Coherent Instructional Sequences Based on Anchor Phenomena

Coherence is one characteristic of high-quality "units of instruction" and is evident at the lesson level, unit level, and program level. These units of instruction are coherent when the components (e.g., parts of a lesson, lesson, chapter, module) begin by considering students' prior knowledge and experiences then build toward more sophisticated outcomes across the three dimensions (science and engineering practices [SEPs], disciplinary core ideas [DCIs], and crosscutting concepts [CCCs]) and toward a performance expectation (PE) or bundle of PEs. Planning coherent instructional sequences requires clearly defined learning goals and outcomes, carefully sequenced concepts, and the selection of activities and classroom assessments well matched to the learning goals (BSCS, 2016).

The NGSS call for phenomena-based or problem-based instructional sequences that situate learning in motivating and engaging contexts. The outcome of this work is that students use the SEPs, DCIs, and CCCs to explain these phenomena or solve problems. A number of different authors have contributed to thinking about the practical aspects of planning for instruction with a focus on explaining phenomena or solving problems (Penuel & Bell, 2016; Ambitious Science Teaching, 2016). In the Five Tools, we draw from the work of Penuel and Bell (2016) and refer to these phenomena or problems as "anchors". An anchor phenomenon or problem can guide the planning of one lesson or a series of lessons. In this way, the anchor(s) contributes to coherence within and across lessons.

For purposes of our Five Tools work, we differentiate general phenomena, concepts, guiding questions, and anchor phenomena.

	Phenomenon	Concept	Anchor phenomenon	Guiding question
Definition	A natural phenomenon is an occurrence or situation in nature that is observed to exist or happen and whose cause or explanation is in question.	A concept is a complete sentence that shows a relationship between important science ideas.	An anchor phenomenon is a natural phenomenon that compels students to explain what happens or how it happens.	A question that students might ask as they wonder about an anchor phenomenon
Examples	While the individual organisms in different environments may vary, the patterns of interactions (relationships) between organisms are consistent across different environments.	While the individual organisms in different environments may vary, the patterns of interactions (relationships) between organisms are consistent across different environments. These relationships among organisms, including humans, can be predatory, competitive, or mutually beneficial.	Wolves, reintroduced to Yellowstone in 1999, have established a new "balance of power" in the ecosystem.	Why did wolves disappear from the Yellowstone ecosystem and why were they reintroduced? What effect did the reintroduction of wolves have on the Yellowstone ecosystem?
Comments	Notice that the phenomenon is the same as the concept. This isn't always the case.		Notice that the anchor phenomenon is a specific example of the general phenomenon or concept.	Note that the guiding questions may include why, how, and what types of questions.
Examples	Respiration rates and heart rates change to maintain homeostasis.	Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy to support cell functions. In these processes, complex molecules containing carbon react	A person from the coast is breathing hard and has a fast heart rate while hiking in the mountains of Colorado.	What makes this happen?

	Phenomenon	Concept	Anchor phenomenon	Guiding question
		with oxygen to produce carbon dioxide and other materials. Blood transfers oxygen and carbon dioxide to and from the lungs and through the body. Oxygen levels are lower at higher altitudes, so the body increases heart rate and breathing rate to maintain oxygen levels throughout the body needed for cellular respiration.		
Comments	The phenomenon in this example is the general pattern implied by the anchor phenomenon.	Notice that several concepts are required to fully explain the phenomenon and the anchor phenomenon.	The anchor phenomenon is a specific example of the phenomenon.	None.

According to Penuel and Bell (2016), a good anchor builds upon everyday experiences of students—who they are, what they do, and where they came from—and is compelling for *all* students, including English language learners and students from cultural groups underrepresented in STEM.

- A good anchor phenomenon will require students to develop understandings and applications of multiple NGSS performance expectations while also engaging in related acts of mathematics, reading, writing, and communication. It has relevant data, images, and text to engage students in the range of ideas students need to understand. It should allow them to use a broad sequence of science and engineering practices to learn science through firsthand or secondhand investigations.
- A good anchor phenomenon is too complex for students to explain or design a solution for after a single lesson. The explanation or solution is just beyond the reach of what students can figure out without instruction. Searching online will not yield a quick answer for students to copy.
- A good anchor phenomenon is observable by students with their senses or technological devices to see things at very large and very small scales (telescopes, microscopes), video presentations, demonstrations, or surface patterns in data.
- A good anchor phenomenon can be a case (e.g., well-described problem) or something that is puzzling and prompts students to ask questions.
- A good anchor phenomenon is of interest to an audience or stakeholder community that cares about the findings or products. (Penuel & Bell, 2016)

Citations

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