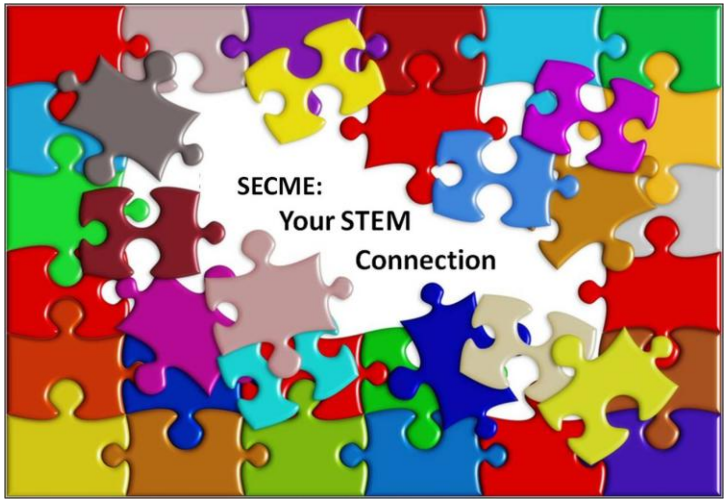
Putting the Puzzle Together
WHY
SECME ENGINEERING DESIGN COMPETITIONS



SECME
And The Next Generation Science Standards

Lynda Byrne, SECME National Education Program Manager

SECME
and
SECME National Student Competitions

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 Program Goals:

SECME programs and student competitions support K-12 teachers as they prepare their students to enter and complete college with a focus on STEM disciplines.

SECME's 34 Year Legacy:
Connecting students to STEM concepts with team engineering design challenges and STEM research.

<u>Engineering Design Challenges</u>

Mousetrap Car
Water Rocketry
VEX Robotics

<u>STEM Research and Writing</u>

Internet Science and Technology Fair
eCYBERMISSION
Essay

Our teacher training for engineering design competitions allow students to connect to the *purpose*, the *how*, and the *why*, to prepare them for real-world applications.

Next Generation Science Standards and Engineering Design

"…represent a commitment to integrate engineering design into the structure of science education by raising engineering design to the same level as scientific inquiry…"

Why?

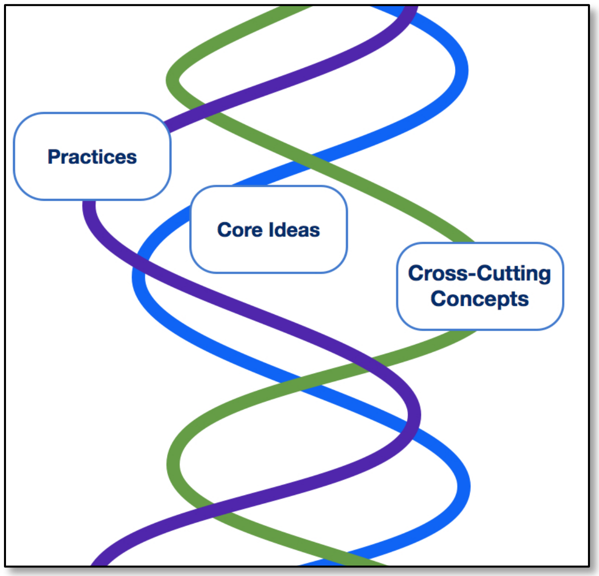
The following practices were NOT explicitly included in science standards until now:

Students are now expected to be able to define problems [situations that people wish to change] by:

- **specifying criteria and constraints for acceptable solutions**
- **generating and evaluating multiple solutions**
- **building and testing prototypes**
- **optimizing a solution**

SECME and NGSS

Three Dimensions Intertwined



Engineering Design in NGSS

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: K-2, 3-5, 6-8, and 9-12

Engineering Design is seen as
BOTH a set of practices AND as a set of core ideas

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

A. **<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.

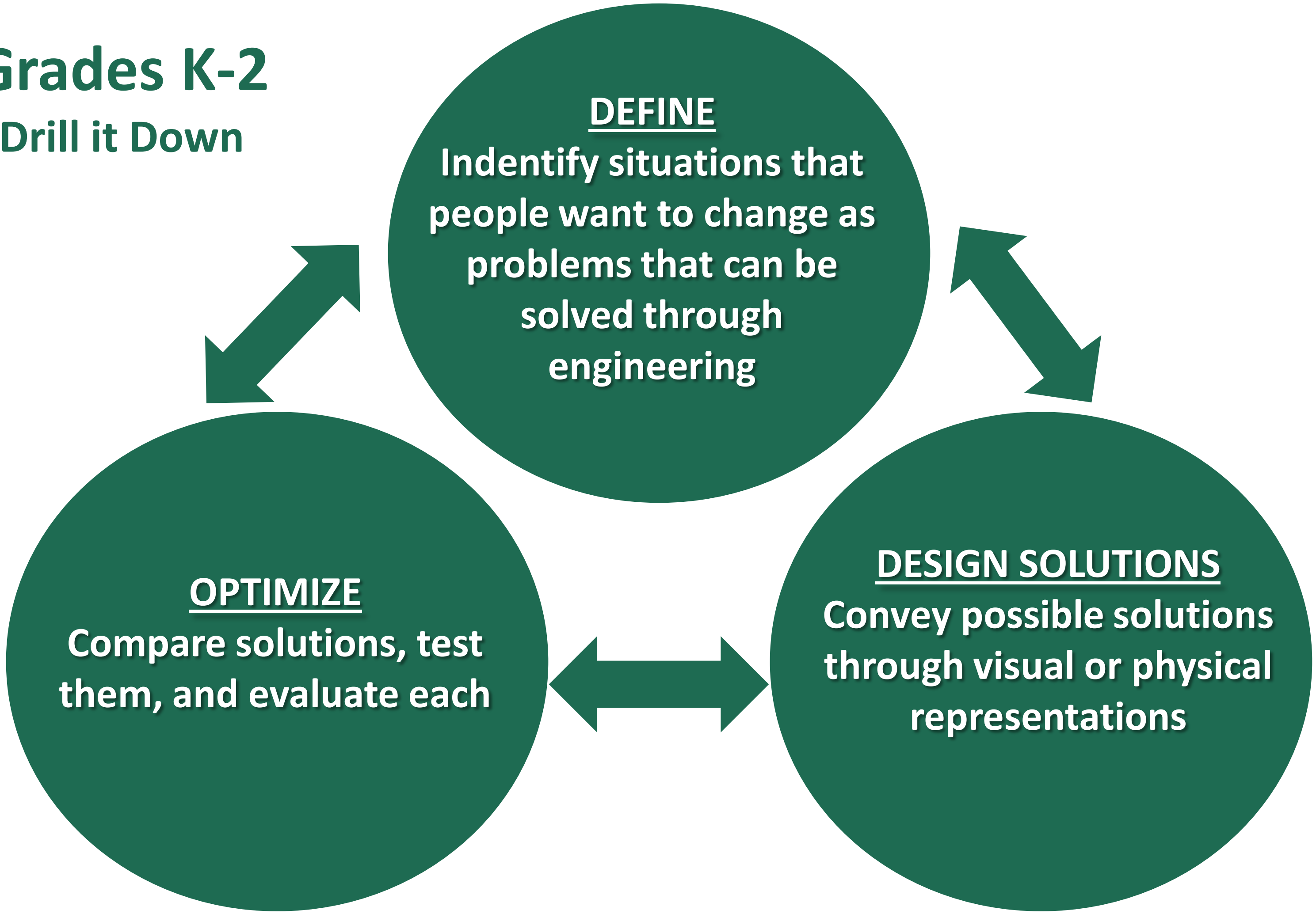
B. **<u>DESIGNING SOLUTIONS</u> to engineering problems** begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.

C. **<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.

And can be <u>drilled down</u> to reflect progress at each grade level

Grades K-2

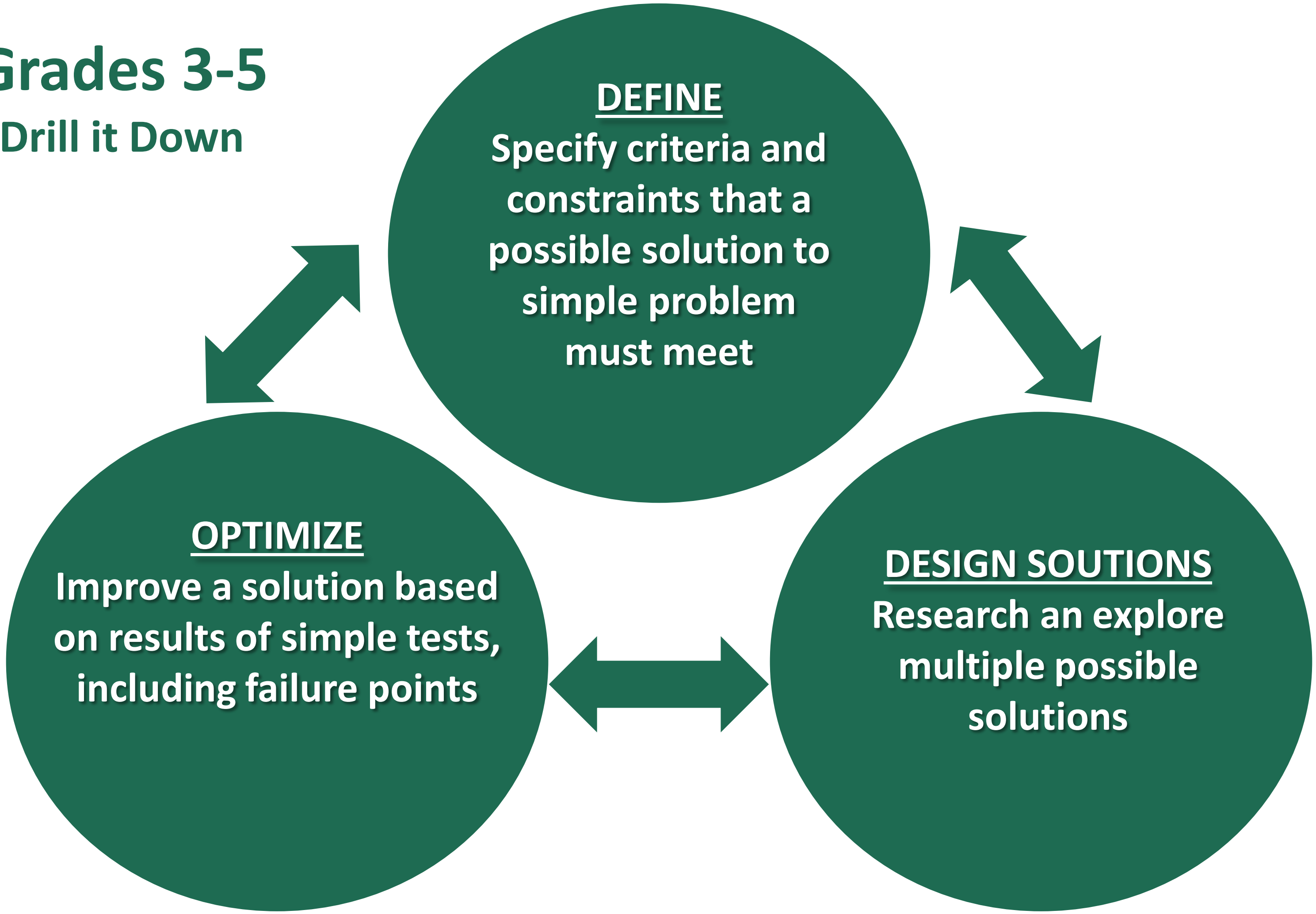
Drill it Down



- Introduces students to "problems" as situations that people want to change
- Emphasis is on thinking through the needs or goals that need to be met, and which solutions best meet those needs.

Grades 3-5

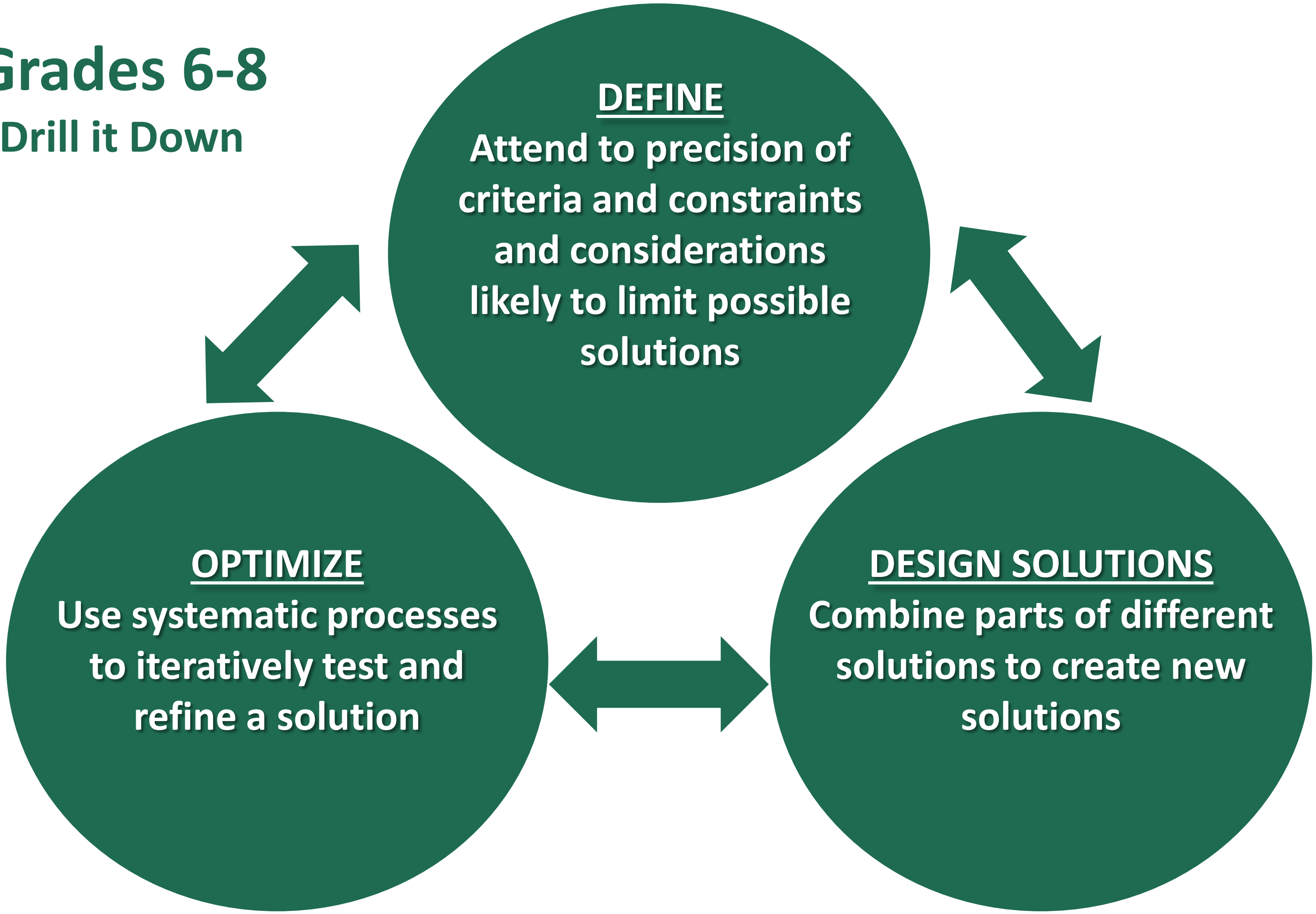
Drill it Down



- Engages students in more formalized problem solving
- Students research and consider multiple possible solutions to a problem
- Generating and testing solutions become more rigorous

Grades 6-8

Drill it Down



- Learns to sharpen the focus of problems
- Identify elements of different solutions and combine them to create new solutions
- Use systematic methods to compare different solutions, test, and revise multiple times

Grades 9-12

Drill it Down

DEFINE

Attend to a broad range of considerations in criteria and constraints for problems of social and global significance

OPTIMIZE

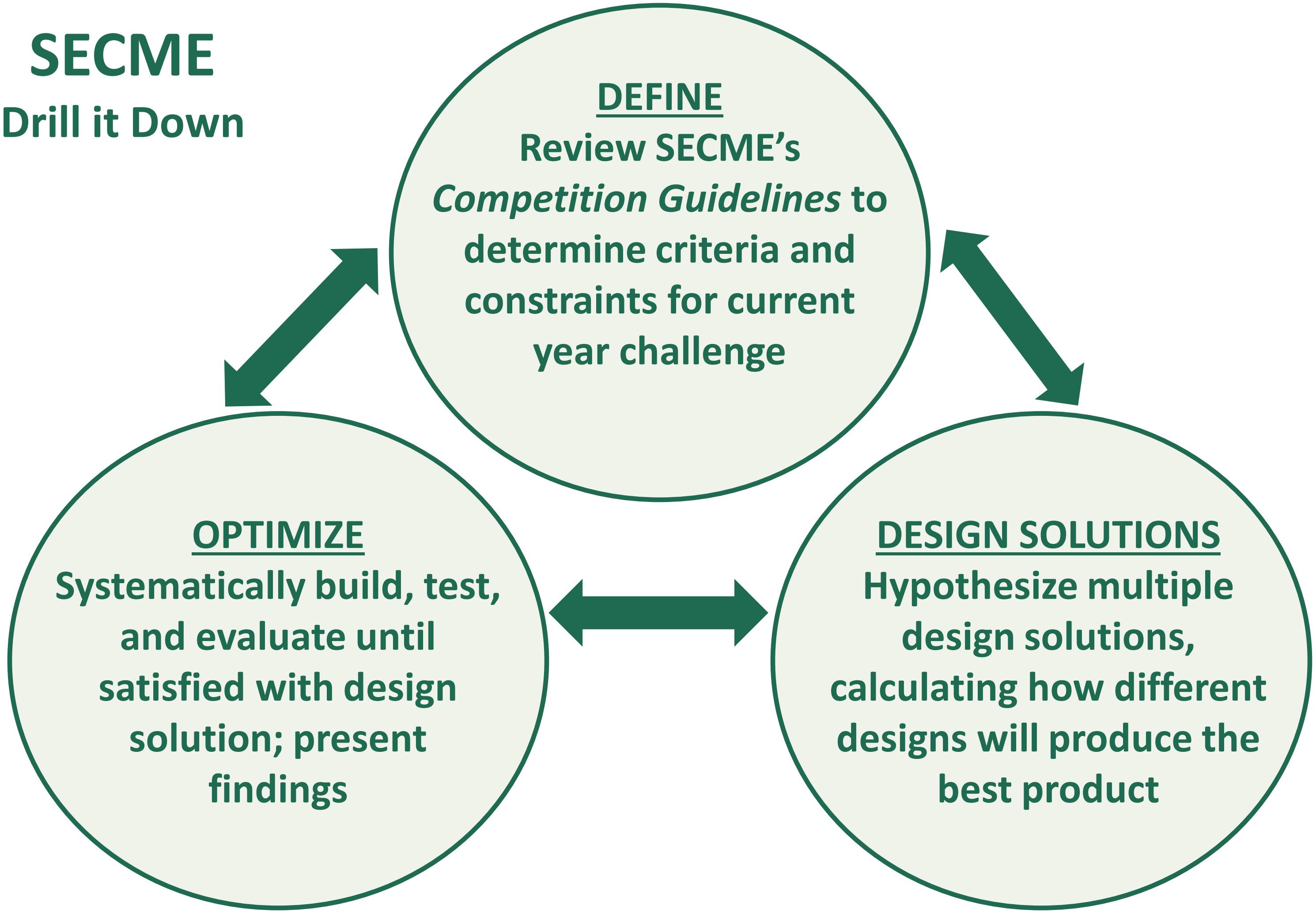
Prioritize criteria, consider trade-offs, and assess social and environmental impacts as a complex solution is tested and refined

DESIGN SOLUTIONS

Break a major problem into smaller problems that can be solved separately

• Complex problems that include social and global significance • Quantify criteria and constraints • Emphasis is on identifying the best solution to a problem • Expected to use mathematics and/or computer simulations to test solutions under different conditions

SECME
Drill it Down



Performance Expectations That Incorporate Engineering Design Practices

	Physical Science	Life Science	Earth and Space Science	Engineering
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

SECME and NGSS

Dimension 1: Science & Engineering Practices

1. Ask questions (for science) and define problems (for engineering)
2. Develop and use models
3. Plan and carry out investigations
4. Analyze and interpret data
5. Use mathematics and computational thinking
6. Construct explanations (for science) and design solutions (for engineering)
7. Engage in argument from evidence
8. Obtain, evaluate, and communicate information

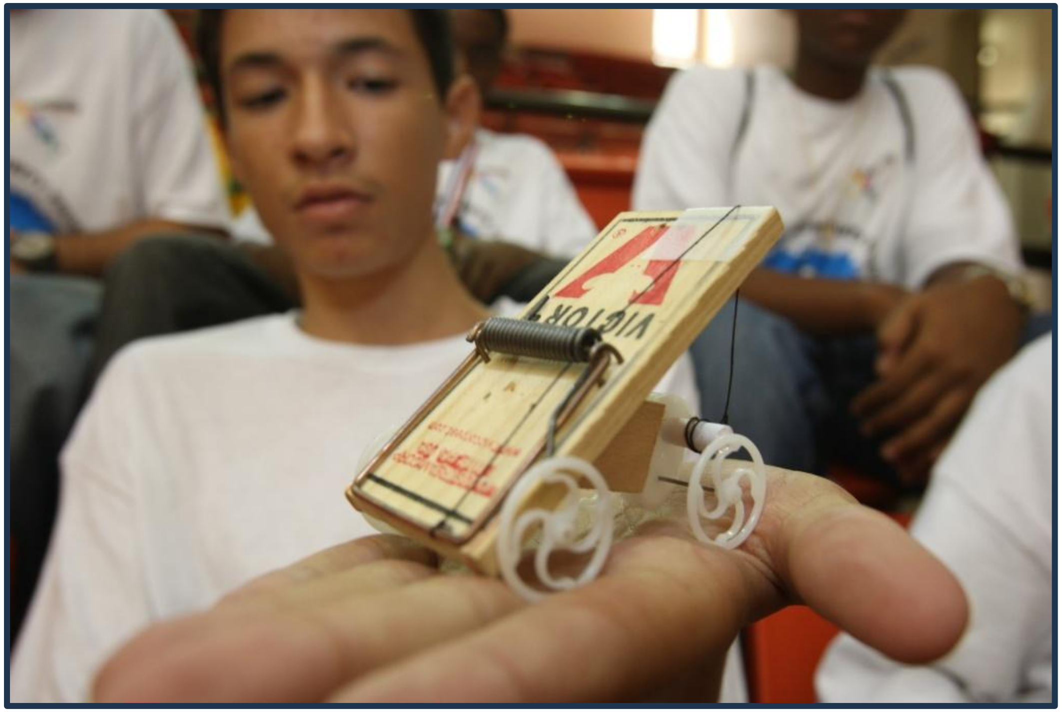
SECME Competitions Align with NGSS's Science and Engineering Practices

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

<u>Sample Alignment</u>

SECME Engineering Design: Mousetrap Car

Cars with Gears



Sample Alignment

SECME Engineering Design: Mousetrap Car

Discuss Limitations

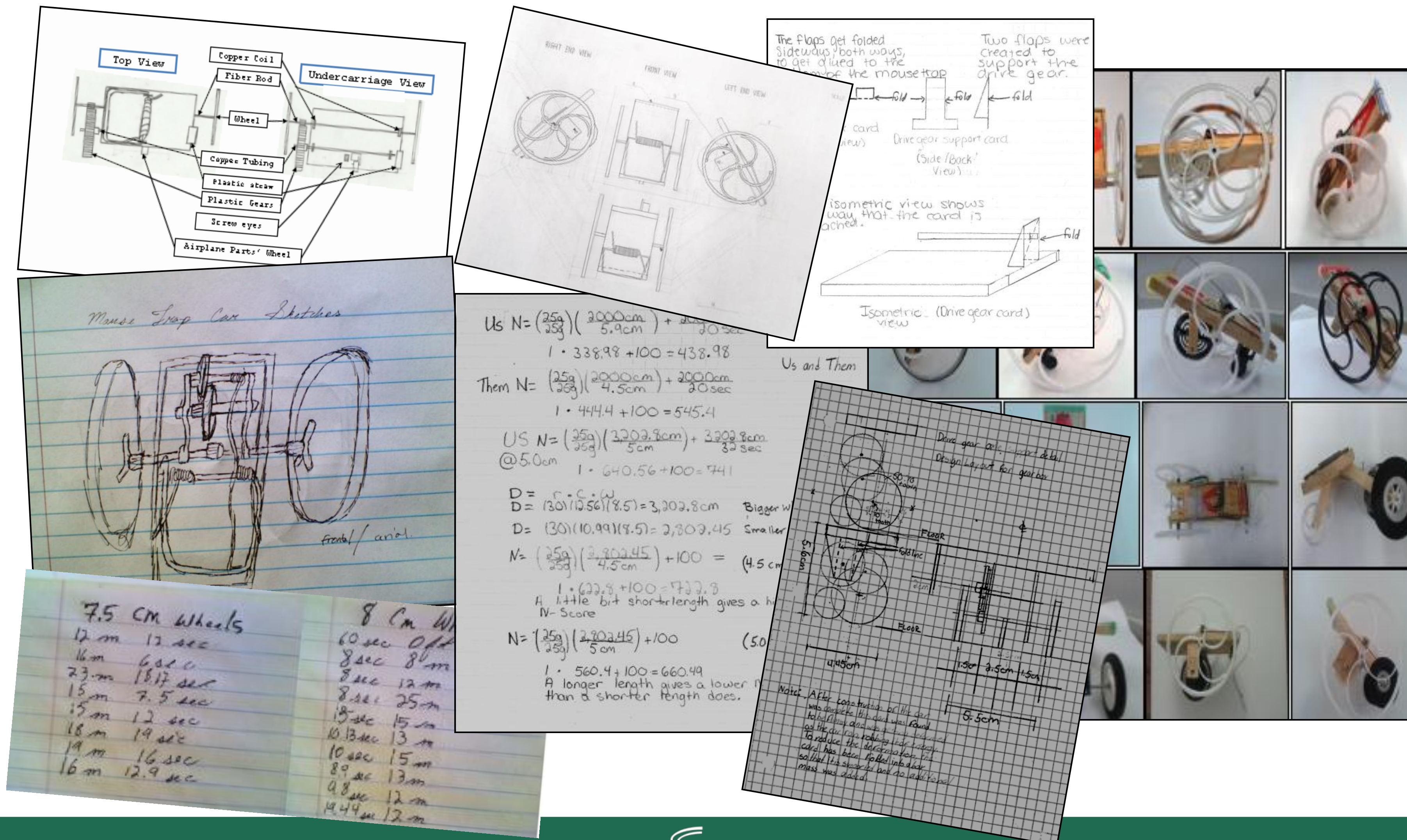
What are the limitation with the use of a lever?

What are the limitations with the use of pulleys?

What are the limitations with the use of gears?

Sample Alignment

SECME Engineering Design: Mousetrap Car



SECME
Diversity in STEM Education

SECME National Competitions

Challenge students to connect to the <u>purpose</u>, the <u>how</u>, and the <u>why</u>

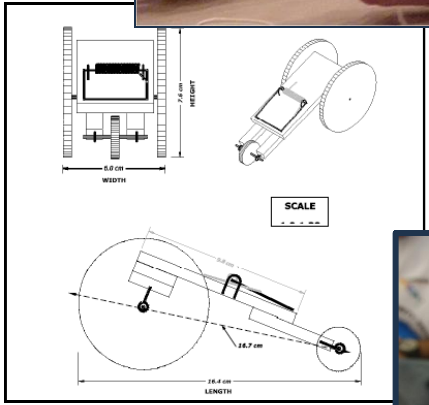
Example:

SECME students teams don't just race a car

Engineering Design Mousetrap Car Competition requires

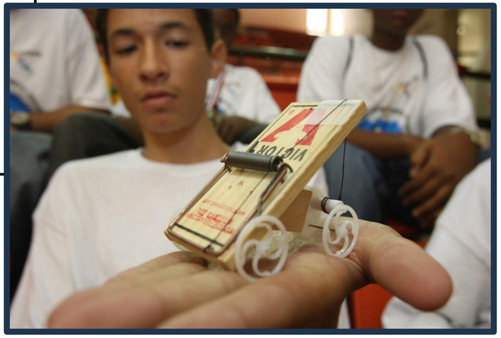
Car Construction

and Run



Technical Drawing

Technical Report



Team Interview with Judges (MS,HS)

Engineering Design in Relation to Student Diversity
(from Appendix I)

Inclusion of engineering with science has major implications for non-dominant student groups.

Focus on engineering:

- 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

- asking questions and solving meaningful problems in local contexts (local needs), 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

Engineering Design in Relation to Student Diversity
(Appendix I)

- ➢ opportunities for "innovation" and creativity at the K-12 level is critical to undertaking the world's challenges

- ➢ exposure to engineering activities (robotics, invention competitions) can spark interest in the study of STEM or future careers

Early engagement is particularly important for students who have traditionally not considered science as a possible career choice, including females and minority students.

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.