Using Knowledge about How People Learn to Define Learning Goals

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Research and Development Effort

- Goal: Develop prototype Domain-Specific Assessments
- U.S. Dept. of Education Institute for Education Sciences
- Current Range of Post-secondary Assessments
  - Placement Tests (Accuplacer, COMPASS)
  - Work skills (Certification tests, Workkeys)
  - Critical thinking (e.g., CLA, Watson-Glaser)
  - Subject-specific tests (ACAT, TUCE, Major Field Tests, College BASE)

Research and Development Effort

- Domain Specific Assessment prototypes are grounded in:
  - Cognitive science expert-novice research
  - Developmental view of learning

Research and Development Effort

- College: Improves students' capacity to think critically and argue rationally
- Cognitive psychologists: Development of general reasoning shaped by depth of students' core content knowledge of "big ideas" in subject domains (Chi, Glaser, & Farr, 1988; McPeck, 1981).

Domain experts use big ideas to apply knowledge in real world

- Studies of expert thinking suggest "big ideas" serve as:
  - Schematic organizers of facts, procedures, and concepts
  - Enhances efficiency of higher forms of reasoning
    - Argumentation, problem solving, creativity
    - Understanding & elaboration of systems
    - Interpretation, building, & evaluation of evidence, models, & explanations
    - Evaluation of performance

Application to Post-Secondary Assessment

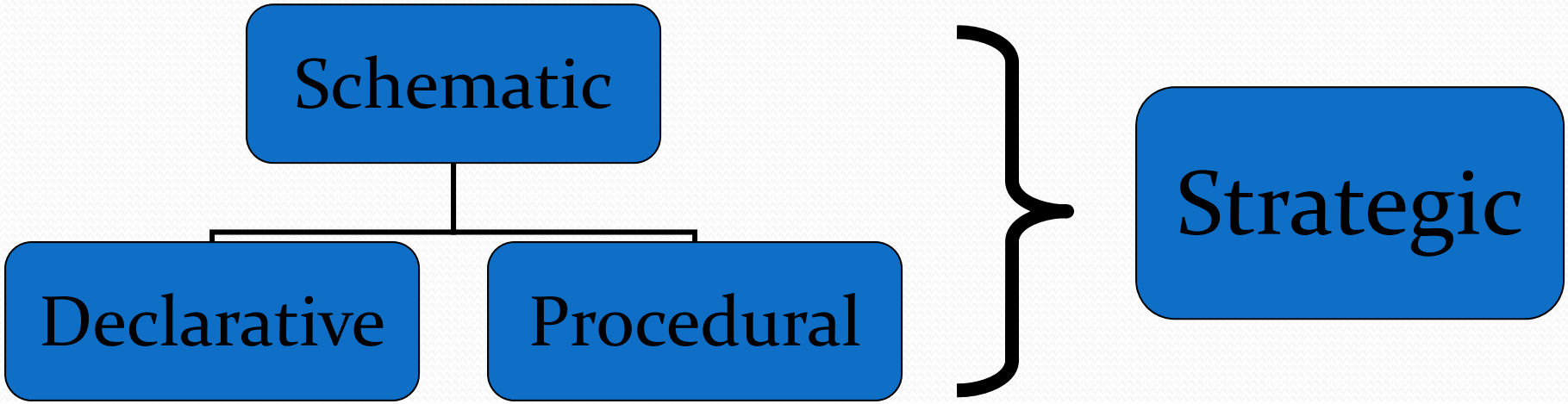
- How well are college general education classes preparing students to apply big ideas to real world problems?
  - Prototype Focal Domains:
    - Biology, Economics

First Step in Assessment Design: Structure of Expert Knowledge in a Domain

- Cognitively-based assessment research hypothesizes the structure of expert knowledge and how it develops
  - Declarative knowledge: Knowing what
  - Procedural knowledge: Knowing how
  - Schematic knowledge: Knowing why
  - Strategic knowledge: Knowing when

- Shavelson, Ruiz-Primo, Li, & Ayala, 2003

Structure of Expert Knowledge



Second Step: Model of How Big Ideas Develop

- Incorporating learning progressions work in science education (Corcoran, Mosher, & Rogat, 2009)

- 6-level rubric:
  1. Unproductive Misconception
  2. Productive Misconception
  3. Singular: Use of 1 normative concept
  4. Relational: Use of 2 normative concepts
  5. Combined: Use of 3+ normative concepts (Nagashima, Brown, Fu, Timms, & Wilson, 2008)
  6. Strategic: Knowing when to apply concepts to real world situations

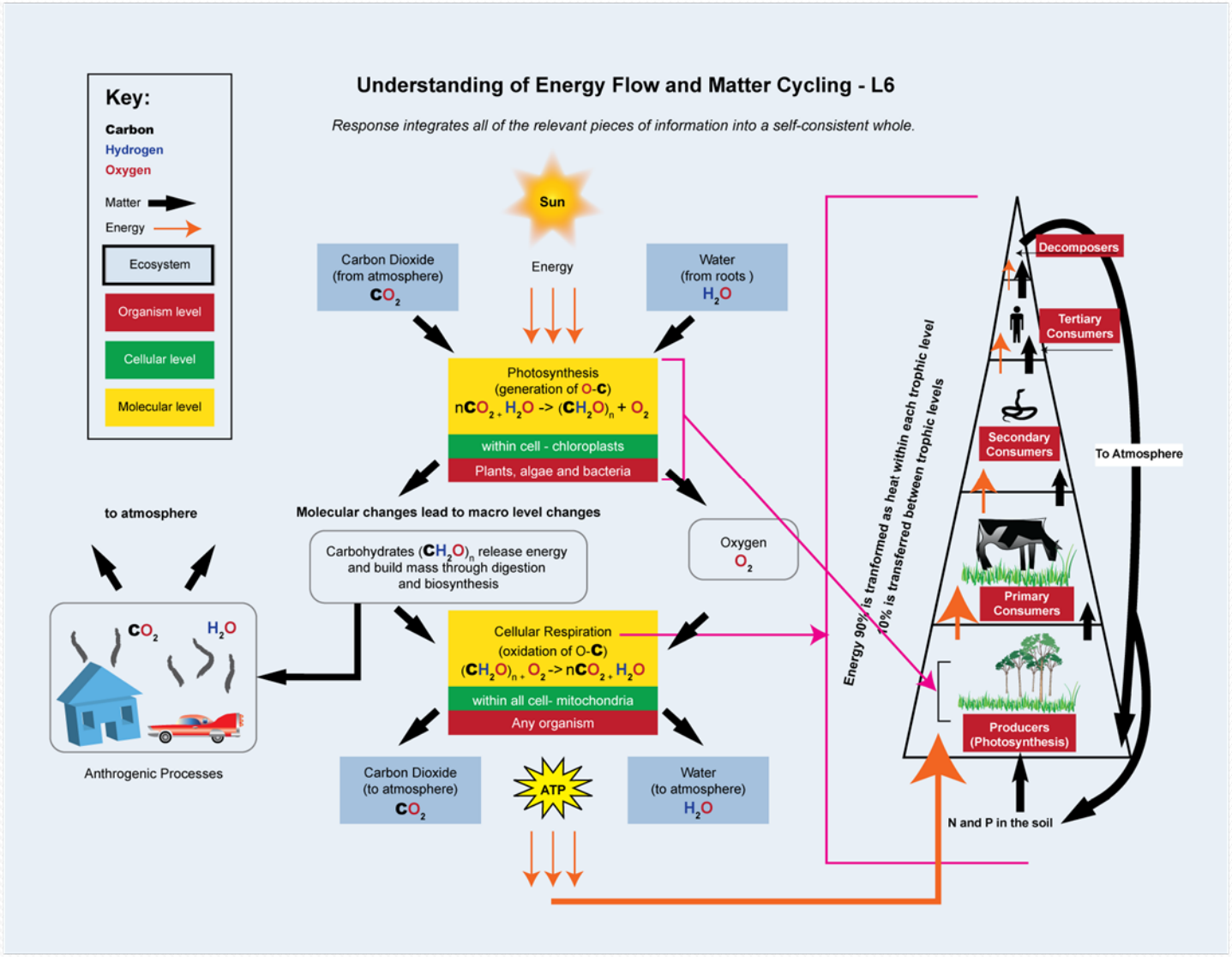
Assessment Design Methods

- Evidence-centered design process (Messick, 1994; Mislevy, 2007; Mislevy & Riconscente, 2006)
  - Analyzes domains of community college biology and economics
  - Interviews with 4-year and 2-year educators and industry professionals
  - Documents valued ways people use the "big ideas" from biology and economics (domain analysis)
  - Documents ways to gather evidence that students have learned the "big ideas" and ways of using them (domain modeling)

Results of Domain Modeling

- Economics
  - Decision making based on Cost-Benefit Analysis
  - Reasoning with the S&D model
  - Evaluating Government Efficiency (Resource Allocation)
- Biology
  - Using Biological Scientific Principles to Predict Outcomes
  - Using Biological Scientific Principles to Analyze and Explain Current Health and Environment News
  - Analyze, Interpret, and Apply the Findings of a Biological Study

Map of Knowledge



Sample Learning Levels and Items

Level	Knowledge/Skills	Big Ideas	Test Item
3	Ability to understand that the *products* of photosynthesis are oxygen and a carbohydrate, the carbon building block of life.	Photosynthesis products; molecular level	*What biological process does the following formula represent? [...]*
4	Ability to understand the molecular process of photosynthesis captures energy and/or builds mass at the organism level.	Purpose of photosynthesis process: molecular, organismal, ecosystem levels	*As part of his presentation, Dr. Harris presented the photograph below depicting living and dead trees. Using the photograph, describe the processes that living trees (A) and dead trees (B) perform in the carbon cycle.*
5	Ability to understand that molecular changes lead to macro-level changes (all biomass, all respiration).	Carbon cycle: molecular, organismal, ecosystem levels	*Predict the likely effect of the tree destruction on the amount of atmospheric carbon dioxide released over the next year into the region's ecosystem.*

Sample Learning Levels and Items

Level	Knowledge/Skill	Big Idea	Test Item
6	Ability to predict how carbon-based life forms transform in the soil through metabolic processes of organisms (all products identified; all levels identified)	Ability to apply full schema of energy flow and matter cycling dynamics in novel situation	*A 7.2 magnitude earthquake in Japan has not only destroyed buildings, but scientists have found it also released large amounts of carbon dioxide into the air by increasing pressure in the deep crustal fault structures. Explain scientifically how the level of carbon became high in these deep crustal faults and in soil in general.*

Item Measuring Big Idea Knowledge

- A citizens group decided that the town needs a plan to reduce the amount of carbon released to the environment while increasing the amount of carbon sequestered. The group prepared to recommend replanting the forest with loblolly pine trees. Then a group of farmers presented a competing proposal. They argued that although farm machinery will be used, planting local food crops will ultimately be a better plan for accomplishing the town's goals.
- **4.7. Original prompt:** Dr. Harris asks the farmers for a plan of how they will use farm machinery. Is Dr. Harris' request warranted? Using your knowledge of the carbon cycle, argue for or against asking the farmers to produce such a plan.

Examples of Assessment for Level 5 and Student Responses at Each Level

Loblolly

- Level 1: Dr. Harris' request is warranted because seasonal crops will not produce **as much O_2** production as long term trees. If the farming equipment is more intrusive than benefit, then trees should be planted.

- Level 2: Against. Trees consume **more CO_2** so according to my knowledge machinery needs to be used so that creates CO_2 and not as much CO_2 is being consumed. Trees were there before so keep trees there to consume more CO_2.

- Level 4: No. I think trees can do better job if it is a matter of increasing O_2 in the air because trees are better photosynthesizers due to abundant leaves that helps this process. But if increasing carbon in soil is the case, crops is a good idea since they decompose easily, providing C in soil.

Revisions

- **Problem noted:** We are getting evidence that they are talking about carbon processes individually (cellular respiration, and photosynthesis), but little evidence that they are thinking about the net relation between carbon producers versus carbon fixers.
- **4. 7 Revised prompt:** With reasoning based on your knowledge of the carbon cycle, support a recommendation for either the citizens' group plan or the farmers' plan. Explain your reasoning.

Item Measuring Big Idea Knowledge

- When she set up the experiment, Louise counted out 50 seeds for each Petri dish. After a week, Louise was instructed to dry out the plant material in each Petri dish, weigh the three samples, and measure the mass of each. Before she completed her measurements, Louise's teacher asked her to predict which condition would produce the least mass.
- What condition will produce the least mass and why?

Examples of Assessment for Level 5 and Student Responses at Each Level

- Wheatberry
- Level 1: Lack of light & water – the essential ingredients to support growth.

- Level 2: A; Both B and C have conditions that allow incorporation of H_2O into the plants, but A has nothing going on but release CO_2.

- Level 4: C. No light, water condition will produce the least mass, because this condition makes no glucose and consumes seeds nutrients.

Practical Use for Community Colleges

- Domain specific assessment helps clarify what kinds of knowledge students are learning
  - Knowing what, knowing how, knowing why, knowing when?
  - Provides insight into “strengths” and “weaknesses” in learning outcomes achieved in content-rich academic departmental programs