
• Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design	3. Evaluating the results of web searches and the reliability of information requires students to challenge the data returned by the search or presented on the website
Practice 2: Developing and Using Models	
• Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or the design criteria.	4. Students construct models of computing hardware and evaluate the merits and limitations to find one that best fits the design criteria
Practice 3: Planning and Carrying Out Investigations	
• Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.	5. Students plan and test Internet searches and consider the results as solutions to problems (information retrieval). Students consider the quality of the result returns including variables that influence search results.
• Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.	6. Students are aware of safe Internet searches and demonstrate responsible use of the Internet.
• Select appropriate tools to collect, record, analyze and evaluate data.	7. If students use various methods to find information, this practice could apply.
Practice 4: Analyzing and Interpreting Data	
• Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	8. Understanding communication as data exchange involves analysis of the communication to model what types of information are exchanged as data. Determining what data to exchange to achieve a desired result involves optimizing a design solution
Practice 5: Using Mathematics and Computational Thinking	
• Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.	9. Understanding how computers process instructions and data (e.g., "making a sandwich") involves creating computational models or simulations.
• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	10. Explore how computers are used as a tool for visualizing data, modeling and design, and art in the context of culturally situated design tools
Practice 6: Constructing Explanations and Designing Solutions	
• Construct and revise an explanation based on evidence obtained from a variety of sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	11. In discussing and considering the concept of machine intelligence and machines that learn, construct and revise explanations using evidence.
Practice 7: Engaging in Argument from Evidence	
• Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.	12. Evaluate different design solutions: Internet searches, data visualization, etc.
• Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	13. Evaluate the reliability of Internet sources of information.
• Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.	14. Construct arguments for and against the idea of intelligent machines; create arguments based on evidence from Internet searches and webpages.
Practice 8: Obtaining, Evaluating, and Communicating Information	
• Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.	15. Possibly covered if the Internet search topics are scientific and/or technical.
• Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.	16. Evaluate different webpages for reliability of information.
• Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).	17. Present different depictions of information and describe how designs were created in the design tools activity.
Science, Technology, Society and the Environment: 2. Influence of Engineering, Technology, and Science on Society and the Natural World (9-12 Connection Statements)	
• New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of cost and benefits is a critical aspect of decisions about technology.	18. Considerations of the impact of pervasive networked communication mechanisms, including privacy concerns.

This material is based upon work supported by the National Science Foundation under Grant DRL-1418149. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Principled Assessment of Computational Thinking