Why SECME Engineering Design Competitions:
SECME and the Next Generation Science Standards

SECME's Mission:

SECME's goal is to increase the pool of historically under-represented and under-served students who will be prepared to enter and complete post-secondary studies in science, technology, engineering, and mathematics (STEM), thus creating a diverse and globally competitive workforce.

SECME has a 34 year legacy of engaging K-12 students in engineering design and STEM research competitions:

Engineering Design
Mousetrap Car
Water Rocketry
VEX Robotics
STEM Research and Writing
Internet Science and Technology Fair
eCYBERMISSION
Essay

The Next Generation Science Standards has included Engineering Design as a component of their standards. Many standards in the three disciplinary areas of Life Science, Physical Science, and Earth and Space Science begin with Engineering Practice and there are separate standards for engineering design at the K-2, 3-5, 6-8, and 9-12 levels. Engineering Design is seen as both a set of practices and as a set of core ideas.

NGSS Implications for SECME Programs

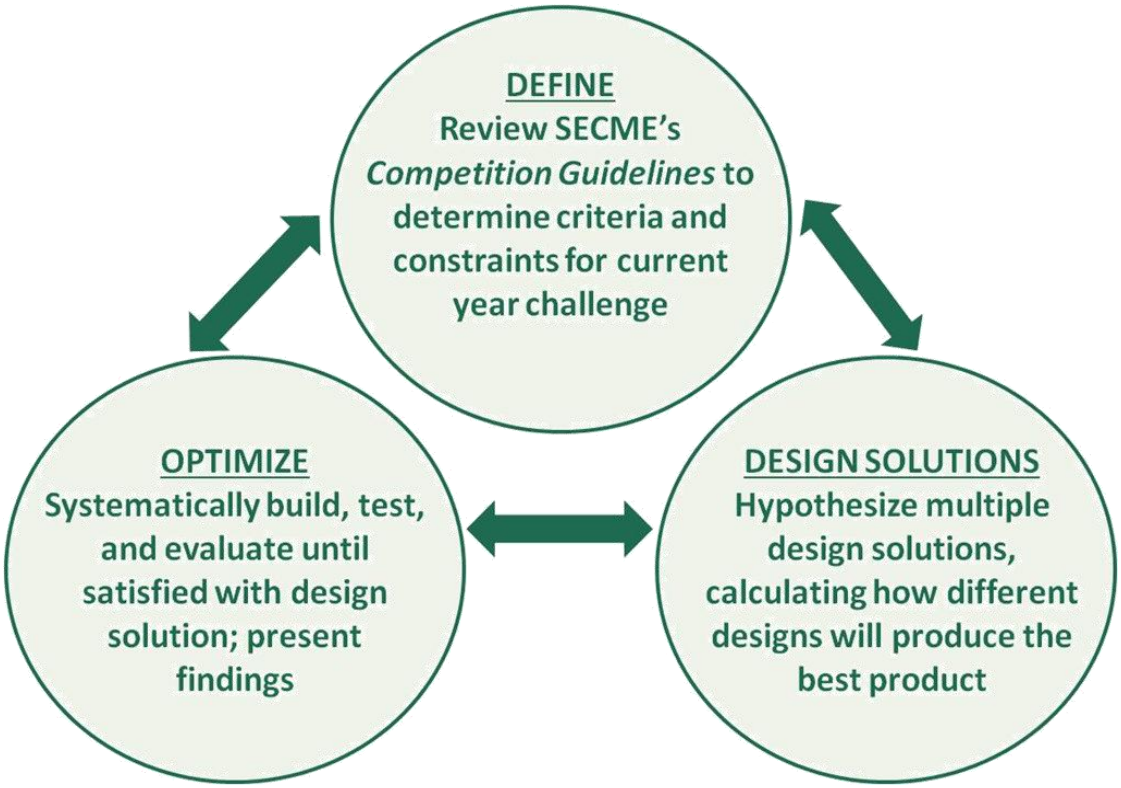
The Next Generation Science Standards inclusion of Engineering Design as a component of their standards has critical implications for the K-12 student populations SECME serves. According to the National Science Foundation, a focus on engineering has the potential to better prepare, identify, and develop our nation's diverse human capital. Additionally, NSF contends that early engagement in engineering practice is particularly important for students who have traditionally not considered science as a possible career choice, including females and minority students. A focus on engineering will be impactful because:

- it is inclusive of students who may have traditionally been marginalized in the science classroom or experienced science as not being relevant to their lives or future
- it asks questions and solves meaningful problems in local contexts (local needs), therefore, diverse students:
    - deepen their science knowledge
    - come to view science as relevant to their lives and future
    - and engage in science in socially relevant and transformative ways
- it provides opportunities for “innovation” and creativity at the K-12 level which is critical to undertaking the world’s challenges
- it provides exposure to engineering activities (robotics, invention competitions) and can spark interest in the study of STEM or future careers

Standards for engineering design reflect the <u>three component ideas of the Framework</u>

1. **<u>DEFINING</u> and delimiting engineering problems** involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.
2. **<u>DESIGNING SOLUTIONS</u> to engineering problems** begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
3. **<u>OPTIMIZING</u> the design solution** involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

SECME Engineering Design Competitions
provide opportunity for teachers to drill down these three component ideas to reflect progress at each grade level.



SECME Engineering Design Competitions
Align with NGSS's Science and Engineering Practices

SECME Engineering Design Competitions allow students to authentically explore how engineering design practices work in their world, helping to make science and engineering relevant to their lives, while working towards Engineering Performance Expectations.

NGSS Scientific and Engineering Practices	SECME Interactive Design Approach
	
1. Ask questions (for science) and define problems (for engineering)	**1. Choose SECME Engineering Design Competition**
2. Develop and use models	**2. Research, brainstorm, and create models to aid in selecting an approach**
3. Plan and carry out investigations	**3. Investigate possible solutions to see which one will best solve the problem (record data)**
4. Analyze and interpret data	**4. Analyze investigation data (via graphical representation, visualization, and statistical analysis) to choose the best solution**
5. Use mathematics and computational thinking	**5. Make quantitative predictions using mathematical representations and apply math concepts (ratio, rate, functions, etc.)**
6. Construct explanations (for science) and design solutions (for engineering)	**6. Build/construct multiple prototypes for testing and analysis**
7. Engage in argument from evidence	**7. Test solution(s)**
8. Obtain, evaluate, and communicate information	**8. Write technical report; Create technical drawing; Prepare for team interview**

SECME Engineering Design Competitions
Align with NGSS' Engineering, Technology, and Applications of Science (ETS)

Because SECME's Competitions align with ETS performance expectations, the competitions can be easily integrated into class curriculum. Additionally, teachers can choose a competition that meets Physical, Life, and Earth and Space Science standards.

	Physical Science	Life Science	Earth and Space Science	Engineering Design
K	K-PS2-2 K-PS3-2		K-ESS3-2 K-ESS3-3	K-2-ETS1-1 K-2-ETS1-2 K-2-ETS1-3
1	1-PS4-4	1-LS1-1		
2	2-PSI-2	2-LS2-2	2-ESS2-1	
3	3-PS2-4	3-LS4-4	3-ESS3-1	3-5-ETS1-1
4	4-PS3-4		4-ESS3-2	3-5-ETS1-2 3-5-ETS1-3
5				
6-8	MS-PS1-6 MS-PS2-1 MS-PS3-3	MS-LS2-5		MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4
9-12	HS-PS1-6 SH-PS2-3 HS-PS2-6 HS-PS3-3 HS-PS4-5	HS-LS2-7 HS-LS4-6	HS-ESS3-2 HS-ESS3-4	HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4

ETS Performance Expectations

Elementary School: K-2
Students who demonstrate understanding can:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Elementary School: 3-5

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Middle School: 6-8

Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool. or process such that an optimal design can be achieved.

High School: 9-12

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved though engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

References

NGSS Lead States. *Next Generation Science Standards: For States, By States*: A Framework for k-12 Science Education: "Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K-12 Science Education Standards." Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013.

NGSS Lead States. *Next Generation Science Standards: For States, By States*: A Framework for k-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas: Supplemental Materials to the Next Generation Science Standards. Appendix F – "Scientific and Engineering Practices in the NGSS" and Appendix I – "Engineering Design in the NGSS." Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. 2013.

National Science Foundation. (2010). *Preparing the next generation of STEM innovators: Identifying and developing our nation's human capital*. Washington, DC: Author.