Creating PreK-12 STEM Pathways through Integrated STEM Units

About the Units

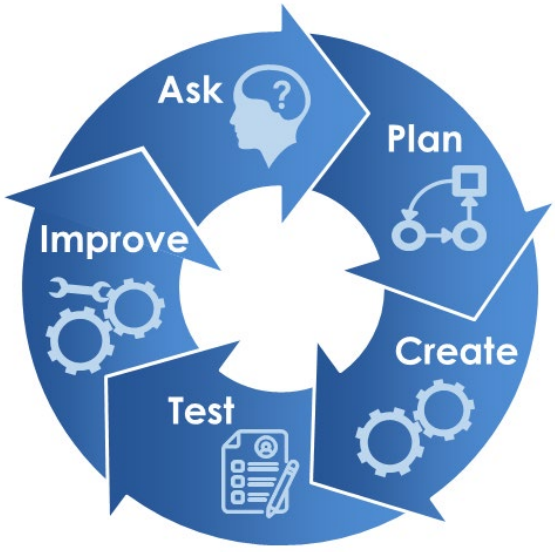
Teacher leaders from Tracy Unified School District in California came together to develop and implement 52 integrated STEM units that align to state and national learning standards. For grades PreK–5, the units take place during the science portion of the school day. For grades 6–12, the units take place in core math and science courses. Regardless of grade level, each unit focuses on an anchoring design challenge and lasts several weeks. Each unit integrates learning standards from the following STEM areas:

Science: Units focus primarily on one grade- or course-specific focal standard (performance expectation) from the *Next Generation Science Standards*. For grades PreK–5 and core science courses in grades 6–12, this is the primary standard of focus. In core 6–12 math courses, the science standard is complementary.

Technology (Computer Science): Each unit integrates one or more standards from the state-adopted computer science standards which are based on the national *K–12 Computer Science Framework*. Students develop at least one computational artifact during each unit.

Engineering: The units follow a five-phase engineering design challenge. Each unit maps the engineering standards (performance expectations) for each grade band of the *Next Generation Science Standards* to one of the five phases of the engineering design process.

Mathematics: Units also integrate math learnings from the *Common Core State Standards*. For core math courses in grades 6–12, one focal math standard typically serves as the primary learning standard for the unit. For grades PreK–5 and core science courses in 6–12, the math standard is complementary.



The Engineering Design Process (EDP)

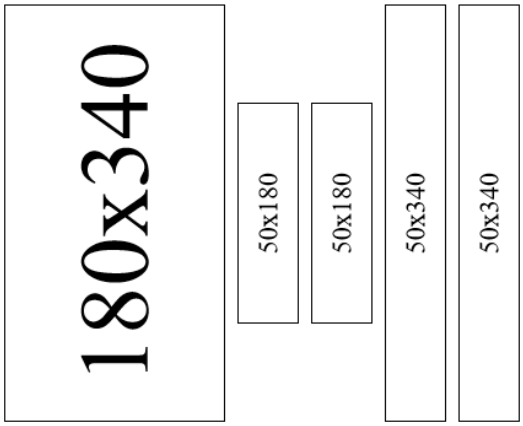
Each unit centers on an anchoring design challenge that persists over a period of weeks. During this period, instruction follows a project-based learning approach whereby students engage in all five phases of an engineering design process to develop an object, process, or system that brings a solution to a problem, desire, or need.

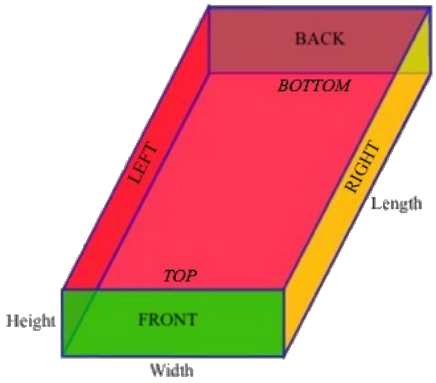
As an example, students in Grade 6 Math engage in a challenge to develop a model swimming pool with color tiles and tape within a given set of constraints. Students ask questions about the challenge and set out to plan their models. Students build their models and later test their models to see how much water the pool can hold and how well it holds water. Based on testing results, students modify their model pools to get better testing results.

Computer Science Technologies

At some point within each unit, students develop a computational artifact. The artifacts result from students learning the concepts and practices contained within the state standards for computer science. Throughout the PreK–12 STEM pathway, students work with a variety of software and hardware components. Sample computational artifacts include:

- Computer-aided designs
- Simulations of objects colliding
- Graphic depictions of data results
- Three-dimensional models
- Programmed robots



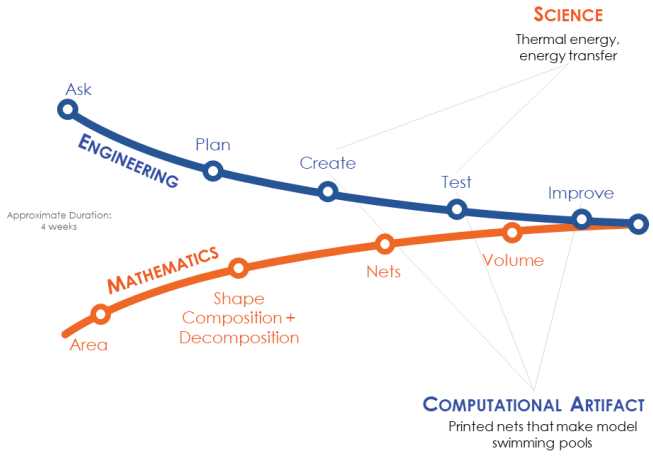


Continuing with the Grade 6 Math example, students use a coding program to generate faces for their model pools that are printed out and taped together to form a paper model of their pool.

Four Major Sections of Each Unit

The Big Picture

This section conveys the larger aspects of the unit—namely how the four STEM areas come together, the primary aim for each STEM area in the unit, and a suggested sequence to unfold the unit over time for students.



Pictured above is the Integrated Unit Storyline for the Grade 6 Math example. It depicts how the engineering design process interacts with key mathematics content over the four-week period. It also shows where the complementary science content comes into play as well as when students develop the computational artifact.

STEM Dive

This section fleshes out greater detail for each of the four STEM areas in the unit. It also includes literacy and language integrations for the unit.

The Mathematics portion of the Grade 6 Math STEM Dive below identifies the focal and related standards for mathematics in the unit:

> Focal Standard: 6.G.4 Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.
>
> Related Standards: 6.G.1, 6.G.2

Assessment Tools

The tools in this section help teachers gauge student progress at various points in the unit—specifically, at the beginning of the unit, throughout the engineering design process, and once the culminating design solution is complete.

The student prompts below come from the Student Experience Inventory for the Grade 6 Math example. The inventory serves as a way for teachers to build relationships with their students and to learn about students' lived experiences, enabling teachers to shape unit experiences to best meet students where they are at.

- *Think about a swimming pool you have seen, heard about, or played in. What do you remember about it?*
- *Tell me about a time you have ever used, seen, or heard of someone using a net to do something.*
- *What kinds of things have you built or put together before?*

Engagement

This section provides engagement ideas and materials lists for conducting the design challenge in classroom and distance learning settings.

The excerpt below comes from the Community and Career Connections for the Grade 6 Math example. This resource puts forth related STEM professionals with whom students can connect during the design challenge, including sample questions:

City Inspector (Public Services)

- *What features of a pool do you inspect?*
- *What tools does pool inspection require?*
- *What happens if an inspector finds design flaws?*

Unit Titles by Grade/Course with Focal Standards

Elementary Units

Pre-Kindergarten (CA Learning Foundations)
- Repurpose some refuse (ES.2.4)
- Stand up a structure (PS.2.2)
- Build a birdfeeder (LS.2.2)
- Design a sun-blocking item (ES.2.2)

Kindergarten
- Redirect a moving ball (PS2-2)
- Design a sun-blocking structure (ESS3-2)
- Rehome an animal (ESS3-1)
- Create an environmental tool (ESS3-3)

First Grade
- Protect a water balloon (LS1-1)
- Design a sound-generating device (PS4-4)
- Design a light-generating device (PS4-4)
- Build a time-telling tool (ESS1-1)

Second Grade
- Disperse the seeds (LS2-2)
- Design a playground (PS1-2)
- Model the land (ESS2-2)
- Slow the damage (ESS2-1)

Third Grade
- Move that toy (PS2-1)
- Protect the plant (LS3-2)
- Simulate an animal adaptation (LS3-2)
- Weather a windstorm (ESS2-1)

Fourth Grade
- Model a pollinator (LS1-1)
- Safeguard a vehicle (PS3-3)
- Withstand an earthquake (ESS3-2)
- Power a device (PS3-4)

Fifth Grade
- Make a pancake (PS1-4)
- Simulate an eco-disruption (LS2-1)
- Filter the water (ESS2-1)
- Drop a parachute (PS2-1)

Secondary Units

Sixth Grade
- Print a pool (Math, G.4)
- Build a business model (Math, SP.4)
- Create a cooler (Science, PS3-3)
- Create a community (Science, ESS3-3)

Seventh Grade
- Build a bungee (Math, RP.2)
- Mold the ice (Math, G.6)
- Envision an ecosystem (Science, LS2-3)
- Save our smelt (Science, LS2-5)

Eighth Grade
- Figure a flight (Math, SP.1)
- Calibrate a collision (Math, EE.8)
- Engineer a gene (Science, LS3-1)
- Create a cable (Science, PS4-3)

Algebra I
- Rig up a ramp (F-IF.4)
- Package a phone (S-ID.6.A-C)

Geometry
- Design a windmill (G-CO.5)
- Develop an algorithm (G-SRT.5)

Algebra II
- Plan a pendulum (A-CED.2)
- Set up a fire alarm (A-CED.2)

Biology
- Build a bioreactor (LS2-3, LS2-7)
- Model a protein (LS1-1)

Chemistry
- Create a calorimeter (PS3-1)
- Model the mitigation (ESS3-6)

Physics
- Design a crash cart (PS2-3)
- Build a light show (PS3-3)

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Visit prek12stem.com to learn more. Contact Scott Reynolds at stem@ctacusa.com for more information.

PreK-12STEM
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Tracy Unified School District