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SFUSD
Science Teaching Toolkit

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What is the SFUSD Science Teaching Toolkit?

This toolkit is designed to be a practical source for strategies and ideas to support your scientifically powerful classroom. While the SFUSD Science Core Curriculum itself—the units built upon the 5E Instructional Model —is the “what,” this toolkit represents the “how.”

When working to implement the Next Generation Science Standards, two central challenges are:

1. *Designing and/or selecting instructional tasks* that provide opportunities for students to simultaneously engage with science practices and learn core concepts.
2. *Providing and managing opportunities* for students to talk productively with one another about their problem solving approaches, solutions, models, etc.[1]

The SFUSD Science Department has created this Science Teaching Toolkit to support teachers and students as we continue our move away from a more directive style of teaching science and toward a more student-centered style. It is designed to be a practical resource of teaching strategies and tools that allow all our students the opportunity to grapple with cognitively demanding science tasks in a discourse-rich classroom environment. We firmly believe that a powerful science classroom involves shared sense-making within a community of learners.

The SFUSD Science Core Curriculum promotes discourse in the teaching and learning of science. Our role as a teacher is described, in broad terms, as a facilitator who is listening carefully to students, framing appropriate questions, and mediating competing perspectives. However, this is not to be interpreted as “teachers stay out of the way and students will learn.” In fact, a teacher’s role is proactive and includes:

- ❖ Designing lesson sequences that promote student learning through discourse;
- ❖ Beginning the lesson with a carefully presented launch;
- ❖ Guiding the lesson with facilitated group work and class discussion;
- ❖ Summarizing the lesson to bring out students’ insights while mitigating possible misconceptions.

We hope you continue to find this toolkit a practical and useful resource as you create powerful science learning for your students.

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[1] Cartier, Jennifer L., Margaret Schwan. Smith, Mary Kay. Stein, and Danielle K. Ross. *5 Practices for Orchestrating Productive Task-based Discussions in Science*.

SFUSD Science Department Guiding Principles

The Value of Science Learning in SFUSD

- Science education develops and sustains students' curiosity, appreciation and wonder about the world.
- Science education prepares and inspires students to participate in analysis and decision-making that affects the well-being of themselves, their community and the environment.

What Science Learning Looks Like in SFUSD

- Students engaged in multimodal and hands-on activities with ample opportunity to make meaning through experimentation, productive discourse, scientific reading, and scientific writing.
- Students connected to and actively participating in their local and global communities.
- Students, teachers, families, and the scientific community learning collaboratively.
- Teachers and students observing, listening, thinking, tinkering, and questioning.

Instructional Shifts of the NGSS

With a move to the NGSS come more than just changes to the science content that students will learn. The NGSS also include a significant shift in how students will show what they have learned. These changes for students require a shift in how teachers will need to teach. In our new Science Core Curriculum, we aim to promote these shifts to help teachers manage changes to their pedagogy and to support students as they appropriate these new ways of knowing. In our classrooms we expect to see fewer lectures (though there are still times for lectures) and more time spent with students making sense of concepts through hands-on learning, reading and talking to peers. We expect to see fewer laboratory experiments with one outcome and more investigations with ranges of outcomes that can lead to deeper scientific understandings. We expect to see fewer worksheets and more students writing in notebooks,and making reports, posters, and media presentations that include explanations using evidence. To help support students and teachers with these shifts, we have identified various signature strategies and approaches to the teaching and learning of science.

Signature Strategies and Approaches

In thinking about how to implement a new curriculum, we wanted to be sure that we were supporting teachers and students in all aspects of the curriculum: content, pedagogy, and assessment. In each of these areas, the NGSS has very different expectations than our prior standards. By focusing on a small subset of strategies and approaches, we believe that we will be able to support teachers and students with the transition to our new standards. Additionally, we believe that with our curricular and pedagogical choices, we will have students that are more fully engaged in their learning and teachers that are more excited about their teaching.

The 5E Instructional Model

When the sequence of science activities aligns with the way that people learn, students learn more effectively. The science education community has articulated and refined an effective sequence often called the 5E instructional model[2]. The 5E model provides a structure for planning a sequence of instruction that places students at the center of their learning experiences, encourages them to explore, construct their own understanding of scientific concepts, and relate those understandings to other concepts.

In this cycle, students
1) are *engaged* by some sort of hook that relates to their interest;
2) have time to *explore* ideas on their own before formal instruction;
3) *explain* their observations using models;
4) *elaborate* and expand on the new learning by applying it to a new context; and in the end,
5) *evaluate* and reflect on their own learning.

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[2] Bybee, R. W. 1997. Achieving scientific literacy: From purposes to practices. Portsmouth, NH: Heinemann

The 5E Instructional Model is a feature of the SFUSD Core Curriculum and was used to design all of the units that make up each NGSS-aligned science course.

5E	Definition	Teacher Behaviors	Student Behaviors
Engage	✓ Generate interest ✓ Access prior knowledge ✓ Connect to past knowledge ✓ Set parameters of the focus ✓ Frame the idea	✓ Motivates ✓ Creates Interest ✓ Taps into what students know or think about the topic ✓ Raises questions and encourages responses	✓ Attentive in listening ✓ Asks questions ✓ Demonstrates interest in the lesson ✓ Responds to questions demonstrating their own entry point of understanding
Explore	✓ Experience key concepts ✓ Discover new skills ✓ Probe, inquire, and question experiences ✓ Examine their thinking ✓ Establish relationships and understanding	✓ Acts as a facilitator ✓ Observes and listens to students as they interact ✓ Asks good inquiry-oriented questions ✓ Provides time for students to think and reflect ✓ Encourages cooperative learning	✓ Conducts activities, predicts, and forms hypotheses or makes generalizations ✓ Becomes a good listener ✓ Shares ideas and suspends judgment ✓ Records observations and/or generalizations ✓ Discusses tentative alternatives
Explain	✓ Connect prior knowledge and background to new discoveries ✓ Communicate new understandings ✓ Connect informal language to formal language	✓ Encourages students to explain their observations and findings in their own words ✓ Provides definitions, new words, and explanations ✓ Listens and builds upon discussion from students ✓ Asks for clarification and justification ✓ Accepts all reasonable responses	✓ Explains, listens, defines, and questions ✓ Uses previous observations and findings ✓ Provides reasonable responses to questions ✓ Interacts in a positive, supportive manner
Elaborate	✓ Apply new learning to a new or similar situation ✓ Extend and explain concept being explored ✓ Communicate new understanding with formal language	✓ Uses previously learned information as a vehicle to enhance additional learning ✓ Encourages students to apply or extend the new concepts and skills ✓ Encourages students to use terms and definitions previously acquired	✓ Applies new terms and definitions ✓ Uses previous information to probe, ask questions, and make reasonable judgments ✓ Provides reasonable conclusions and solutions ✓ Records observations, explanations, and solutions
Evaluate	✓ Assess understanding (self, peer, teacher) ✓ Demonstrate understanding of new concept by observation or open ended response ✓ Apply within problem situation ✓ Show evidence of accomplishment	✓ Observes student behaviors as they explore and apply new concepts and skills ✓ Assesses students' knowledge and skills ✓ Encourages students to assess their own learning ✓ Asks open-ended questions	✓ Demonstrates an understanding or knowledge of concepts and skills ✓ Evaluates his/her own progress ✓ Answers open-ended questions ✓ Provides reasonable responses and explanations to events or phenomena

ABC-CBV

The acronym ABC-CBV (Activity Before Concept, Concept Before Vocabulary) provides a guide for how teachers can best sequence learning experiences to support students with developing conceptual understanding. "Instead of presenting and explaining a concept and then launching into activities and investigations, ABC teaching begins with the activity or investigation so students first have an opportunity to interact directly with phenomena, objects, or materials before being presented with the concept. ABC can be extended with CBV (concept before vocabulary). After students have been presented with the concept, which they can attach to the activity they experienced, the vocabulary is then introduced."[3] This sequence of learning is exemplified by the 5E instructional model. By starting each subunit of learning through Engage and Explore activities, all students will have experiences and develop questions about the phenomenon or science concepts in the subunit (ABC). As students move through the Explain they begin to identify and use the science vocabulary that is essential for the concepts that they are learning. In the Elaborate and Evaluate, students have opportunities to show their new understanding of the concepts and vocabulary by using their own words to show their learning in novel situations (CBV).

Science Notebooking

Science notebooking provides students with a place for their learning. By keeping a notebook and using it to organize thoughts, ideas, questions, observations, and data, students - and their teachers - can chronicle learning over time. While there are some different design elements to various notebooking traditions, nearly all include a Table of Contents, page numbers, and space for student writing and reflection. Students' science notebooks should be a safe place for students to think about their learning, to collect important observations about their science experiments, to save drawings and data, and to make sense of their experiences. Not all teachers grade notebooks, but rather periodically review students' notebooks to provide feedback on the scientific accuracy of their thinking. Regardless, Science Notebooking is one of our district strategies that we believe will help bring science thinking and learning to every student in a way that works for them.

[3] Konicek-Moran, Richard, and Page Keeley. *Teaching for Conceptual Understanding in Science*

Structures for Collaboration and Instruction: Promoting Student Talk in the Science Classroom

In the NGSS, students are expected to take on a large role of sense-making in the classroom. Rather than having a teacher provide the main learning points, students will have experiences that build on each other to help them develop robust and complex ideas about science phenomena and concepts. In order to promote student learning, teachers will need to provide spaces where students feel safe making mistakes, getting feedback from other students, providing feedback to other students, and checking themselves and others for understanding. By responding to students with high-level questions, students can be supported in analyzing, synthesizing and applying information, rather than simply memorizing facts from a textbook. From adjusting wait time to developing norms around questioning, teachers can promote more student talk in the classroom. This, in turn, can help support students as they make sense of challenging science content. Some resources for supporting classroom conversations and questioning strategies are:

- 3 Goals 8 Talk Moves to Engage English Learners in developing their understanding through talk
- Talk Moves Cards to provide learners with sentence starters to guide academic conversations adapted by Christina Huizar from Jeff Zwiers & Marie Crawford Academic Conversations pp 32-33
- Conversation Norms and Sample Lessons to teach learners how to have academic conversation adapted from Jeff Zwiers & Marie Crawford Academic Conversations pp 32-33

Claim Evidence Reasoning (C-E-R)

- **Claim + Evidence + Reasoning -** The use of scientific argument is the means by which scientists advance hypotheses which may later become scientific theory. Using a framework for scientific argument is a means for students to demonstrate their understanding of scientific principles by investigating a claim or claims and connecting evidence that they generate or learn about to a claim. Ultimately, students should be able to put their argument into writing.

Project Based Learning (for Middle School & High School Physics)

Project Based Learning (PBL) is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging and complex question, problem, or challenge.

Aspects of PBL that SFUSD focuses on:

Challenging Problem or Question
Sustained Inquiry
Authenticity
Student Voice & Choice
Reflection
Critique & Revision
Public Product

Adapted from: https://www.bie.org/about/what_pbl

Groupwork (for Middle School)

Groupwork can help students develop a host of skills that are increasingly important in the professional world. Positive group experience have also been shown to contribute to student learning and retention.

Properly structured, groupwork can reinforce skills that are relevant to both group and individual work, including the ability to:

- Break complex tasks into parts and steps
- Plan and manage time
- Refine understanding through discussion and explanation
- Give and receive feedback on performance
- Challenge assumptions
- Develop stronger communication skills.
- **Video** Supporting Language and content learning to provide Newcomers access to content (graphing)
- Participation Quiz: Real time feedback on group work and norms

Other Strategies for Supporting Science Learning

1. Sense-Making Strategies

In the past, much of the sense-making that occurred in classrooms happened by teachers and was shared with students. The NGSS expect students to be the main drivers in the sense-making of science content. As a result, teachers have the responsibility of providing relevant science experiences for students and for providing students with the space to think about their ideas, propose new ideas, get and provide feedback about those ideas, and to come up with new ideas if needed. In support of providing students with opportunities to make sense of their science content, SFUSD is encouraging teachers to model the following strategies with their students.

Strategies and resources to support sense-making:

- Mark it Up
  - Annotating text is a way for students to identify key information and/or parts of a text that they do not understand. This can include main idea(s), claims, relevant data/evidence, significant phrases, academic and/or discipline specific vocabulary.
- Concept Mapping
  - Through the creation of concept maps, students can show other students and teachers their thinking about how different concepts connect to one another. This gives us insight into how this student grasps the science content in question - revealing both the limits of their knowledge and any misconceptions that may have developed. By revisiting concepts maps over time, and reviewing other students' maps, students can deepen their understanding and make more accurate and interesting connections among various science ideas.
  - The purpose of this concept map is to promote language development throughout the unit. Allowing students to give names to concepts and to share their ideas about how the concepts are related will help their oral and written language development.

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2. Strategies to Address the Language Demands of Science

Strategies and resources to support meeting the language demands of science:

- Anticipatory Guide:
  - Anticipation guides are useful for activating students' prior knowledge about science concepts and focusing students' attention on key content in a text.

- A Close Reading Protocol for Science Text:
  - Close reading encompasses the habits of reading that proficient readers develop such as using their metacognitive skills to better comprehend what they are reading.

- Listening Triads:
    - Listening triads are an easy strategy for structuring small group reading and discussion. They give students practice in active listening and monitoring their own comprehension as they read.

- Paired Reading
    - This activity links dialogue and reading to enhance student comprehension of text and can ultimately lead to some form of writing assignment. Students are asked a question and/or given a focus for their reading. They are then given the opportunity to express their ideas about what they will read and what they might learn. Partners then take turns reading and summarizing what has been read, and when finished, revise their original thinking as needed.

- Think Pair Share
    - The Think-Pair-Share strategy is designed to differentiate instruction by providing a structure to individually think and respond to a scenario/problem/question before sharing and discussing with a partner and then share with a whole group or cross groups.

- Stop and Check:
    - Chunking is used to breakdown challenging text of any length. It forces students to stop and digest dense text and rephrase or create a representation of the key concept.

- Stronger and Clearer:
    - The purpose of this activity is to help students strengthen and clarify their academic ideas. Each time they talk to a partner, they build from and borrow the ideas and language of previous partners. Students should try to make their answer stronger each time with better and better evidence, examples, and explanations; and try to make their idea clearer each time by using a topic sentence, logical ways to organize and link sentences, and precise words.
- Fostering Heterogenous Collaboration:
- SERP: Read to Learn in Science:
    - Link to Stanford and SERP Media's work in identifying the challenges of reading scientific text and strategies to support all learners before, during and after a reading task.

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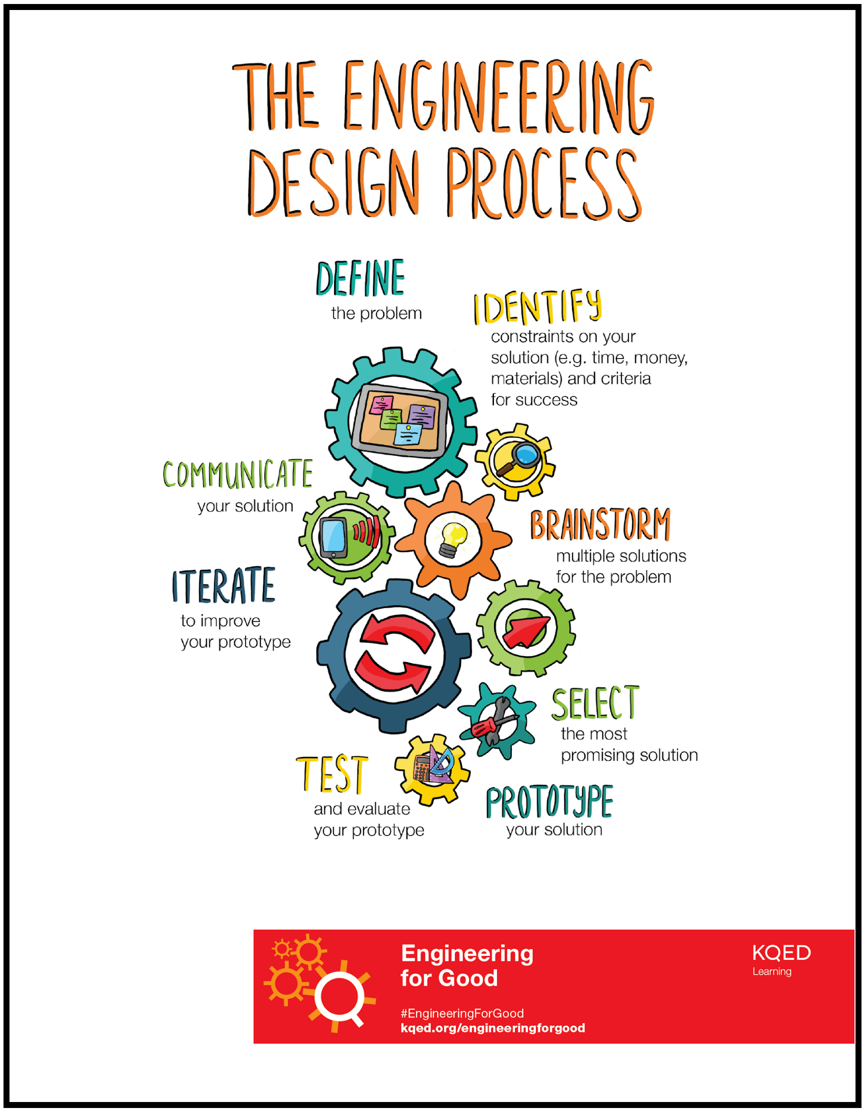
3. Intentional Use of Technology in the Science Classroom

Strategies and resources to support the intentional use of technology in the science classroom:

- Finding the Technology within the NGSS Science and Engineering Practices
- Using Technology for Gathering and Manipulating Data
- Using Simulations to Support Science Learning
- Developing Data Literacy Using Tuva

4. Supporting Students in Engaging in the Engineering Practices

- There are many different engineering design processes, but they all share many of the same components. KQED has created a graphic of the design process that clearly - and artistically - illustrates the process for students and teachers. All engineering design processes require students to identify a problem, brainstorm ideas, and select the best from among the ideas, after considering various criteria and constraints, to create a prototype of a solution. Then, after testing the prototype, you create new versions of your prototype - often quickly - to fine-tune your solution. To see how the engineering design process relates to a taco party, visit http://tinyurl.com/KQEDtacoparty or click here.



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