TI STEM Exchange

Engaging Students in Science: Using Crosscutting Concepts to Prompt Student Sensemaking of Phenomena

May 3, 2022 6:00 – 7:30 pm CT

TI STEM Exchange

Texas Instruments

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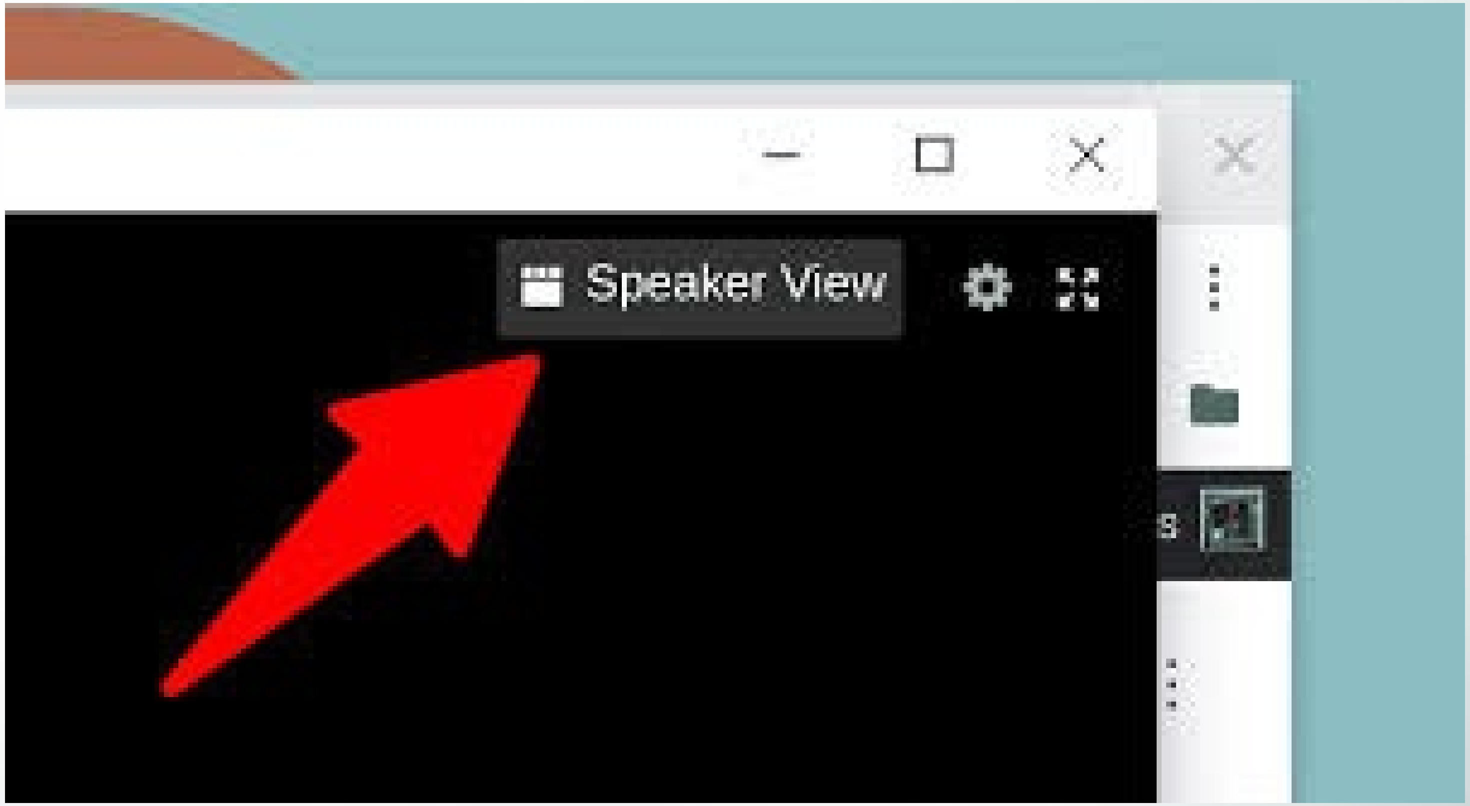


MODERATOR

Stacey van der Veen

Founder and Lead Consultant, LLC Leadership in Science

Stacey has extensive experience supporting school districts implementing the Next Generation Science Standards (NGSS). Before founding Leadership in Science, she was the Manager of Education Programs for the Merck Institute for Science Education (MISE).. She started her career teaching science and math at high schools in Newark, New Jersey, and New York City and has over 20 years of K–12 teaching and administrative experience. Stacey earned her master's in secondary science education from the Harvard Graduate School of Education and her B.A. in biology from the University of Pennsylvania.

@leadinsci

Tonight’s Presenters

PANELIST

Brett Moulding

Director of Professional Development, Partnership for Effective Science Teaching and Learning

Brett taught chemistry for 20 years, served at the Utah State Office of Education for 15 years, and was a lead writer on the Next Generation Science Standards (NGSS), as well as being deeply involved in the development of “A Framework for K-12 Science Education,” and “Science and Engineering for Grades 6-12: Investigation and Design at the Center.” He has provided professional learning across the country and has published books in support of these works and strategies to effectively engage students in three-dimensional science learning.

@ti_calculators

PANELIST

Rachael Manzer

STEM Coach, Winchester Public Schools

Rachael is a STEM Coach for Winchester Public Schools in Connecticut and recognized science leader. She served as President of the Connecticut Science Teachers Association, the K-8 Science Curriculum Leadership Team, and on the State-Federal STEM Education Summit. In addition to coaching 4-H robotics teams to the world championships, Rachael works side by side with teachers to implement the NGSS. She is completing a doctorate in curriculum and instruction at the University of Connecticut..

@RachaelManzer

PANELIST

Candace Penrod

Science Supervisor, Salt Lake City School District

Candace brings over 25 years of experience to her work toward science access for all. She is the co-founder of the Utah STEM Ecosystem with a focus on cradle-to-career STEM access, opportunity and education. She holds Master of Education and a Master of Science degrees from the University of Utah, and is currently pursuing a doctorate degree in science education at Utah State University. She sears of the board for the National Science Educator Leaders Association and the Utah Science Teachers Association.

Engaging Students in Science: Using Crosscutting Concepts to Prompt Student Sensemaking of Phenomena

TI STEM Exchange
May 4, 2022
7:00 – 8:30 pm ET

Tonight's Agenda

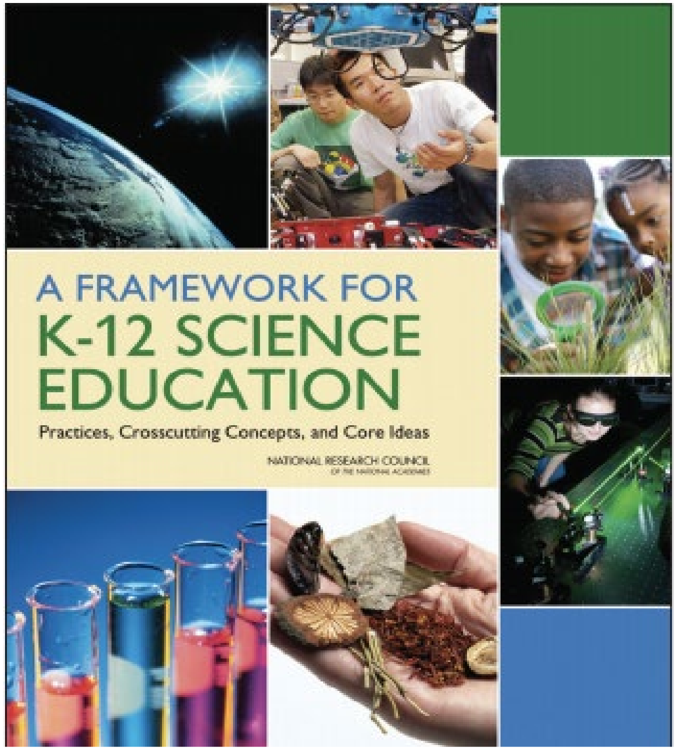
During tonight's session we will:

- **Discuss** how Crosscutting Concepts support student science learning
- **Demonstrate** how Crosscutting Concepts can help students make sense of phenomena
- **Practice** integrating Crosscutting Concepts into student performances

Student Science Performances

The NGSS and state standards aligned to the *NRC Framework for K-12 Science Education* are assessment standards. These standards describe performance expectations for sampling student learning.

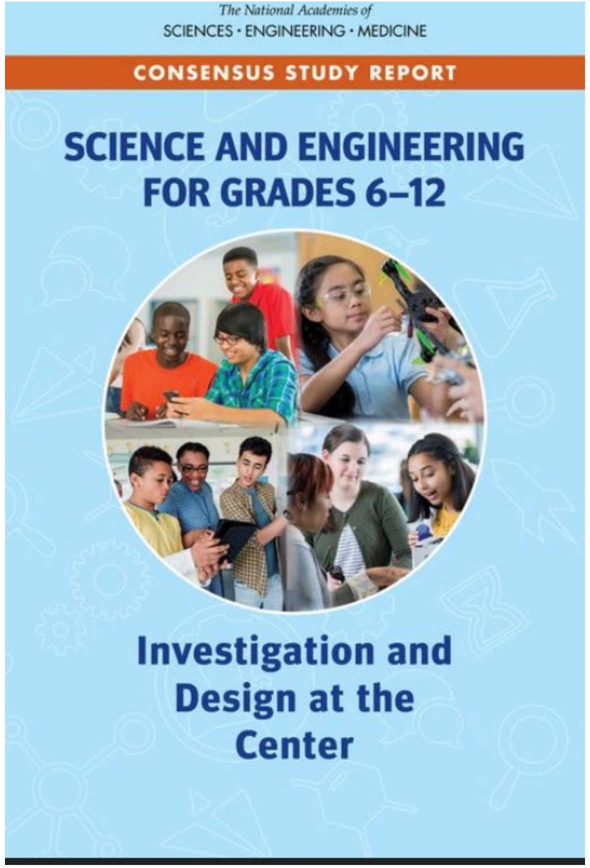
Curriculum and instruction are much broader than assessment standards, however, the student performances used to direct science investigation can and should be written as **three-dimensional student performances.**



Investigation and Design at the Center

"Engaging students in learning about natural phenomena and engineering challenges via science investigation and engineering design increases their understanding of how the world works. Investigation and design are more effective for supporting student learning than traditional teaching methods."

(National Academies of Sciences, Engineering, and Medicine. 2019. Science and Engineering for Grades 6-12: Investigation and Design at the Center. Washington, DC: The National Academies Press. https://doi.org/10.17226/25216)



Science Investigation

"**Scientific Investigation**" is the full endeavor of students doing science. Investigation engages students in using multiple practices, crosscutting concepts, and core ideas to develop explanations for the causes of phenomena.

Scientific Investigation is more than NGSS Practice #3, "planning and carrying out investigations."

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information.

Student Science Performances Instructional Sequence

The sequence of science performances in an investigation is essential to provide students with the evidence needed to construct explanations and develop arguments for how the evidence supports or refutes those explanations.

The sequence of performances begins with the phenomenon and continues to the performances students use to gather the evidence needed to support their explanations.

The **crosscutting concepts** focus the investigations.

Gather	• Obtain Information • Ask Questions/Define Problems • Plan & Carry Out Investigations • Use Mathematics & Computational Thinking • *Use Models to Organize Data and/or Information*
Reason	• Evaluate Information • Analyze Data • Use Mathematics and Computational Thinking • Construct Explanations/Solve Problems • Develop Arguments for why or how Evidence Supports Explanations or Claims • *Use Models to Predict & Develop Evidence*
Communicate Reasoning	• Communicate Information • Communicate Arguments (written/oral) for how the Evidence Supports an Explanation • *Use Models to Communicate Reasoning*

Instructional Sequences

Effective instructional sequences engage students in

- **Observing phenomena** and developing questions.
- **Gathering** data and information (e.g., developing questions, experiments, observational studies, simulations, reading, listening, models).
- **Reasoning** how the evidence students have gathered supports or refute an explanation for the causes of phenomena.
- **Communicate their reasoning** to self and others througl writing, speaking, and models
- Applying science learning to make sense of phenomena **beyond the classroom.**

The Dimension of Crosscutting Concepts

1. **Patterns:** Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
2. **Cause and Effect:** Events have causes, sometimes multifaceted. Deciphering causal relationships and the mechanisms by which they are mediated is a major activity of science and engineering.
3. **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
4. **Systems and System Models:** A system is an organized group of related objects or components: models can be used for understanding and predicting the behavior of systems.
5. **Energy and Matter:** Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.
6. **Structure and Function:** The way an object is shaped or structured determines many of its properties and functions.

<table>
<tr><th colspan="3">Organizing crosscutting concepts by how students use them
to make sense of phenomena</th></tr>
<tr><th>Causality</th><th>Systems</th><th>Patterns</th></tr>
<tr><td>Causes and Effect
Structure and Function</td><td>Systems are useful ways to describe phenomena in terms of the changes in matter, energy, and forces that affect the interaction of components of systems.</td><td rowspan="2">Patterns can be used as evidence to support explanations.
Patterns give observation greater meaning.
Science seeks causes of naturally occurring patterns.</td></tr>
<tr><td rowspan="2">The things we study in science have causes. The causes can be described in terms of cause and effect or how the structure determines the function.</td><td>Energy and Matter
Stability and Change
Scale – Proportion – Quantity</td></tr>
<tr><td>The proportion of components in a system affect how the system operates. Systems may operate differently at different scales or</td><td>Patterns</td></tr>
</table>

Crosscutting Concept Focus Investigations

Crosscutting concepts are useful for focusing the investigation of phenomena occurring within and among systems.

- **Focus** investigation on **causality** of phenomena
  - Determine how structure affects the function of phenomena. Determine the causes of phenomena.

- **Focus** investigation on phenomena occurring in **systems.**
  - The cycling of matter among systems.
  - The flow of energy among systems.
  - The proportion of components in the system.
  - Stability or changes in systems.

Using Crosscutting Concepts to Focus Student Performances

Construct an explanation for why few organisms live in the Great Salt Lake.
Investigate how roots work to help plants live.
Construct an explanation for how sunlight speeds up a chemical reaction.

Using Crosscutting Concepts to Focus Student Performances

Construct an explanation for why few organisms live in the Great Salt Lake.	Construct an explanation for how the **proportion** of salt in the water **affects** the diversity of organisms living in the Great Salt Lake.
Investigate how roots work to help plants live.	Investigate how the **structure** of roots **functions** to help plants live.
Construct an explanation for how sunlight speeds up a chemical reaction.	Construct an explanation for how the **transfer of energy** from sunlight **affects** the rate of chemical **change**.

Adding Crosscutting Concepts to Questions

Phenomenon: Last week, I had a cut on my hand, and now it has healed.

What did you notice about the healing cut? →	What patterns of change did you observe over time as the cut healed?
Describe the layers of skin and their composition →	How do the components of the skin system interact to provide the matter needed to heal?
What are the phases of mitosis? →	How does the structure of a skin cell change to produce new cells to heal the cut?

Breakout Group Activity:

Phenomenon: Frozen fish thaw faster when sitting on the countertop than on a dishcloth.

Add crosscutting concepts to the tasks below to focus student performances.

1. Develop questions to investigate the phenomenon.
2. Plan an investigation to gather evidence to explain the phenomenon.
3. Develop a model to show why the ice on the countertop melts faster than the ice on a towel.
4. Construct an explanation for why the ice melts on the countertop faster than on the towel.

Breakout Groups Instructions (15 minutes)

1. Once in your group introduce yourself to others joining you.
2. As a team, use the Breakout Group Discussion Sheet and add crosscutting concepts to each task written to the fish thawing phenomenon in order to focus each of the performances.
3. Try using a variety of crosscutting concepts to determine how each can be used to focus the student performances.
4. Discuss the advantages of using crosscutting concepts for student learning.

Welcome Back! Let's Share Out.

How Did the Inclusion of a Crosscutting Concept Affect the Task Description?

Green Leaves Investigation

Phenomenon: The top of a leaf is darker than the underside.

Class Discussion: *Questions to Initiate Discussion:*

*Q: What **patterns** in leaves did you observe across all of the species?*

*Q: How does the **structure** of the top side of a leaf differ from the bottom side?*

*Q: How is the **function** of the top of a leaf different from the leaf underside?*

*Q: What is the role of the leaves in the plant **system**?*

*Q: Why is **energy** input important to leaf cells?*

*Q: Why don't plants run out of the **matter** they need for photosynthesis?*

Is Two Better Than One?

- Crosscutting concepts are powerful tools to focus students' attention on key aspects of science phenomena.

- One way to enhance the use of crosscutting concepts is to use them in pairs or *couplets* to focus students' attention of causal relationships in phenomena.

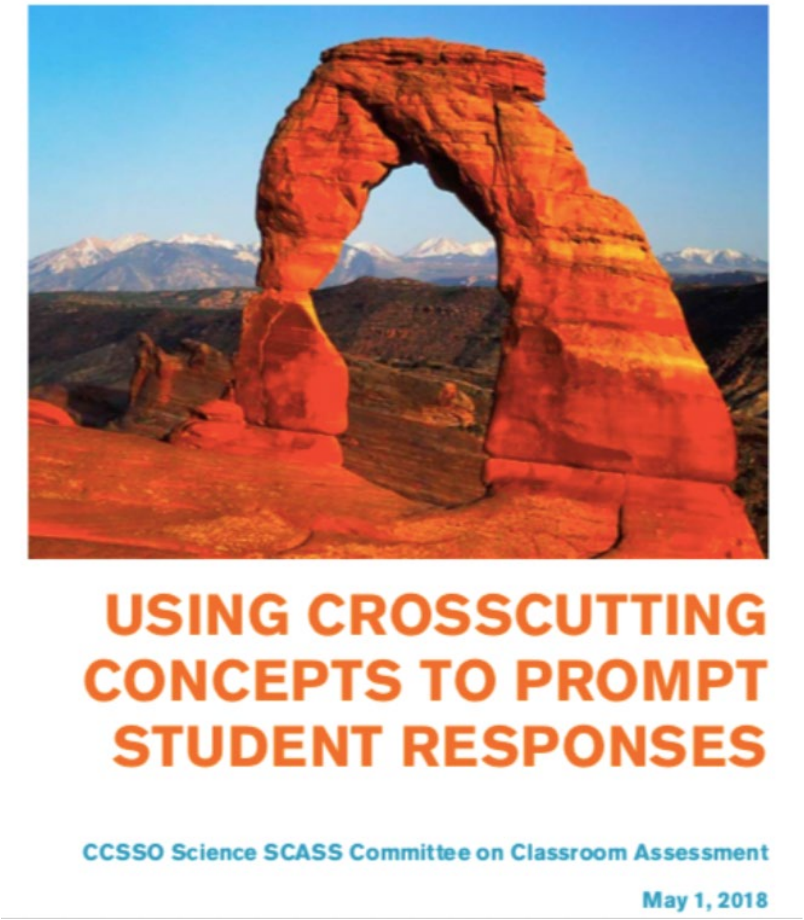
Coupling Crosscutting Concepts

Examples:

1. How does the proportion of salt in the solution affect the transfer of water across the cell membrane?
2. Why can some geological changes only be observed on a time scale of millions of years?
3. What patterns were observed in the composition of dye solutions that were stable compared to the dye solutions that were unstable when each was exposed to sunlight?
4. How does changing the concentration of lead in the water affect the proportion of large fish in the population?

Resources for Crosscutting Concepts

- *Appendix G of the Next Generation Science Standards* - Developed to provide deeper insight behind the crosscutting concepts this appendix includes nine guiding principles and tentative learning progressions across K–12.
- *Using Crosscutting Concepts to Prompt Student Responses* - This pdf document provides guidance on how to use "prompts structured around the crosscutting concepts" to support student sensemaking.



AHA Moments? Questions?

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Closing Comments

Engaging Students in Science Using Crosscutting Concepts

> *TI Education Technology is transforming the way teachers teach and students learn STEM (science, technology, engineering and mathematics) subjects.*

Vince O'Connell

Director of School Partnerships| Texas Instruments

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Check out our previous STEM Exchange events

https://education.ti.com/en/resources/ti-stem-exchange

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Thank you!

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