Learning and Assessment
Ontologies of Cognitive Processes:
Step 1: Problem-Solving

Eva L. Baker & Girlie Delacruz

CRESST UCLA
Contrasting Design Models for Problem Solving:
Guiding Learning and Assessment
AERA Session 32.034
Why Ontologies?

• An ontology is a network representation of a domain, with most examples found in content areas
• AI & technical history
Properties Of Ontologies

- Boundary defining
- Visual
- Relational
  - Hierarchical
  - Functional
  - Chronological
  - Mixed
- Levels to permit detail or other assets
- Expert and NLP generation and revision

© Regents of the University of California
Developmental History 1: (The World Is Flat)

- Research on functional links in complex knowledge domains (Dancereau, 1985)
- Eliciting student understanding of domains through scored knowledge maps (1998)
- Consolidation of procedural knowledge and identification of key priorities (ONR, 2002)
- Representation of expert opinions related to limited area of mathematics (Vendlinski, et al, 2003)
- Crosswalks from verbal standards to visualized networks (2009)
Developmental History 2: Adding Functionality

$n$-dimensional

- Seek consensus: experts, teachers, kids
- Identify critical elements for learning
- Posit learning sequences
- Create sampling space and emphasis for assessments
- Monitor progress in tasks designed to represent ontology (meta-tags, data mining)
- Shift to cognitive, social and emotional skills

© Regents of the University of California
What Are Common Thoughts on Problem-Solving Complexity in Assessment Task Demands?

1. Prompts: embedded or specified
2. Steps: quantity and cognitive demand variation
3. Task type: procedural, search or select from information
4. Barriers in multiple contexts: confusability, difficulty of overcoming barrier
How Can Complexity Play Out in Scoring

- Alternative processes allowed
- Alternative processes differentially valued
- Outcomes may differ
- Outcomes embedded in content
- Sophistication in qualifications and evidence of scorers
  - Views of content, cognition and other attributes of performance
- Training, reliability, validity
Ontologies for Design and Assessment

- Codifies common core standards

- Ontologies and knowledge specifications

- Game design, assessment, professional development

- Guides what to teach in game, what to measure, what to focus on in professional development
Why Ontologies For Problem-Solving?

- Capture optimal level of complexity of performance
- Otherwise revert to routine examples
Iterations of Problem-Solving Ontologies

- Clarification of purpose: embedded in content domains
- Expert involvement —world famous psychologists
- Initial relational structures
- Curated to reduce duplication and ambiguity
- Review by experts and potential users
- Trials to create domain embedded problem solving
Object-Oriented Assessment Design

- Select domain and problem-solving elements
  - Instructional Goals / Background Knowledge
    - Example Objectives
    - Physics Concepts Pertaining to Goals / Misconceptions
      - Students are able to explain that resultant forces arise when two or more forces in different directions are added together, and when applied to an object, the object's resulting direction of motion and rate of acceleration will be determined by the magnitude and direction of the resultant (net) force applied.
      - Forces are composed of magnitude and direction.
      - Students will apply multiple forces from different directions to the object to get the object to a specific location.
      - net force as a vector
      - vector addition (2D)
      - Misconceptions:
        - The motion of the object is always determined by the last force applied to it.
      - Students are able to model a solution where by applying a force opposite to the direction of an object's motion, the result will be a slowing and/or stopping of motion, depending on magnitude of the supplied force and duration of time it was applied.
        - Forces are composed of magnitude and direction.
        - Given an object moving in a constrained direction, the student will apply a force of sufficient magnitude, and in the opposite direction of motion to bring the object to rest.
        - Given a block sliding on ice at constant velocity, the student will determine what magnitude force to apply at what time and for how long in order to stop the block at a specified location.
        - momentum
        - time
        - speed
        - force
        - impulse
      - Students understand that for objects in motion (all moving at the same velocity), the more massive the objects, the more force in the opposite direction of motion is required to bring the objects to rest within a given amount of time.
        - Given different objects in motion having the same velocity, each with different mass, the player will estimate which objects require more/less force to come to rest within a given amount of time.
        - momentum
        - mass
        - force
        - time

- Create elicitation and response models
  - Identify assets for recombination: characters, concept types, problem-solving demands, scenarios, response modes

© Regents of the University of California
Object-Oriented Assessment Design: Problem-Solving
Object-Oriented Assessment Design: Problem-Solving (Cont’d)
Sample Assessments
Sample Games

In every new world you master new challenges!
Summary: Step 2 +

2. Problem-solving and cognitive demands add a new dimension of complexity over and above the richness of content (Glaser)

3. Expanded 21st century skills: Cognitive, social, intrapersonal

4. Tools needed to address problem-solving complexity
   - Content ontologies
   - Cognitive (and other) ontologies
   - Combinatoric models
   - Computational models for internal and external verification (validity)
http://blog.makezine.com/2008/02/29/scifi-objects-and-more-ma/

- Samsung.com
- Apple.com
- Ideaconcepts.com
- Howstuffworks.com