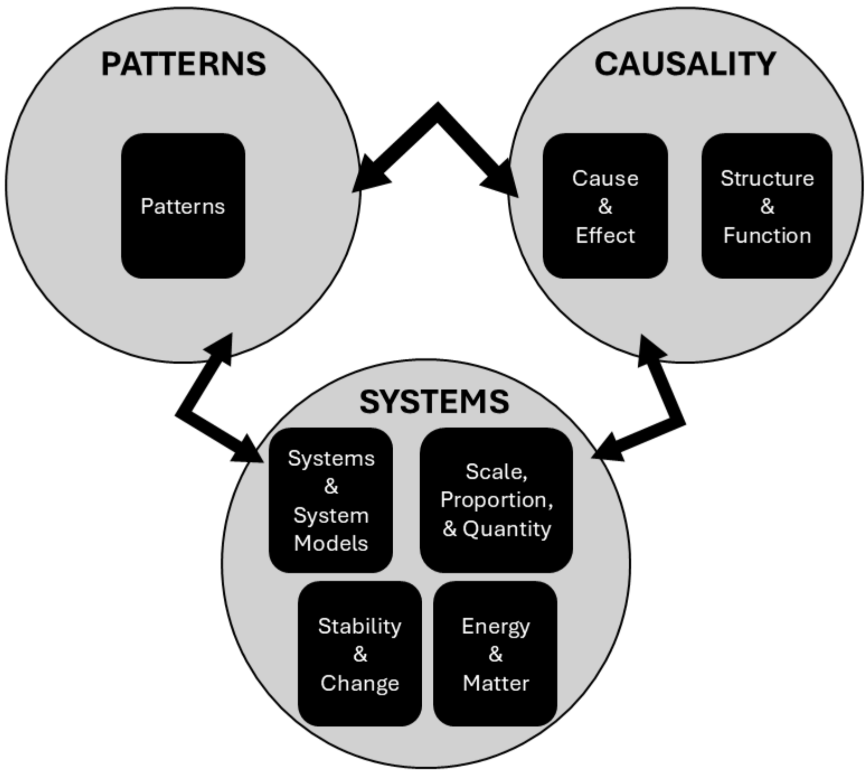
Using Crosscutting Concepts in Secondary Science Classrooms

Organizing Crosscutting Concepts to Support Student Reasoning

One effective way to organize Crosscutting Concepts (CCCs) is by clarifying how they support students' conceptual understanding. As students investigate phenomena or problems, they identify patterns that help explain causes of changes in systems, especially in relation to matter, energy, stability, scale, and proportion. To support this approach, CCCs can be organized into three groups:

- **Patterns:** Students are generally skilled at identifying patterns. When instruction explicitly highlights the CCC of Patterns, students become adept at using patterns as evidence. Often, phenomena or problems are observable patterns that occur in the natural and designed worlds.
- **Causality:** Students should understand that explaining the causes of phenomena or problems is central to the understanding of both the natural and designed worlds. The CCCs of Cause and Effect and Structure and Function can be used to initiate student reasoning about relationships.
- **Systems:** Using systems allows students to logically analyze the boundaries of a phenomenon or problem, describe interactions within a system, understand how a system relates to surrounding systems, and identify causes of changes in a system. These components are related to the CCCs of System and System Models, Energy and Matter, Stability and Change, and Scale, Proportion, and Quantity.



The following strategies support classrooms where CCCs are thinking tools that guide students as they observe, question, and explain the world around them:

- Use phenomenon-based instruction to anchor learning in real-world, complex scenarios.
- Develop a classroom culture of "figuring out."
- Use CCCs daily to support students in "figuring out" phenomena.
- Use CCCs to frame student-led investigations and support evidence-based discussions about complex or abstract systems.
- Provide opportunities for students to compare how a CCC applies across different science domains.
- Ask students to justify their use of a CCC in explanations.
- Encourage CCC language in classroom discourse.
- Support metacognitive reflection on how CCCs shaped their understanding or helped them revise their thinking.

Building on these general strategies, teachers can support student use of CCCs as powerful thinking tools by tailoring their approach to each of the seven CCCs. The following section provides sentence frames and prompts for each CCC, offering practical ways to help students articulate their thinking, make connections across scientific ideas, and reflect on how CCCs shape their understanding of phenomena and problems throughout the learning process.

Patterns

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Patterns Students identify repeated similarities in natural and designed systems. These patterns help them classify data, ask questions, and make predictions. In science and engineering, students use patterns as evidence to support explanations and solutions.	• What relationships did you notice in your observations? • What patterns did you notice in the phenomenon you were observing? • What do the relationships of patterns that you noticed mean for the science concept that our learning is focused on? • Do you expect this pattern to be stable over time? Why or why not? • The pattern that I noticed is _____ because _____. • If the [pattern observed] continues then I predict _____.	• Asking Questions and Defining Problems • Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Obtaining, Evaluating, and Communicating Information

Causality

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Cause and Effect Students investigate cause and effect relationships to explain how and why events happen. They explore both simple and complex causes and use this understanding to make predictions. In science and engineering, students test ideas about what causes change in systems.	• What happened? Why did it happen? • Did one event change or cause something else? • What relationships did you notice about these events? • What evidence supports the cause-and-effect relationship? • One cause of __ could be ___ because ___. • ___ caused ____. The evidence to support this is ___.	• Planning and Carrying Out Investigations • Engaging in Argument from Evidence

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Structure and Function Students explore how the shape and structure of an object, organism, or system affects what it can do. They analyze how parts work together and how structure supports function. In engineering, students design structures to meet specific needs.	• How does the way this object/living thing is put together help with its job? • What structure performs [function]? Why? • What about this structure allows this to [function]? • Can more than one structure perform the same function? Why or why not? • [Structure] performs [function] because ____. • I observed the [structure] and noticed ____ which helps with its function. • [Structure] and [structure] have the same function because _____.	• Asking Questions and Defining Problems • Developing and Using Models • Constructing Explanations and Designing Solutions • Obtaining, Evaluating, and Communicating Information

Systems

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Scale, Proportion, and Quantity Students use measurement and mathematical relationships to describe systems and phenomena. They consider how size, time, and energy affect what is observed. Changes in scale, proportion, or quantity can influence how a system behaves or performs.	• Why is scale important in this science idea? • How can we measure ___? Why? • Why might quantity be important with this science concept? • How can proportion make it easier to understand this science idea? • Scale is important to this concept because ____. • ____ was used to measure _____. • Proportion is important to the concept because ____.	• Analyzing and Interpreting Data • Using Mathematics and Computational Thinking • Developing and Using Models

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Stability and Change Students examine how systems remain stable or change over time. They analyze the conditions that support stability and the factors that drive change. Understanding these patterns helps students explain and predict system behavior.	• What evidence is there that the system is stable? • What changes appear to be happening in the system? • What will happen to the system over time? Will the system remain stable? Why or why not? • The system appears stable because ____. • ____ appears to be changing within the system. • The system (will/will not) remain stable over time because ____.	• Developing and Using Models • Constructing Explanations and Designing Solutions
Energy and Matter Students examine how energy and matter move into, within, and out of systems. They model and describe how energy is transferred and how matter is conserved. These observations help students explain phenomena and solve problems in both natural and designed systems.	• Where is energy/matter used in this system? • What is energy used for in this system? Is it converted or does it remain the same? • What happens to matter in this system? • Do energy and matter interact within this system? Why or why not? • Energy/matter is/are used in this system by ____. • Energy is important in this system because ____. • Energy or matter in this system changes from ____ to ____.	• Developing and Using Models • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence

Crosscutting Concept	Sample prompts and sentence frames to elicit student thinking about phenomena or problems	Science and Engineering Practices that often align to the concept
Systems and System Models Students develop an understanding of systems by identifying their parts and boundaries. They create models to represent how components interact within a system. These models help students focus on key relationships and explain or predict how the system behaves in natural and designed contexts.	• What are the connections between the parts of the system? • What is the result of the system? • What is each part of the system responsible for? • How can this system be modeled to show the components, the process, and the connections? Why did you choose this model? • The system parts are connected by ____. • The model of the system I chose is _______ because ___. • The system parts such as ___, ___, ___ work together to ____.	• Developing and Using Models • Analyzing and Interpreting Data • Constructing Explanations and Designing Solutions • Planning and Carrying Out Investigations

Tips for Using Crosscutting Concepts

CCCs are essential tools that help students connect ideas across science disciplines and make sense of complex phenomena. However, their power lies in not just naming them, but in how they are used to support student thinking. When CCCs are embedded meaningfully into instruction, they become cognitive tools that guide students in observing, questioning, analyzing, and explaining the world around them. This requires intentional planning and consistent opportunities for students to engage with CCCs in varied and authentic contexts.

Teachers can support this process by modeling CCCs as reasoning tools, encouraging their use in discourse, and providing time for reflection on how CCCs shape understanding. When students are given repeated, authentic opportunities to use CCCs, they begin to see the concepts not as isolated ideas, but as powerful lenses through which to view and make sense of science.

To support this instructional shift, the following four approaches—**lenses, tools, bridges, and foundations**—offer practical and flexible ways to incorporate CCCs into teaching, learning, and assessment. Each approach highlights a different function CCCs can serve in the classroom and provides a pathway for deepening student engagement and sensemaking.

- **Lenses:** Using CCCs to deepen understanding of a phenomenon or problem and reveal new aspects to explain.
- **Tools:** Using CCCs to help clarify confusion and build on existing knowledge to create new explanations and ideas.
- **Bridges:** Using a CCC to connect different phenomena, problems, or units.
- **Foundations:** By using a CCC to establish common practices, language, purposes, or meanings, students learn when and why to apply CCCs.

Lenses: How does using a specific CCC help us see new things about this phenomenon or problem?	Tools: How can CCCs help us to make sense of a phenomenon or problem?	Bridges: How can the CCCs be applied to explain a new phenomenon or problem?	Foundations: Do we know when, why, and how to use the CCCs?
Supporting sensemaking: Focuses student thinking to support productive learning.	**Supporting sensemaking:** Expands and deepens student understanding of each CCC. Serves as a frame for "putting the pieces together" to explain phenomena or problems.	**Supporting sensemaking:** Strengthens the knowledge structures students build around science concepts.	**Supporting sensemaking:** Deepens student understanding of why CCCs are useful tools used by scientists to understand, interpret, and communicate.
Within instruction, look for: • Students incorporate CCCs into discussion and assessment responses. • Students engage in Science and Engineering Practices through the use of CCCs.	**Within instruction, look for:** • Students engage with diverse examples of and contexts for a CCC. • Students recognize when a familiar CCC is applied to a new context. • Students use CCCs to support deeper understanding of Disciplinary Core Ideas.	**Within instruction, look for:** • Students use a CCC at the beginning of a unit when encountering an anchor phenomenon and use the same CCC at the end of the unit to make sense of a new (analogous) phenomenon. • Students use a CCC as a common theme or concept that ties together different phenomena or problems.	**Within instruction, look for:** • Students co-construct the definitions of CCCs and how they are used to understand, interpret, and communicate. • Students have opportunities to discuss and/or reflect on which CCC(s) they used to make sense of something and why that particular CCC was useful.

Lenses: How does using a specific CCC help us see new things about this phenomenon or problem?	Tools: How can CCCs help us to make sense of a phenomenon or problem?	Bridges: How can the CCCs be applied to explain a new phenomenon or problem?	Foundations: Do we know when, why, and how to use the CCCs?
Within a task, look for: • The task driving question explicitly uses a CCC. • Explicit use of CCCs in prompts.	**Within a task, look for:** • Prompts use CCCs to scaffold sensemaking – either by requiring use of multiple CCCs and/or using one CCC at multiple levels of complexity.	**Within a task, look for:** • Students use a CCC as a common theme or concept that ties together phenomena or problems from instruction with the phenomenon or problem driving the task.	**Within a task, look for:** • Students have opportunities to explain and/or reflect on which CCC(s) they used to make sense of something and why that CCC was useful.

References

Achieve. (2016). *Using Phenomena in NGSS-Designed Lessons and Units*. Retrieved from https://www.nextgenscience.org/sites/default/files/Using%20Phenomena%20in%20NGSS.pdf

Cooper, S., Novak, D. (2024). *Developing meaningful science assessments: Sensemaking with the Crosscutting Concepts*. Retrieved from www.contextus.science

Georgia Department of Education. *Supporting Crosscutting Concepts K-5*. Retrieved from https://lor2.gadoe.org/gadoe/file/3fb28bd4-24cf-46fa-8ae4-b3fafe4f2f24/1/Science-k-5-crosscutting-concepts-support.pdf

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

Nordine, J., and Lee, O. (Eds.). (2021). *Crosscutting Concepts: Strengthening Science and Engineering Learning*. NSTA Press.

South Carolina Department of Education. (2021). *South Carolina College- and Career-Ready Science Standards 2021*. Retrieved from https://ed.sc.gov/instruction/standards/science/standards/south-carolina-college-and-career-ready-science-standards-2021-approved/

South Carolina Department of Education. (n.d.). *K-12 Conceptual Vertical Articulation of the Crosscutting Concepts*. Retrieved from https://ed.sc.gov/instruction/standards/science/instructional-resources/ccc-vertical-articulations/

South Carolina Department of Education. (n.d.). *Performance Target*. Retrieved from https://ed.sc.gov/instruction/standards/science/instructional-resources/

Vick, N., Novak, M.J., Voss, D.C., Reiser, B.J., and Rivet, A. E. (2024) *Helping Students Use Crosscutting concepts to Guide Sensemaking of Anchoring Phenomena*. The Science Teacher 91:4. Retrieved from https://doi.org/10.1080/00368555.2024.2358179

Willard, T. (2020) *The NSTA Atlas of the Three Dimensions*. NSTA Press.