I chose to analyze the following sets of standards at the high school level:

- Next Generation Science Standards [NGSS]
- Common Core State Standards - Mathematics [CCSS]
- Standards for Technology Literacy [STL]

All three sets of standards relate to problem solving and engineering design in some capacity although each have their own take on the topics. The NGSS considers overarching ideas, what are referred to as Science and Engineering Practices, and highlights them throughout the Disciplinary Core Ideas which is where you would find the actual performance standards. In doing so, the NGSS focuses on nature of science as a vehicle for understanding the expected curricular topics. The CCSS provides detailed performance expectations across the mathematics curriculum. These expectations weave in problem solving as it relates to each major topic. The CCSS also focuses on how modeling plays a role in choosing the right mathematical technique and concept to solve a problem. The STL specifies the importance of student understanding of technology and its place in society. Unlike the NGSS and CCSS, these standards do not attempt to create curricular necessities - rather they speak to what are referred to as Benchmark Topics that allow for individual schools, districts, or states to create the relevant curriculum. The standards highlight problem solving as part of the engineering design process.

What stands amongst the three sets of standards is the way that they approach the problem solving process. All three sets of standards encourage students to first define the problem to be solved and determine the necessary constraints. In the NGSS, this is part of Practice 1: Asking Questions and Defining Problems (NGSS Appendix F, p4). It states that students, “should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution.” In the CCSS, this is highlighted in the section on modeling (CCSS, p72). The standards recommend that students begin by, “identifying variables in the situation and selecting those that represent essential features.” Finally, in the STL, this concept is referenced in standards 8, 9, and 11. Standard 8 (ITEEA, p91) addresses student understanding of the, “attributes of design.” Standard 9 (ITEEA, p99) considers engineering design specifically, while Standard 11 (ITEEA, p115) provides an outline of the design process in general. In each set of standards, stress is placed on determining the parameters or variables of the problem and the constraints, or limits that must be placed on the problem.

Each set of standards also encourages modeling, although in a slightly different way. In the CCSS, specific mathematical modeling tactics appear throughout the content specific standards. The standards document does, however, comment explicitly on the practice of modeling as a technique for problem solving. The document states that, “modeling links classroom mathematics and statistics to everyday life, work, and decision-making” (CCSS, p72). As such, the CCSS speaks directly to the role of modeling in problem solving. A mathematical model involves describing and representing the relationships between variables to draw conclusions. The NGSS states in Practice 2: Developing and Using Models (NGSS Appendix F, p6) that, “models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations.” In science, models are used to explain a system under study and to generate predictions about the real world. That aligns exactly with the claim the CCSS makes about using models in mathematics to connect to everyday life. Furthermore, the connection between the NGSS and CCSS is strengthened by Practice 5: Using Mathematics and Computational Thinking (NGSS Appendix F, p10) which states that students should be able to, “create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.” While in science, models can be physical or abstract, in engineering the term model is more often than not used to describe a physical model. The STL discusses modeling as making a prototype and states in Standard 9K (ITEEA, p105) that, “a prototype is a working model used to test a design concept by making actual observations and necessary adjustments.” Regardless of the type of model - mathematical, conceptual, or physical - the role of modeling is highlighted as an important part of the problem solving process across the standards.

The standards point out that the task of modeling must consider various assumptions and factors. The STL comments on the factors that must be considered as part of the design and problem solving process regardless of the technology under review. Standard 9I (ITEEA, p104) states that when modeling or developing a prototype that the, "design principles include flexibility, balance, function, and proportionality." Standard 9J (ITEEA, p104) goes further to consider personal characteristics such as, "creativity, resourcefulness, and the ability to visualize and think abstractly," of the designer or modeler. Finally, in Standard 9L (ITEEA, p105) there are practical considerations such as, "safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics)." The STL acknowledges and recognizes the importance of a variety of factors when designing. Likewise, the NGSS takes into account similar factors as part of Practice 3: Planning and Carrying Out Investigations (NGSS Appendix F, p7). It specifies that when conducting an investigation the design must be refined to consider, "number of trials, cost, risk, and time." Additionally, Practice 3 articulates that any investigation or design solution should be carried out, "in a safe and ethical manner including considerations of environmental, social, and personal impacts." In Practice 4: Analyzing and Interpreting Data (NGSS Appendix F, p9) the NGSS speaks regarding data analysis in the problem solving process and encourages, "clarifying problems, determining economic feasibility, evaluating alternatives, and investigating failures." The CCSS also highlights variability in creating models and states that formulating models, "depends on acquired expertise as well as creativity" (CCSS, p72). The discussion on modeling in the CCSS goes on to ask that students consider optimization, resources (time and tools), and, "limitations of our mathematical, statistical, and technical skills" (CCSS, p72). Each set of standards acknowledges that modeling and solving problems must take into account a variety of different design considerations although they highlight different aspects of modeling and design.

Finally, the standards can be compared regarding the way in which they articulate that conclusions should be drawn and communicated. The NGSS has highlighted this as Practice 8: Obtaining, Evaluating, and Communicating Information (NGSS Appendix F, p15). As it relates to drawing conclusions, the NGSS encourages the use of, "multiple sources to obtain information used to evaluate the merit and validity of claims, methods, and designs." Furthermore, it goes on to reinforce that communicating results can be done in a variety of ways, such as, "using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions." In a similar fashion, the CCSS (CCSS, p73) recommends use of, "graphing utilities, spreadsheets, computer algebra systems, and dynamic geometry software," to model mathematical phenomena and communicate information about the model. The STL also recommends analyzing and communicating the outcome of the problem or design strategy in multiple formats. Standard 11R (ITEEA, p124) states that students should be able to, "evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models." While each set of standards highlights different manners by which to present the results, they all stress that the outcome should be clearly communicated and in doing so, teaches students about the process itself.

In science, math, and technology applications the engineering design problem solving method is a unifying concept across the disciplines. The standards across the disciplines all make the case that problem solving should follow a similar set of directions. In each case, students are tasked to identify the problem to be solved, identify the relevant criteria and constraints, create a model or prototype, evaluate or test the model, make modifications, analyze and interpret the results, and communicate the conclusions. Each discipline considers these steps in a slightly different fashion, but the underlying message is the same.

Next Generation Science Standards [NGSS]. (n.d.). *NGSS High School Sciences Storyline*. Retrieved from https://www.nextgenscience.org/overview-dci.

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