What do students know about science systems in the natural world? If students have a deep understanding of a science system, they should understand core principles and be able to use their knowledge to reason in different contexts. The challenge of science assessment is to develop tools that not only tap into declarative and procedural knowledge, but also schematic and strategic knowledge that allows students to demonstrate how they reason through complex systems.

Methods

Sample. We identified 124 items related to Ecosystems and Atoms and Molecules at the middle school level from an analysis of 30 state, national, and international tests. We conducted an analysis of released and sample items related to ecosystems and chemistry from more than 10 exams.

In our analysis of existing items from 30 state, national, and international tests, we found that 98 static items and 6 dynamic items from 25 assessments met our search criteria of being related to either Ecosystems or Atoms and Molecules at the middle school level.

Cognitive Demands

Declarative “Knowing that”
- Students can recall, define, represent, use, and relate basic principles.

Procedural “Knowing how”
- Students can perform simple and complex procedures, e.g., controlling variables when designing experiments.

Schematic “Knowing why”
- Students can explain and predict natural phenomena.

Strategic “Knowing when and where to apply knowledge”
- Students can transfer knowledge and skills into new situations and reason through novel tasks to meet goals.

Science Practices

The majority of items in the sample involve the first two science practices—identifying principles and using principles (63)—as opposed to the other two practices: applying and explaining scientific evidence and using inquiry (31). The skills students need to reason through new, unobserved phenomena are not tapped into by existing assessment items.

Science Assessment

To tap into student knowledge of a science system, items should assess student knowledge across the model levels to ensure integration. Items were coded by the model level or levels the items assessed: Components, Interactions, or Emergence.

Results

Science Practices. The large majority of items in the sample involve the first two science practices—identifying principles and using principles (63)—as opposed to the other two practices: applying and explaining scientific evidence and using inquiry (31). The skills students need to reason through new, unobserved phenomena are not tapped into by existing assessment items.

Science Assessment

To tap into student knowledge of a science system, items should assess student knowledge across the model levels to ensure integration. Items were coded by the model level or levels the items assessed: Components, Interactions, or Emergence.

Findings

1. Current assessments do not tap into a wide range of science skills, particularly science practices.
2. Few items tap strategic knowledge (e.g., using knowledge to transfer to new problems and complex reasoning skills).
3. Current items do not assess science systems evenly across the model levels.
4. New tasks are needed to tap into complex reasoning skills.

Next Steps

Static items are limited in the range of skills they can assess directly. In ongoing work we are developing assessment items in response to new problems and complex reasoning skills. We will compare student performance on static and dynamic assessment items providing different information about students’ proficiency related to identifying principles, using principles, and using inquiry.

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