STEM TEACHING TOOL #41

Prompts for Integrating Crosscutting Concepts Into Assessment and Instruction

The new vision for science education features a three dimensional view of learning that involves: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Many educators already incorporate crosscutting concepts into their teaching, but may still be looking for ways to amplify these concepts or to make them more explicit for their students, including in their classroom assessments.

This set of prompts is intended to help teachers elicit student understanding of crosscutting concepts in the context of investigating phenomena or solving problems.

These prompts should be used as part of a multi-component extended task. They should not be used in isolation, and the blanks provided are intended to be filled using the content of the scenario presented at the beginning of the multi-component task. The prompts can be open-ended, as shown below. They can also be turned into multiple-choice questions. These prompts were developed using the Framework for K-12 Science Education and Appendix G of the Next Generation Science Standards, along with relevant learning sciences research.

These prompts are currently being tested or evaluated in the field. We request you send feedback and information about how you have used the prompt to william dot penuel at colorado dot edu.

Please note that some prompts may not be suitable for students in early grades, while others may be low-level for high school students. Designers should consult the learning progressions in Appendix G of the NGSS to choose a prompt that is appropriate for different grade level bands.

Our team has also created a similar tool to help educators create tasks that incorporate the science and engineering practices into their teaching, found at stemteachingtools.org/brief/30. You can learn how to develop 3D formative assessments here: http://tinyurl.com/3Dassessmentdevelopment

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Crosscutting Concept: Systems and System Models

A Framework for K-12 Science Education description of **systems and system models**: Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

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*When eliciting information about the **components and interactions** of systems and system models, ask students:*

- What are the key parts of the [a natural object, designed object, or organism described in the scenario]?
- Draw the parts of the system described in the scenario.
- How do the parts of [a natural object, designed object, or organism described in the scenario] work together?
- Draw a picture that shows how the parts of the system described in the scenario work together.
- What can the parts of [a natural object, designed object, or organism described in the scenario] do together, that the individual parts cannot do alone?
- How do the different components of the system interact?
- What would happen in this system if you increased [component of the system]?
- What would happen in this system if you decreased [component of the system]?
- How do you think [component] would respond to [change in another component of the system]?

*When eliciting information about the **boundaries** of systems and system models, ask students:*

- What is the boundary of the system described in [the scenario]?
- What are the consequences of drawing the boundary of the system around ________ as opposed to ________ in a model?
- Draw a boundary to indicate what is inside and outside of the system.
- Can the system be physically isolated, in order to study it?
- Are their sub-systems in this system that can be isolated for analysis? If so, what are they?
- How does [subsystem A] relate to [subsystem B]?

When there are feedback loops presented in the scenario, ask students:

- For homeostatic systems: What feedback loops make this system stable?
- What feedback loops make this system unstable?
- How do positive feedback loops in this system affect how it functions?
- How do negative feedback loops in this system affect how it functions?
- For chaotic systems: How do feedback loops in this system make the system's behavior unpredictable?

*When eliciting information about the **flow and cycling of energy, matter, and information**, ask students:*

- What energy flows into the system?
- What energy flows out of the system?

- What matter cycles into the system?
- What matter cycles out of the system?
- How does energy flow within the system?
- How does matter cycle within the system?
- How does information flow within the system?
- What information is flowing into the system?
- What information is flowing out of the system?
- Draw a picture that shows how energy is flowing into, within, and out of the system.
- Draw a picture that shows how matter is cycling into, within, and out of the system.
- Draw a picture that shows how information is flowing into, within, and out of the system.

*When the model is of a **complex** system, ask students:*

- What properties emerge from interaction of components in the system that can't be seen just by looking at the interactions?
- How does [emergent property] of the system affect interactions in the system, once [that emergent property] emerges?

*When the model is of a **designed** system, ask students:*

- Create a set of instructions for building [system] that another child can follow.
- If you could control X in the system would it stop Y? Why or why not?
- How could you test whether this system satisfies the design constraints described in the scenario?

When eliciting understanding of the limitations, assumptions, and approximations of system models, ask students:

- What part of the system does the model show? Why are these parts shown?
- What parts of the system are not shown in the model? Why are these parts not shown?
- What are the key assumptions of the model?
- How do the assumptions affect the reliability of the model?
- What is estimated, rather than observed directly, in the model?
- How do estimates affect the precision of the model?
- Could you use the model to reliably predict ________________?
- Could you use the model to precisely estimate what would happen if ________________?