A System for Creating Assessment of Higher-Order Reasoning in Specific Undergraduate Domains

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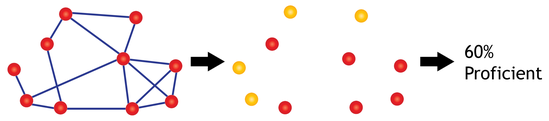
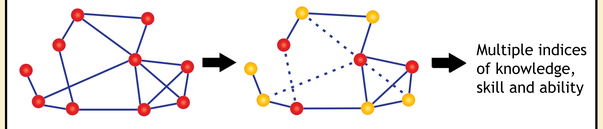
Goals:	To make visible, by means of assessment, the important, foundational knowledge in domain areas.
Practical Use:	Provides a way to identify and test the most important knowledge and skills that students will need to apply their college learning in the workplace or higher education.
Conventional Approach:	Sample factual knowledge and then ask multiple discrete, decontextualized questions in a test.
Our Approach:	Assessment tasks require making connections among ideas, and using the ideas to understand and solve problems in real world scenarios.

Conventional Approach



Students demonstrate knowledge of specific facts or procedures. Proportion correct used as inference of overall proficiency.

Our Approach



Students demonstrate facts, procedures, and overall schematic connections. Can make inferences about schematic completeness.

Research Questions

- **Alignment Substudy:** To what degree do content experts believe the tasks from the new assessments also align with forms of knowledge relevant to each domain?
- **Cognitive Analysis Substudy:** Do the new assessment tasks elicit evidence of students' use of schematic and strategic knowledge, key big ideas, and other domain knowledge types—procedural and declarative?
- **Instructional Sensitivity Substudy:** Are there significant differences in the amount of learning achieved between students who have completed courses in a domain with those who have not?
- **Correlational Substudy:** Do the assessments measure distinct or similar constructs compared to existing tests, and do they correlate with other measures of student performance?

Design

Year 1: Domain analysis with experts. Domain modeling with community college instructors.
Year 2: Prototyping, piloting, and revision. Formal testing.
Year 3: Validity analysis to answer research questions.

Task Creation Support

- Design patterns help test developers craft performance tasks around big ideas of the domain
- Sample tasks at right were developed using the design patterns from the project

Economics Design Patterns
- Using economic reasoning in decision making,
- Reasoning about market interactions,
- Evaluating efficiency of government policies

Biology Design Patterns
- Using biological principles to analyze and explain current issues,
- Using biological principles to predict outcomes,
- Using scientific method to critique study findings

Economics

Big Ideas: Supply & Demand; Cost Benefit

Knowledge Types: Declarative; Schematic; Procedural; Strategic

Scenario: Steel Mills and Earthquakes

Two neighboring countries, North Seismalia and South Seismalia, have steel mills and a reliable domestic market. Currently North and South Seismalia do not trade steel with one another. The supply and demand schedules for steel in both countries are the same, and given by the following table:

Price per ton	Quantity Demanded (Tons per day)	Quantity Supplied (Tons per day)
$500	1,000	200
$600	800	400
$700	600	600
$800	400	800
$900	200	1,000

Big Ideas	Sample Test Questions	Knowledge Types
	In order to keep the price of steel attractive for industrial customers, North Seismalia has imposed a price ceiling on steel at $700.	
Supply & Demand	1. Sketch the price ceiling on North Seismalia's graph and explain the impact of this price ceiling.	Procedural; Schematic
	Suddenly the region is disturbed by a massive earthquake. Steel mills are damaged beyond repair such that the steel output in each country at every price point falls exactly in half.	
Supply & Demand	2. Show the immediate impact of the earthquake in each country. Be sure to indicate in the graphs the new expected quantity supplied, quantity demanded, and price in each country. Explain in words the consequences of each country's pricing policy for supply, demand, and price.	Procedural; Schematic
Supply & Demand	3. Which country has the more efficient pricing policy? Explain why.	Schematic

Biology

Big Ideas: Energetics; Evolution

Knowledge Types: Declarative; Schematic; Procedural; Strategic

Scenario: Lab Experiment and Carbon Sequestration

Louise, a ninth-grader, was assigned to do an experiment for her biology class. The experiment involved planting wheat seeds in three different conditions: (A) light but no water, (B) light and water, and (C) water and no light. Louise checked the Petri dishes after a week and saw the following:

A. Light, No Water

☐ cellular respiration
☐ photosynthesis

B. Light, Water

☐ cellular respiration
☐ photosynthesis

C. No Light, Water

☐ cellular respiration
☐ photosynthesis

Big Ideas	Sample Test Questions	Knowledge Types
Energetics	1. Look at the checkboxes beneath each of the pictures of Louise's wheat seeds and seedlings. Check off all the processes that are occurring.	Declarative
Energetics	2. At the beginning of her experiment, Louise carefully measured the total mass of each set of 50 seeds in each Petri dish. Each was 1.5 grams. She noticed that one of her classmates had just tossed a pinch of seeds into each Petri dish without counting them or measuring their mass. Louise thinks her classmate's experimental results will not be able to be interpreted. Why?	Procedural
	Louise's big brother, Larry, went to work for an environmental organization committed to reducing atmospheric carbon dioxide, one of the greenhouse gases contributing to global warning. The organization received funds to purchase land. Organization leaders want to purchase tracts of land with plant life that will increase the capture of carbon more than is currently captured.	
Energetics	3. Larry and his team are considering land with the three types of plants listed below. Compare the carbon-capturing potential of three types of land and recommend one of the three. Explain your reasoning. • Land with stable, mature forest • Land with grass for grazing • Land with tree seedlings	Strategic

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