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As science education continues to evolve and improve, students' understanding of core disciplinary

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Appendices

Appendix A

- Successes and failures are reflections of my aptitude
- Intelligence and ability are static characteristics

- I do not take part in activities that do not come easily to me
- If I have difficulty completing a task it is because I lack ability in that area

- Challenging tasks cause me to grow frustrated and give up
- I become defensive when given negative feedback
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Appendix B

Socks are something most people use on their feet, fulfilling the needs for warmth, protection, or even fashion. However, a sock can also be used to solve other problems or satisfy different needs and wants—especially if you found yourself in a jam with limited resources. How many other uses for a sock can you think of? Start by thinking about the form, function, and composition of an ordinary pair of socks. Consider how those attributes may be valuable or serve an alternative function/purpose. List your answers below or on an extra piece of paper.

Cars are used to transport people and goods from one place to another. While cars come in many different colors, the colors we use on vehicles can change depending on what is being transported! Could you imagine a world where you didn't have a choice? What if we painted every vehicle on the roads with the same color yellow? How would it affect society? List as many potential outcomes as you can for each category (use more paper if needed):

(negative outcomes)	(negative outcomes)

Modeling is a labor-intensive process that requires attention to detail and a willingness to make adjustments and respond positively to failure. Failure is built into the modeling process, so focusing on this practice can help students grow accustomed to approaching their work with a growth mindset. In fact, failure is a very important part of the modeling process, because failures that occur in a model can be prevented when the stakes are much higher. It is certainly preferable to discover a structural flaw in a model bridge than in a real one!

[illegible]

Students should be encouraged to carry out investigations at every level of their K–12 education. Ideally, these investigations will range from those suggested by a teacher to those that arise from the student's own questions (NRC Framework, 2012, p. 61).

Investigations should have a clear purpose and utilize methodology that generates data to support or cast doubt upon a predicted outcome. In teaching students to plan and carry out investigations, there should be an expectation that their methods will become more systematic and specific over time, whether the tools and subject of their investigation is in the field or the laboratory.

It is important to note that the eight engineering practices are complementary and overlapping. For example, the process of planning and carrying out an investigation will necessarily require the students to ask questions, develop models, and obtain and evaluate data.

[illegible]

The analysis and interpretation of data is a fundamental skill for any scientist or engineer. Raw data is generally unruly, disorganized, and unusable until it is distilled into a productive format. Through the course of their K–12 science education, students should continually increase their toolkit for analyzing and interpreting data. This process will be most interesting to students when they understand that analysis and interpretation of data allows for, and is improved by, creativity. After all, the core purpose of analyzing and interpreting data is to turn raw material into something that can be readily communicated to others and evaluated. This process is how a massive list of measurements of the beak sizes of finches in the Galapagos can be transformed into a chart, how that chart can give rise to a narrative about beak sizes being affected by the relative severity of storms and droughts, and that narrative can explain the diversity of species. Again, encouraging creativity in this practice can help inspire students to fully engage with the material.

[illegible]

In the modern world math, science, and engineering all rely heavily upon the use of computers and digital technology. Accordingly, students must have a basic proficiency in computational thinking to capture and interpret vast data sets and to perform high level calculations. At its core, this practice is about acknowledging the fact that mathematics and technology are inextricably integrated into science and engineering as tools for the collection and interpretation of data as well as media for the communication of ideas. Wherever possible, technology should be incorporated into the classroom so that students will be comfortable using algorithms, functions, and computational models.

[illegible]

This practice represents a synthesis of science and engineering goals in that scientists endeavor to construct explanations for the causes of phenomena and engineers endeavor to design solutions to problems (Next Generation Science Standards, Appendix F, p. 11, 2013). By integrating the goals of science and engineering into a single practice, the Framework is presenting a vision of science education that goes beyond the scientific method and seeks to stimulate students by providing a window through which they can see how their studies may affect and improve the real world. Rather than simply finding an evidence based explanation for a phenomenon, modern science students will commonly be asked to apply that evidence based explanation in service of problem solving practices. The core notion here is that engineering practices can benefit our conception of scientific principles and vice versa.

[illegible]

If asked to list the skills traditionally attributed to a scientist, few students would mention argument. However, there is an extent to which scientific study is, in truth, entirely about argument. Science is about constructing explanations and finding correct answers, and the process by which a hypothesis or theory is tested involves advocating for or against a proposition using logic and evidence. Of course, argument in science and engineering ideally serves a different purpose than argument in philosophy or law. Instead of arguing to prove that superiority of one's own position, the purpose of scientific argument is to find a correct answer. Counterpoints and contrary evidence should not be dismissed or attacked, but understood and incorporated where possible so that ideas can be compared and evaluated honestly on their merits. Emphasizing the engineering habits of mind will help to prevent scientific argument from devolving into a battle of egos.

[illegible]

The new science pedagogy has a decidedly holistic bent and attributes an increased value to language skills. The ability to absorb new ideas, argue and evaluate a hypothesis or design solution, and communicate information are all valuable skills for a scientist or engineer. Scientific ideas are commonly obtained, evaluated, and communicated through tables, charts, diagrams, etc., but this process also occurs through conversation, articles, and journalism. In the modern media landscape, scientific ideas are more likely than ever to be submitted to the court of public opinion so the ability to make a compelling presentation of information is growing ever more important. In the classroom, crafting a compelling narrative about a problem or a design solution can help students to relate to the material and be stimulated by it. The evaluation prong of this practice should be understood to include information literacy in addition to the more traditional scientific practice of analyzing data. Digital media has given rise to an abundance of readily available sources, so the ability to compare different sources and assess their reliability is an important skill. Students should be able to review citations and think critically about the way in which a source collects and employs data.