V-Model Approach to K-12 Learning
Wednesday, February 27, 2019

INCOSE San Diego

Presentation will start at 6PM PT

The Need for Systems Engineering in K12 Schools

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INCOSE Western States Regional Conference 2018

About Me

- 15 years in education
- Former researcher and Forensic Analyst
- Taught: Physics, AP Physics, Biology, AP Bio, Earth, Forensics, Environmental Science
- Escondido Union HS District (Escondido, Ca)

Next Generation Science Standards

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NGSS

- Science AND Engineering to be taught in every grade K12
- Shift away from memorizing facts to *doing* science and engineering
- Emphasis on hands-on investigation and discovery

Next Generation Science Standards

- 19 have adopted
- 19 have adapted

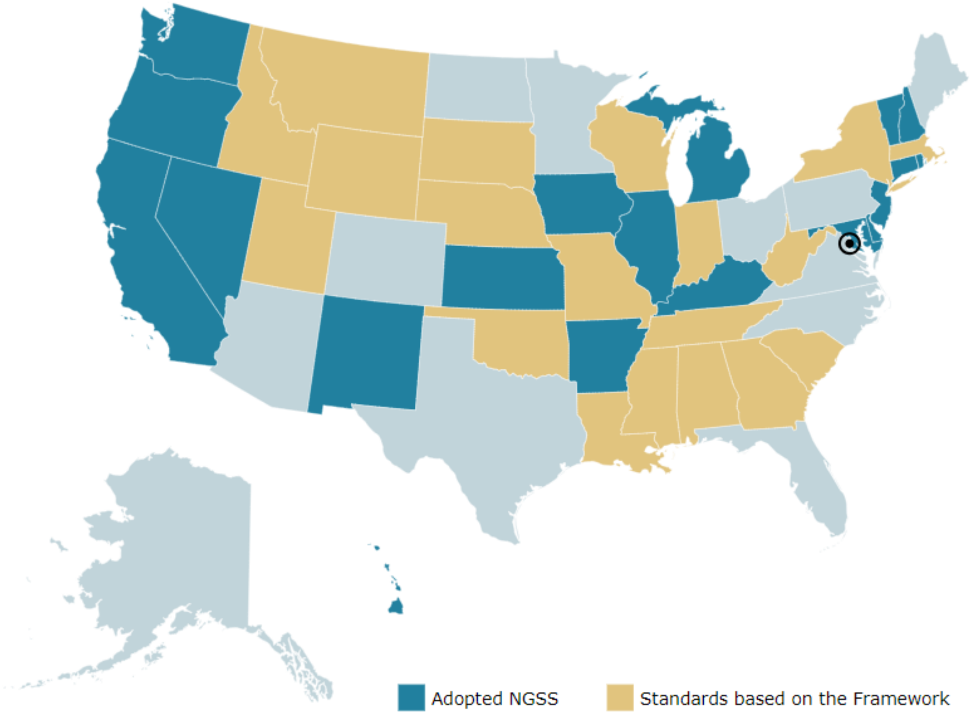
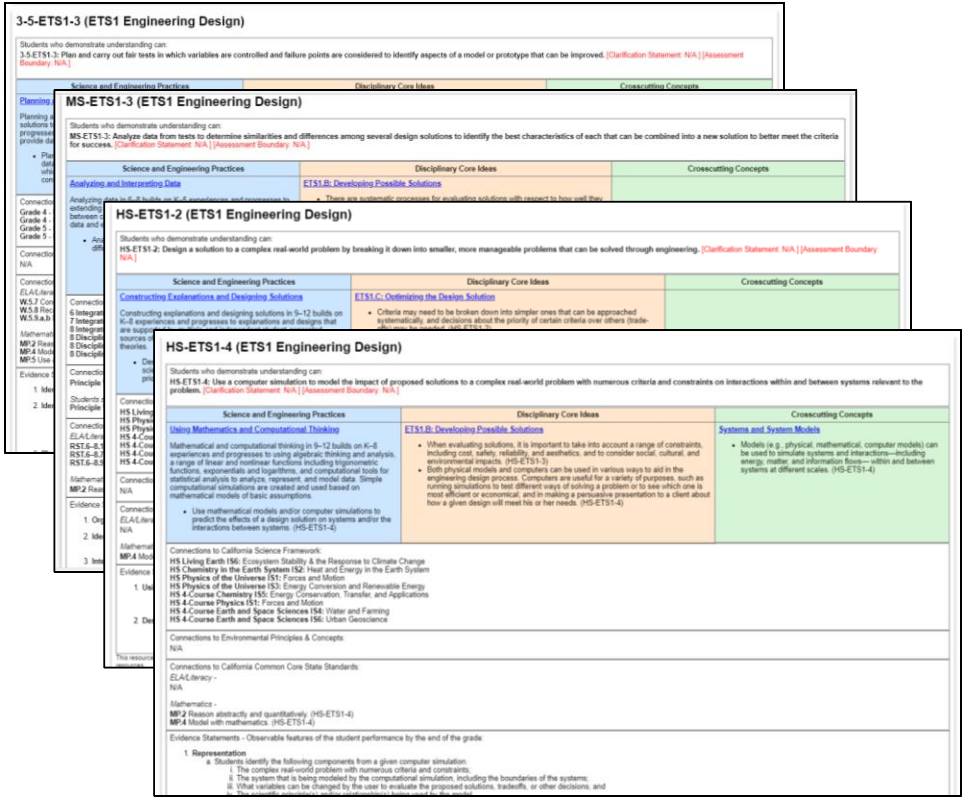


*Image from NSTA, http://ngss.nsta.org/About.aspx

Is ENGINEERING different from SCIENCE?

Engineering Standards



- …criteria and constraints for solutions …
- …breaking it down into smaller, more manageable problems …
- …prioritized criteria … range of constraints…
- …model the impact of proposed solutions …systems relevant to the problem.

The Difference

SCIENTIST

- Focus on unknown
- Create theories
- Ask questions then find answers
- Find the laws of nature
- Tell engineers what to make

ENGINEER

- Focus on known
- Implement theories
- Use the answers to make inventions
- Use the laws of nature
- Tell scientists the constraints to product ideas

SCIENCE

ENGINEERING

HOW do I TEACH ENGINEERING?

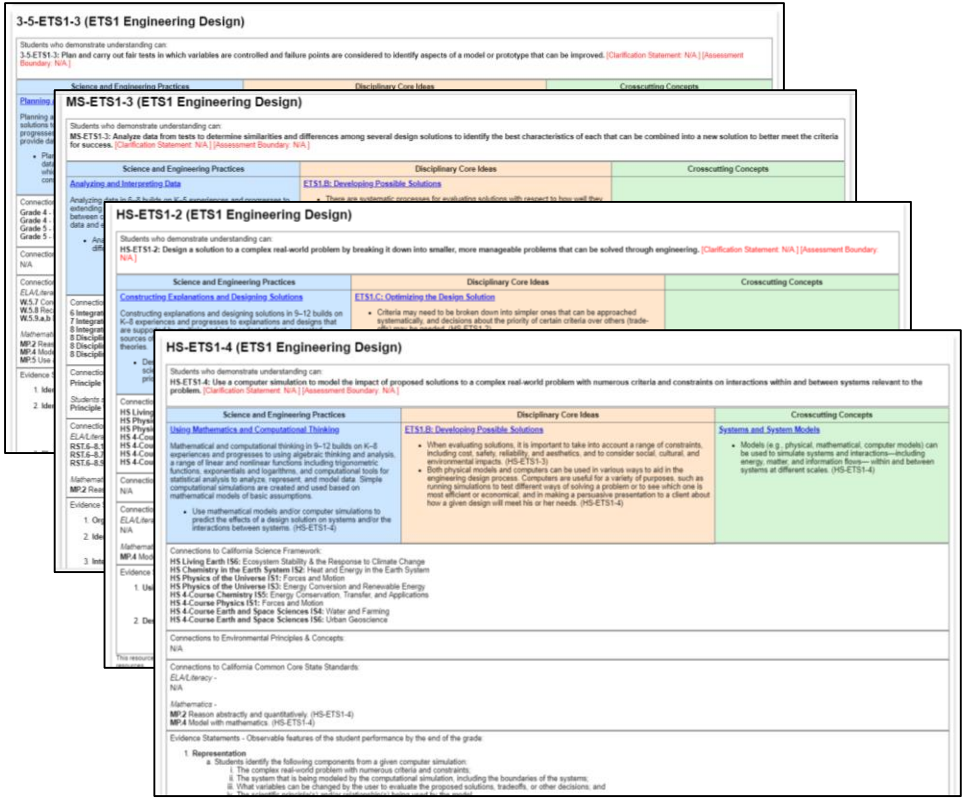
Method

Scientific

- Observation
- Question
- Hypothesis
- Experiment
- Analysis/Conclusions

Engineering

Engineering Standards



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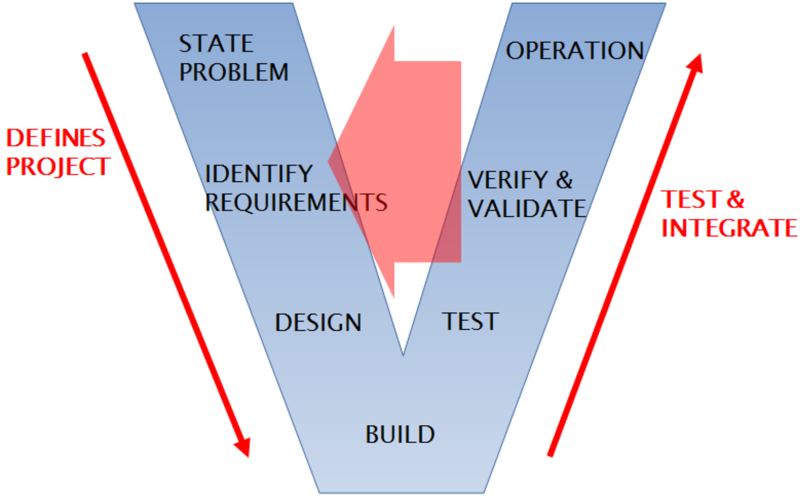
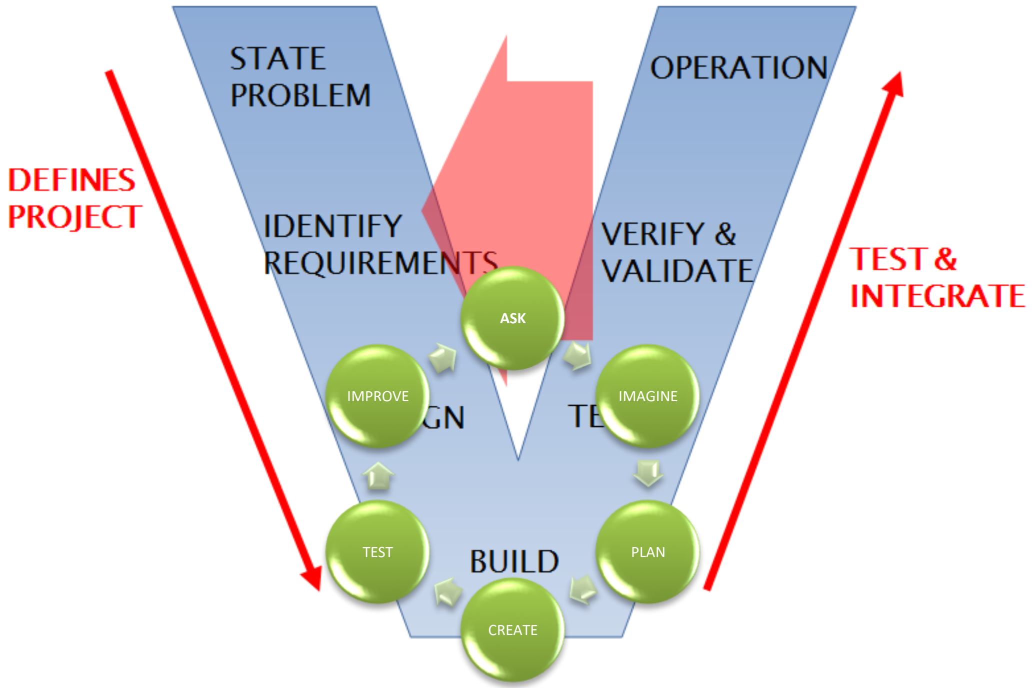
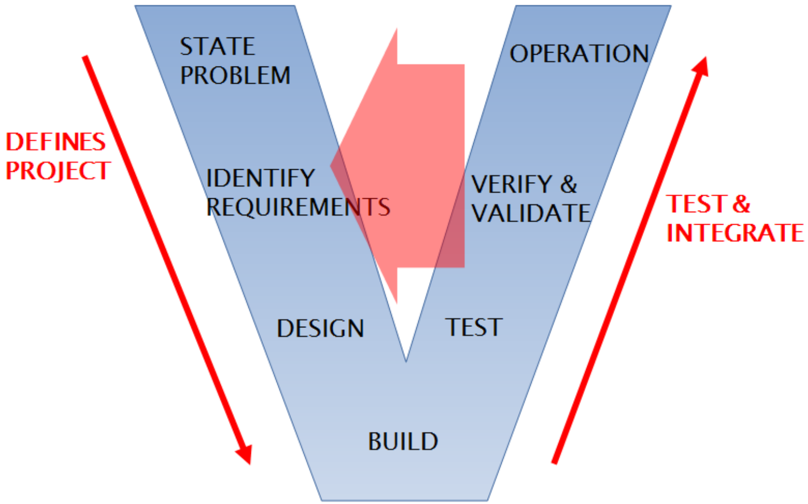


V Model of Systems Engineering



Engineering Spin on Projects

- State the problem
- Requirements
  - Physical, functional, interface, other
- Design – Build – Test
- Verify the requirements
- Validate the project



NAME of project	Date Start: ________ Date End: ________

IDENTIFY PURPOSE

What product is being made?

LIST of REQUIREMENTS

Physical Requirements
(dimensions, size, materials, etc)

Functional Requirements
(what item must be able to do, the task)

Interface Requirements
(how device/item interacts with immediate environment)

DESIGN (RESEARCH/BUILD)

Where are students going to find this research?

How long will you give them to build? What supplies will you provide for them? (paper, colored pencils, scissors, glue, tape, etc?)

TESTING

How much time will students be given to test? What equipment are you providing for them to test? Do they need to provide tables? Graphs?

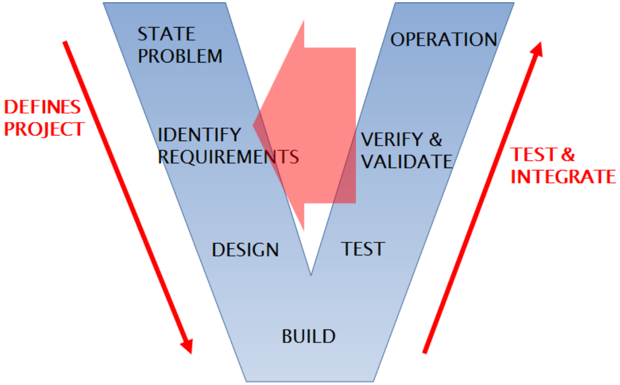
VALIDATION and VERIFICATION

VALIDATION: How will you measure that students met their purpose?

VERIFICATION: How will you measure that students met their requirements?

ASSESSMENT

- Students verify, teacher validates



VERIFICATION

REQUIREMENTS VERIFICATION

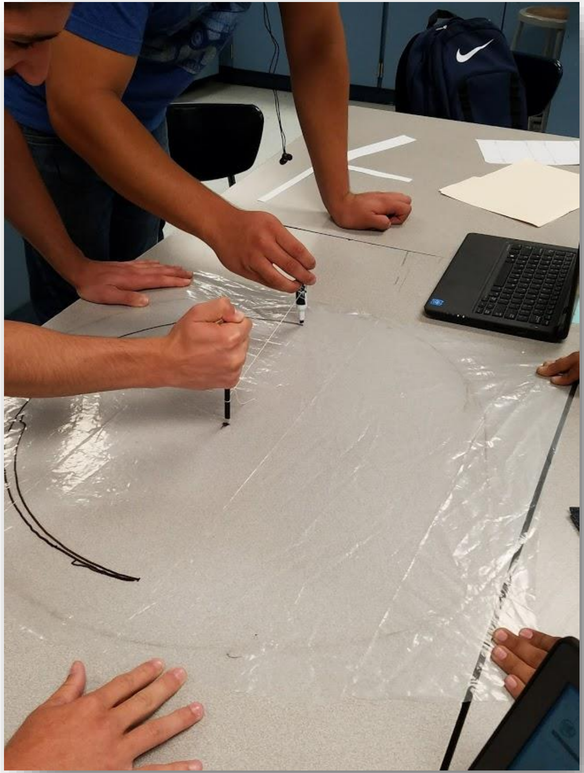
Your team must verify that the requirements were met. Circle on the verification rubric below how you met each of the stated requirements.

PHYSICAL REQUIREMENTS	4 OBJECTIVE	3 THRESHOLD	2 SUB THRESHOLD	1 DEVIATED
Materials	Only supplied materials used	Only supplied materials used, but had to get extra once	Only supplied materials used, but had to get extra twice	Built out of materials not supplied, extras three or more times
Dimensions	Largest dimension is ≤0.5 m in any direction	Largest dimension is 0.6 m in any direction	Largest dimension is 0.7 m in any direction	Largest dimension is > 0.7 m in any dimension

FUNCTIONAL REQUIREMENTS	4 OBJECTIVE	3 THRESHOLD	2 SUB THRESHOLD	1 DEVIATED
TIME of Flight	Time of flight >5s	Time of flight between 3-4.9 s	Time of flight between 1-2.9s	Object fell without reduced flight time.
Item Status upon Delivery	No damage	Item delivered with minimal damage (crack or small piece missing)	Damaged but not destroy (3 or more pieces broken)	Damaged beyond repair (>3 pieces broken)
Landing Zone	Package lands in 0.5 m landing zone	Package lands within the 0.6 m landing zone	Package lands in the 0.7 m landing zone	Package land in zone beyond 0.7 m

Human-Machine Interface REQUIREMENT	4 OBJECTIVE	3 THRESHOLD	2 SUB THRESHOLD	1 DEVIATED
Attachment of Package	Package easy to put on and off by stranger without damaging box	Package easy to put on and off with instructions to a stranger without damaging box	Package not easy to get on/of by stranger OR box gets damaged	Package not easy to get on/of by stranger AND box gets damaged

Systems Approach in the Classroom



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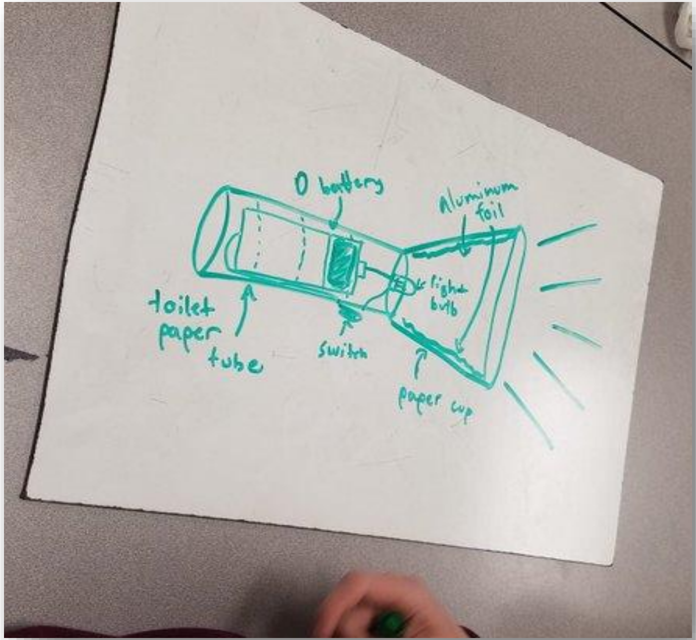

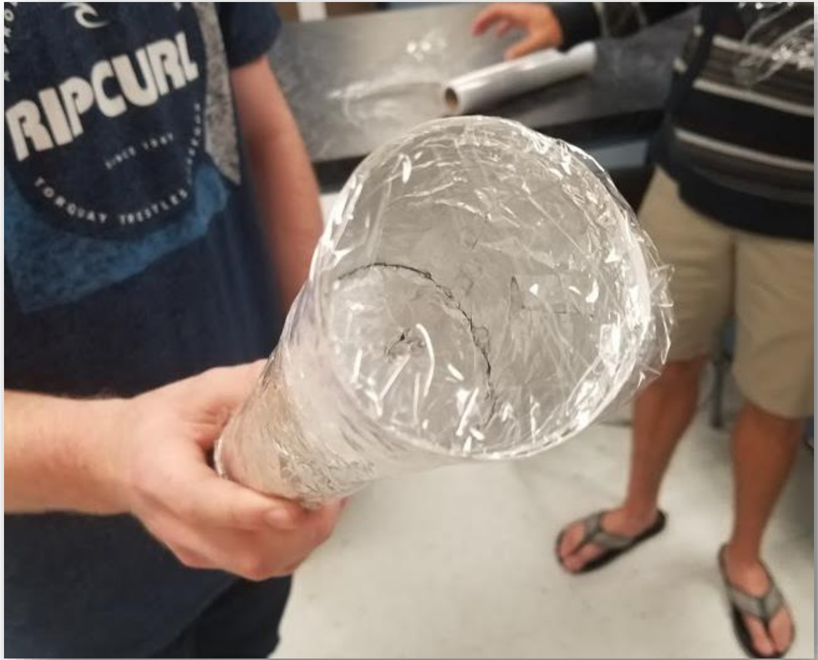

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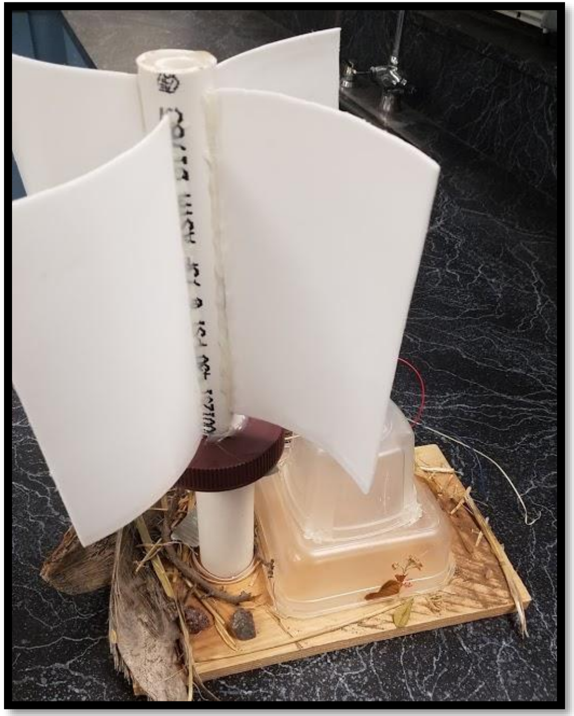

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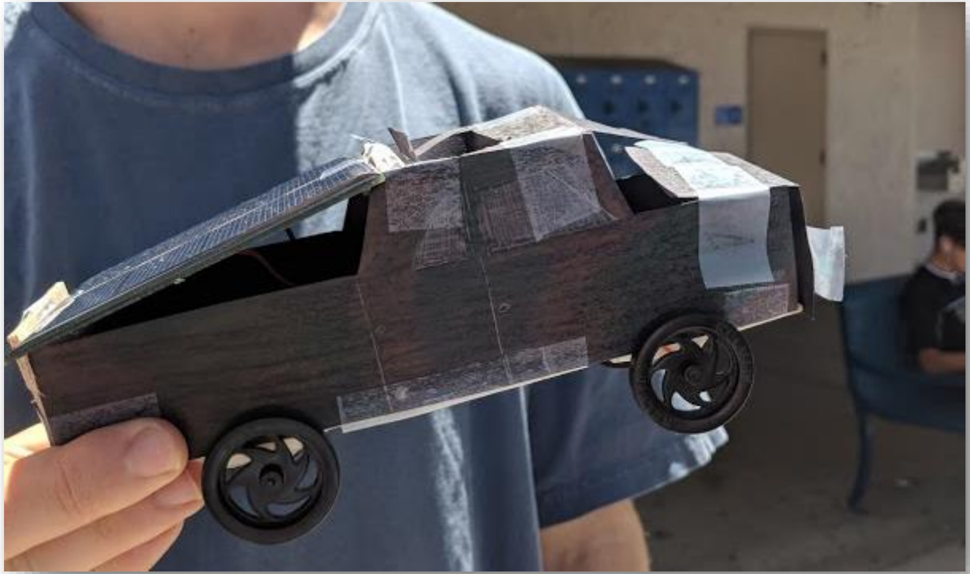

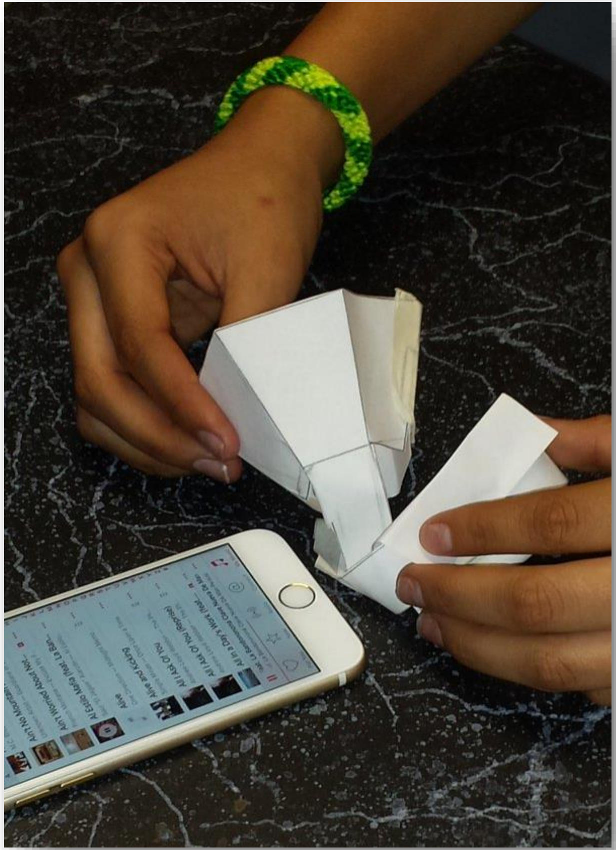

Systems Approach in the Classroom

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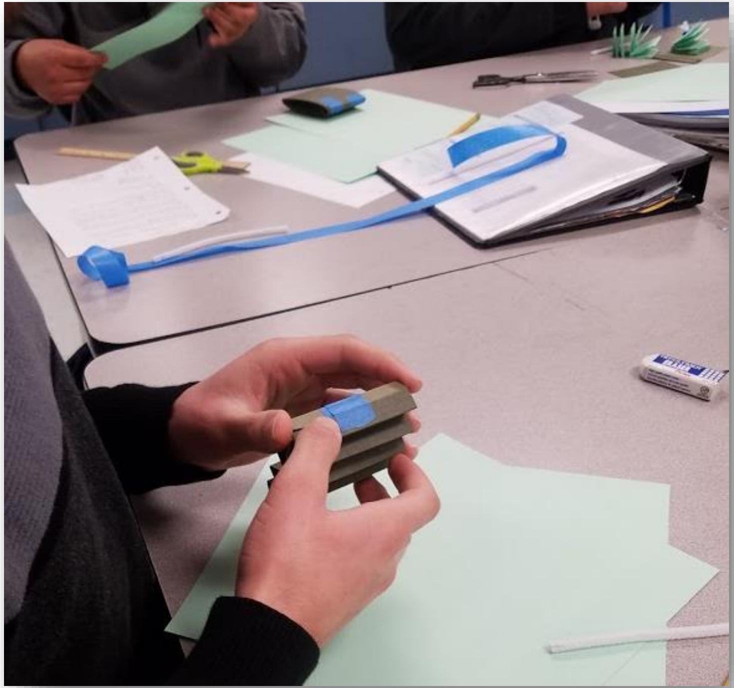
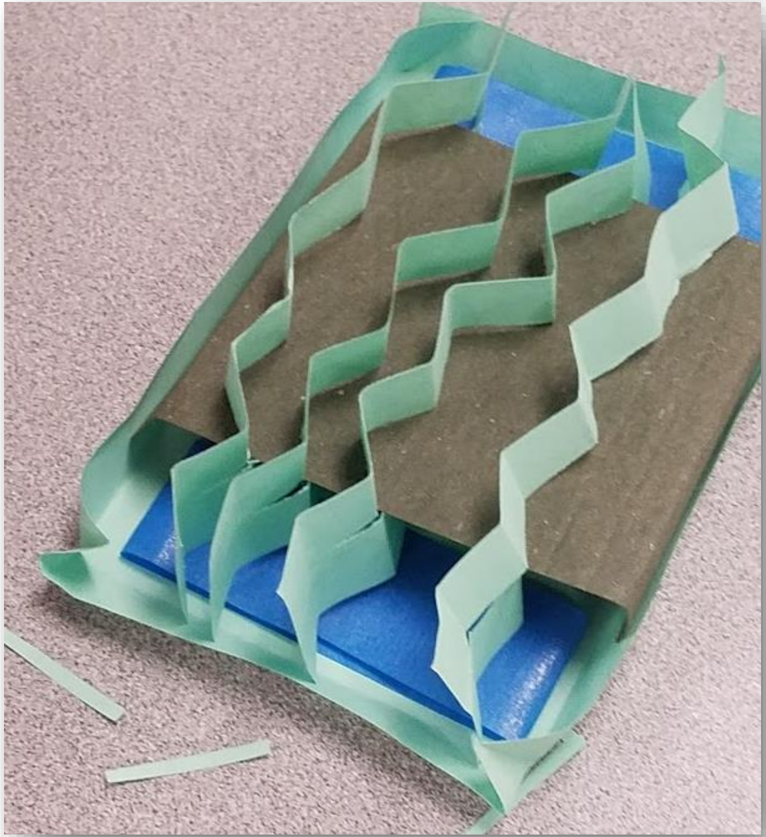
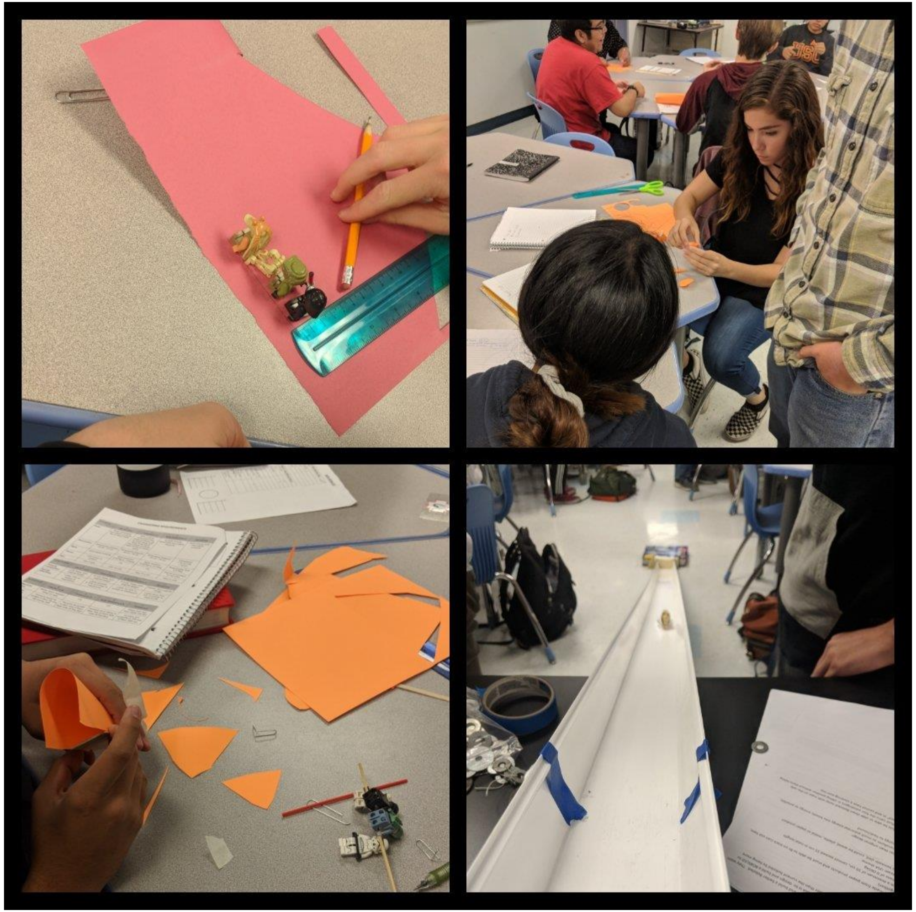
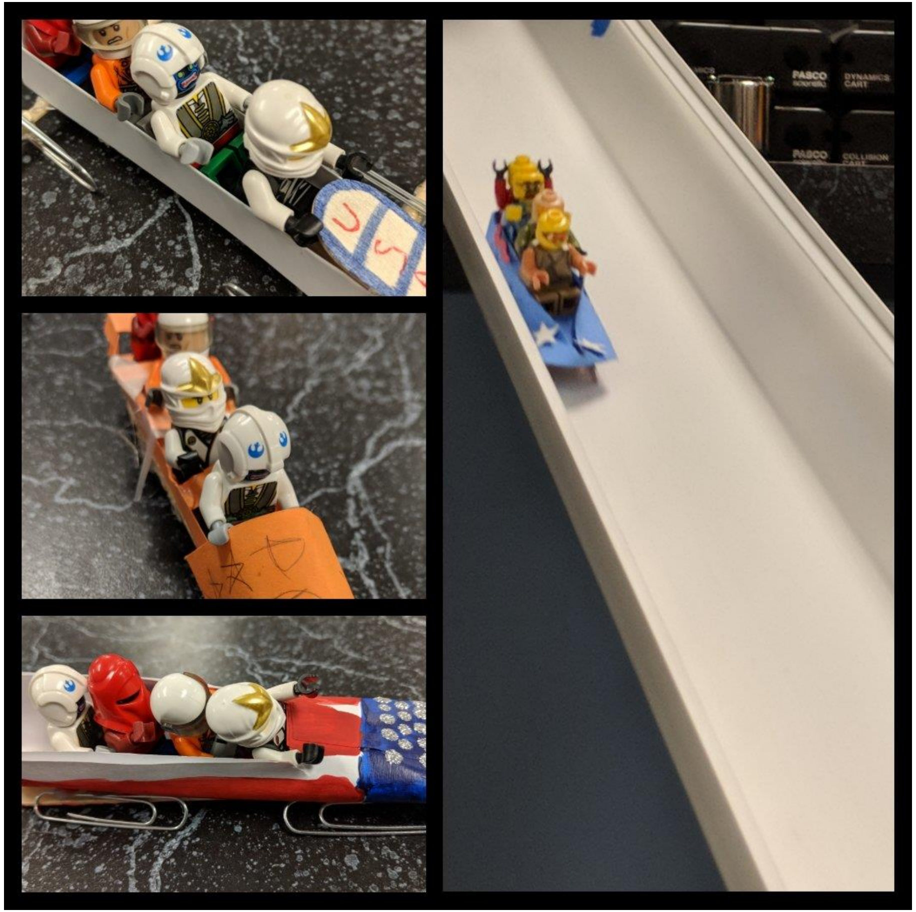








USA Bobsled Skeleton @USABS · 17 Nov 2018

Replying to @TraceySchalnat @NGSSMadeMeDoIt and 2 others

These look pretty fast! @eamslider24, @justinbolsen, @breinbolt, @vogtfornic, @codiebascue13... which one would you drive!?

1 2

1 more reply

Student Reflections

If there had been no requirements, how would this have changed your approach to this task?

- “The requirements sort of help us back into our thinking process…”
- “It would’ve been harder because you would’ve had many options to include…”

Which requirement do you think was most important to your customer?

- “I think the human/machine because they would have to place humans into the sled which could be difficult and affect how they like the product”
- “To have the men stay inside, upright. Safety is very important…”

Which requirement do you think was most important as the engineer?

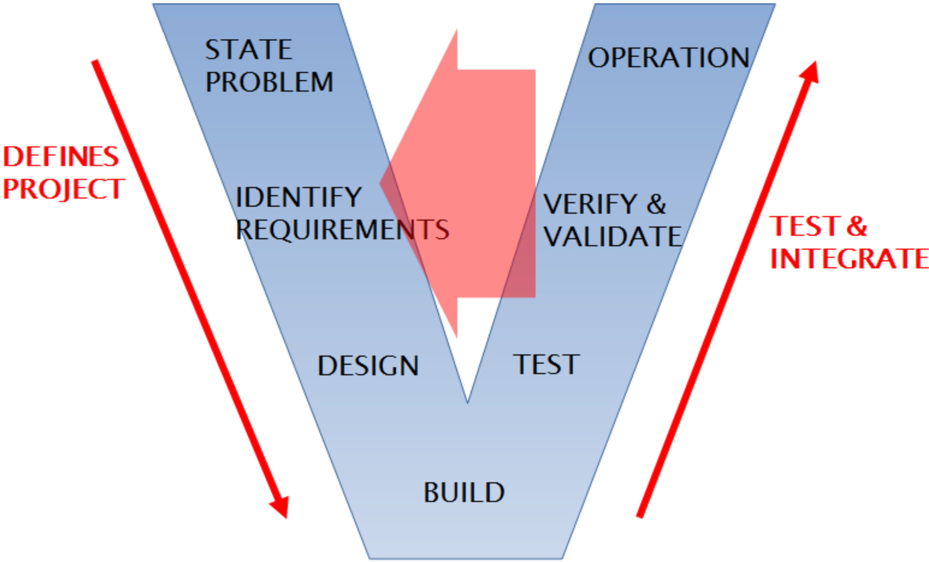
- “Time. In the sport of bobsledding your sled could not look good but still have the fastest time to get down the track.”
- “The Energy efficiency…due to it being able to affect the overall time, speed, and functionality of the bobsled”

If you got to add another requirement, what would it be?

- “A specific height…not all different type of people can fit.”
- “A time threshold would have to be met in order to be meeting the objective because the faster it goes the higher the chance there is to win.”

Observations of Success

- Failure leads to success
- Negotiations (Requirements trades and deviations)
- Backward design to identify requirements, how to test
- Self assess
- Experimentation increased
- Modeling of system

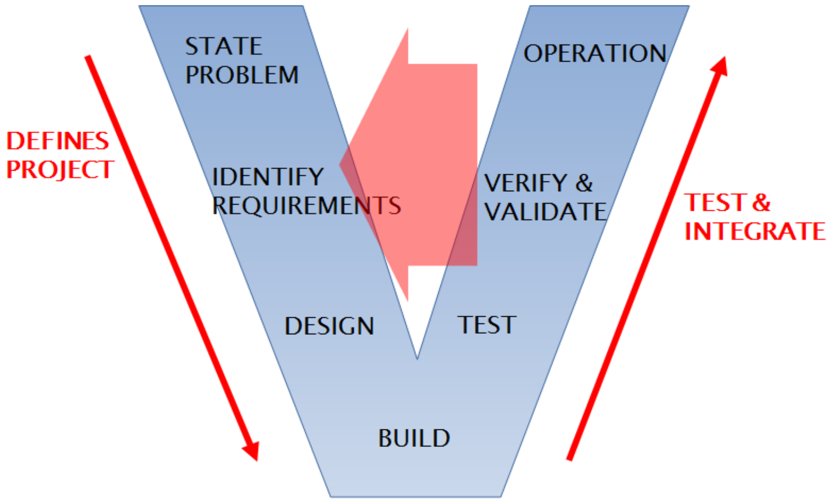


Other Applications

- Chemistry: Design a device to keep the finger cold. (thermo)
- Environmental Science: Find a property that would support off-grid living
- Biology: Microbial fuel cell grant from INCOSE
- Middle School and Elementary pilots

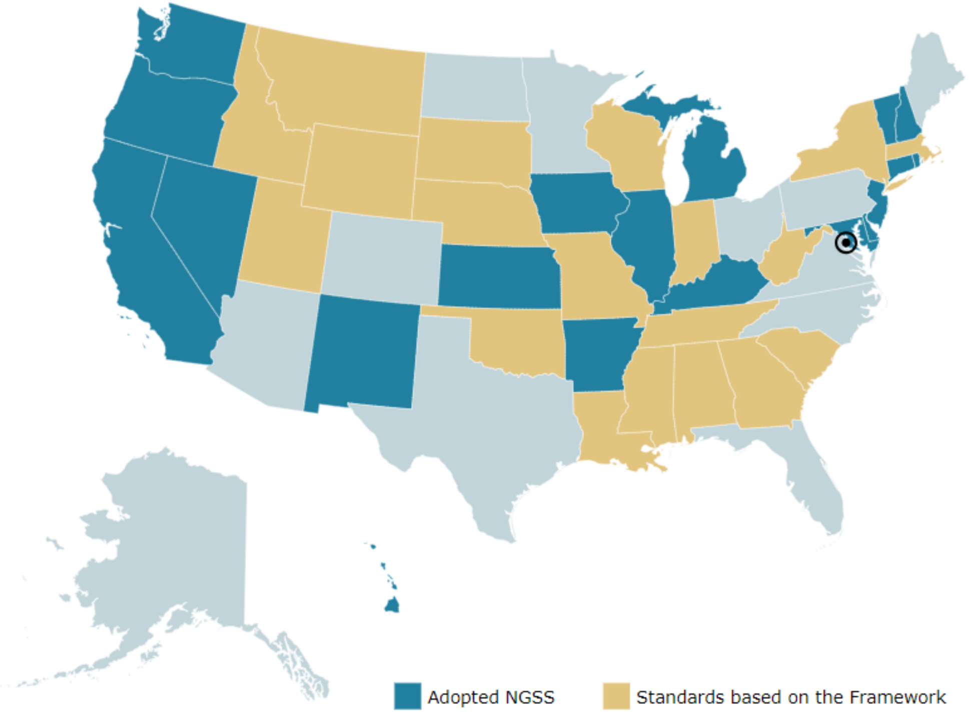
SUMMARY

- Validated it works for
  - Students
  - Teachers
  - Across grade levels
  - Across subjects



Next Steps

- Action Items



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References

California Alliance for NGSS CA4NGSS.org

California Department of Education's webpage: http://www.cde.ca.gov/pd/ca/sc/ngssintrod.asp

California Science Teachers Association (CSTA)'s webpage: http://www.cascience.org/csta/ngss.asp and monthly newsletter, "California Classroom Science": http://www.classroomscience.org/

Achieve's Next Generation Science Standards website: http://www.nextgenscience.org/signup

National Science Teachers Association (NSTA)'s NGSS@NSTA website: http://ngss.nsta.org/ http://ngss.nsta.org/About.aspx

STEM Teaching Tool http://stemteachingtools.org/

Engineering Standards

- Analyze a major global challenge to specific qualitative and quantitative **criteria and constraints for solutions** that account for societal needs and wants.
- Design a solution to a complex real-world problem by **breaking it down into smaller, more manageable problems** that can be solved through engineering.
- Evaluate a solution to 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.
- 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.**

What SKILLS do students need?

Top 10 skills

in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

Source: Future of Jobs Report, World Economic Forum 2016