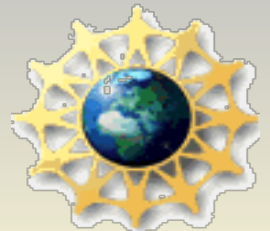# Using a Backward Design Process in Evaluating Students' Reasoning
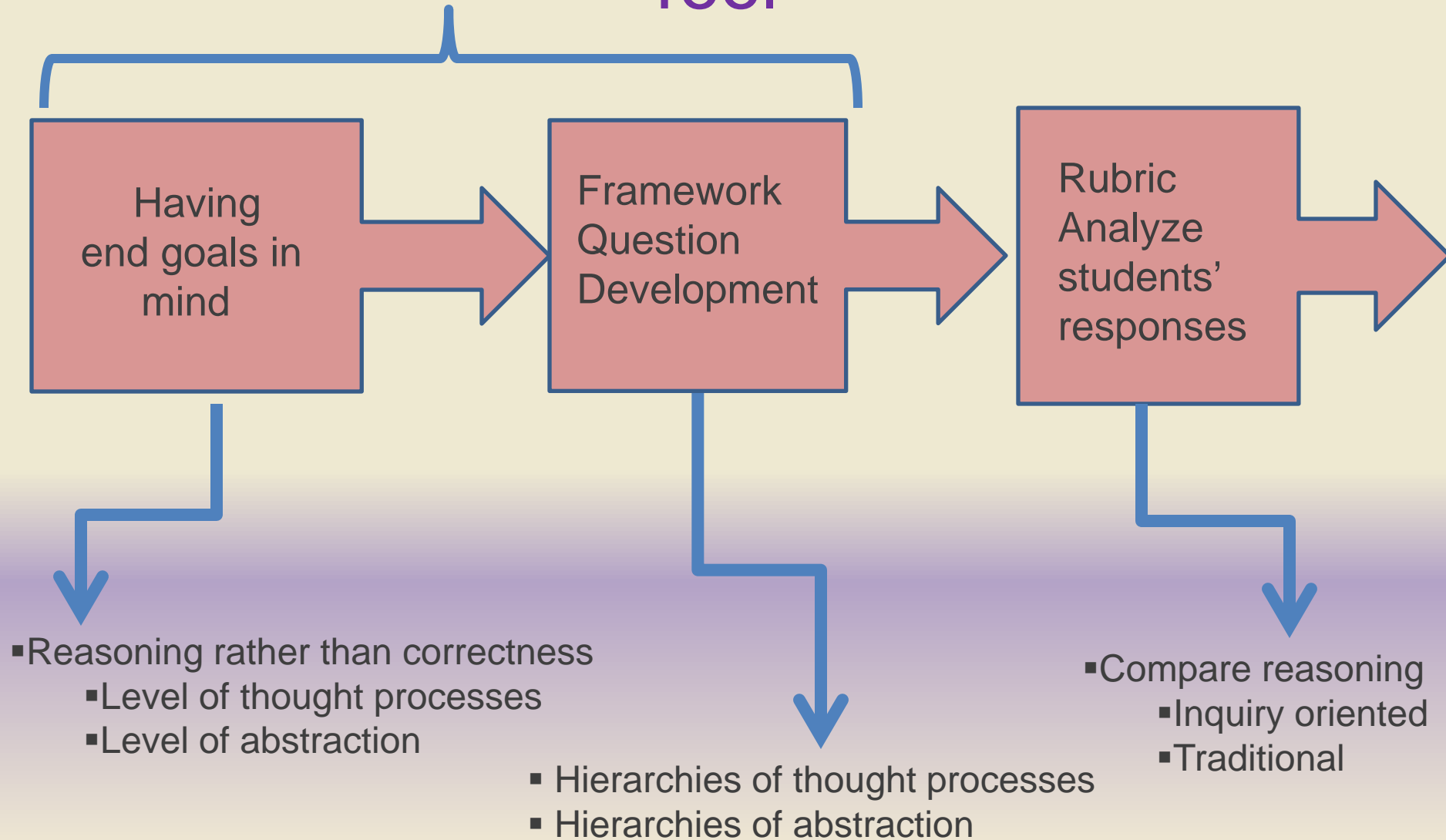
Mojgan Matloob,
Sytil Murphy & Dean Zollman
Kansas State University

Cynthia Sunal & Dennis Sunal
University of Alabama

Cheryl Mason
San Diego State University

K SU PER

Kansas State University
Physics Education Research

1

Design an Inquiry Oriented Assessment Tool

| Having end goals in mind | → | Framework Question Development | → | Rubric Analyze students' responses | → |

- Reasoning rather than correctness
  - Level of thought processes
  - Level of abstraction

- Hierarchies of thought processes
- Hierarchies of abstraction

- Compare reasoning
  - Inquiry oriented
  - Traditional

Assessment Tool Structure

- Written extended content questions

- Pre-determined level of thought processing
  - Cognitive demand
  - Knowledge types
  - Concept links

- Pre-determined level of abstraction
  - Observable and non observable entities

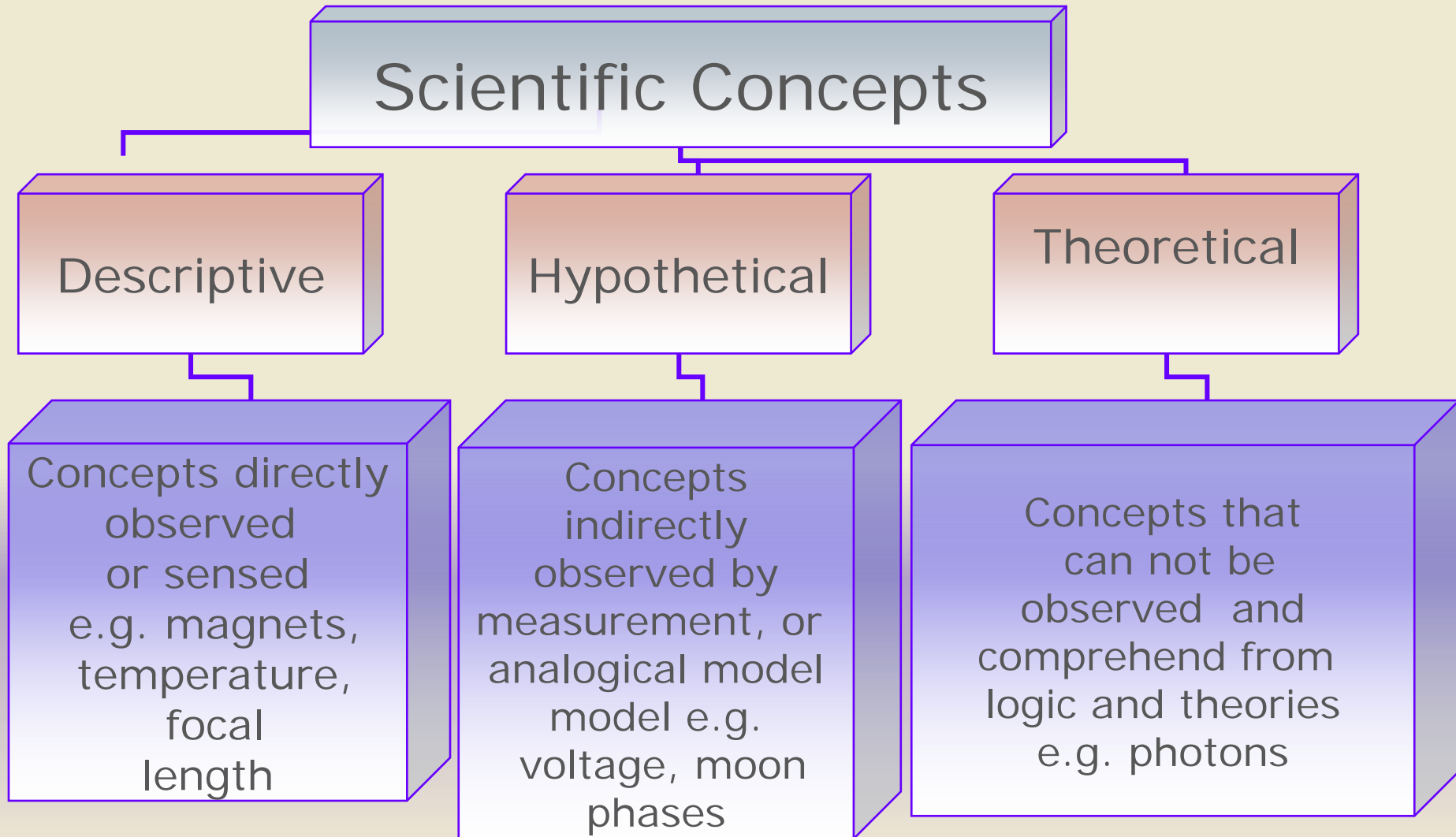- New context $\Rightarrow$ Underlying similarities
  - Prior knowledge

Bloom's Revised Taxonomy for Classifying Reasoning

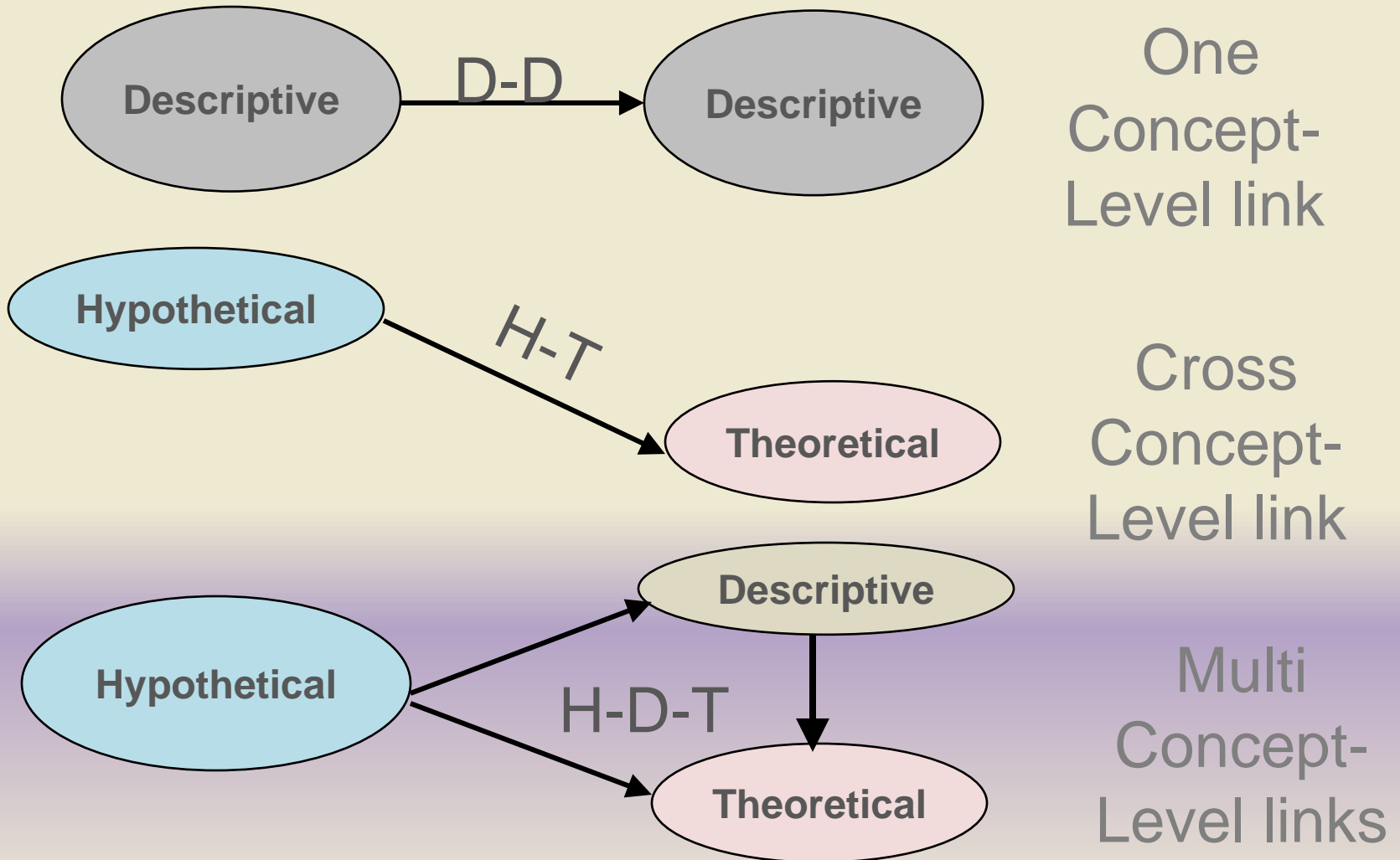| Revised Taxonomy (Anderson & Krathwoll, 2001):			
Knowledge Dimension	**The Cognitive Process Dimension**		
	Remember	**Understand**	**Apply**
Factual Knowledge			
Conceptual Knowledge			
Procedural Knowledge			

[1]Anderson et. al, 2001

What are observables?
Modification to Lawson's[2] definition

Scientific Concepts

Descriptive | Hypothetical | Theoretical

Concepts directly observed or sensed e.g. magnets, temperature, focal length

Concepts indirectly observed by measurement, or analogical model model e.g. voltage, moon phases

Concepts that can not be observed and comprehend from logic and theories e.g. photons

2-Lawson et. al (2000)

Type of concept links[3]

One Concept-Level link

Cross Concept-Level link

Multi Concept-Level links

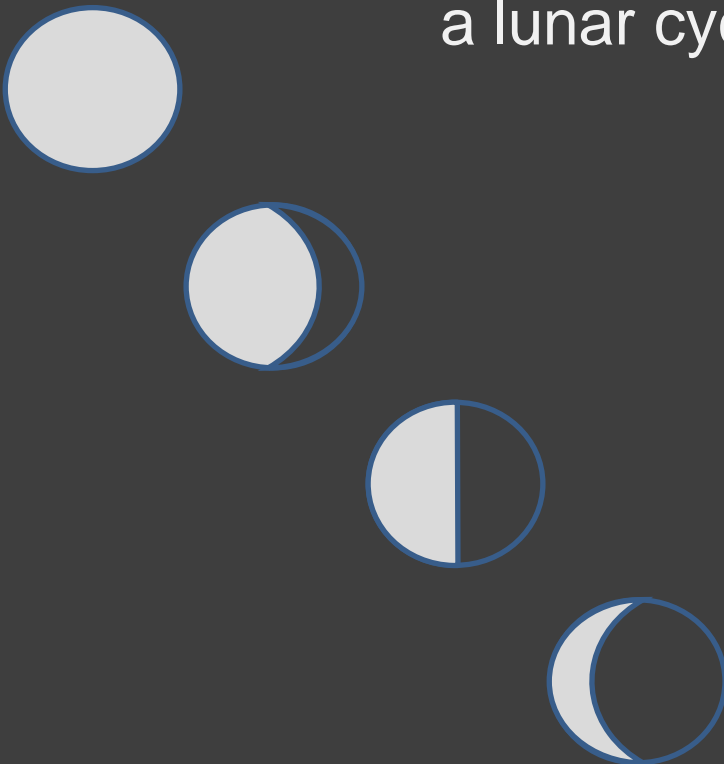3-Neiswandt & Bellemo 2009

Samples questions
Hierarchies of sophistication

- Context
    Moon Phases

- Levels of knowledge
    Procedural, Conceptual

- Levels of cognitive process
    Compare, Infer, Apply

- Level of abstraction
    Hypothetical-Hypothetical-Descriptive

Question development - 1ˢᵗ level of complexity

Question 1:
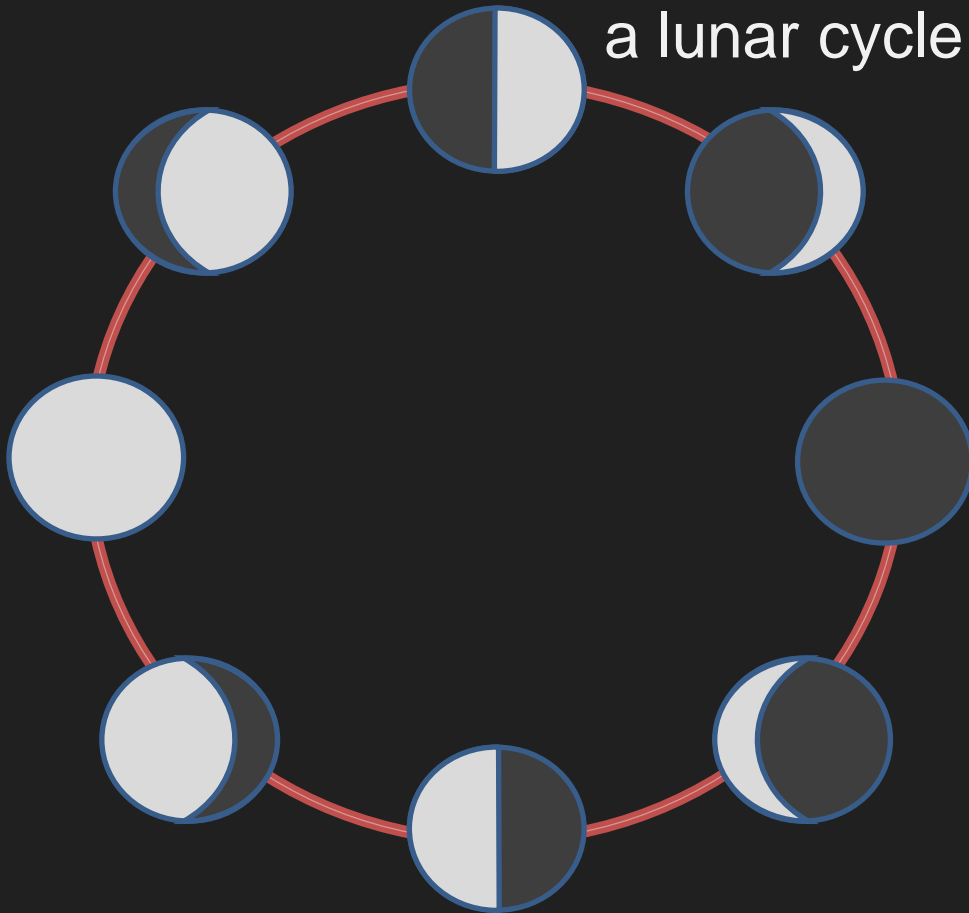Observe and record moon phases in a lunar cycle.

Type of knowledge	Factual
Cognitive process	Recognize
Concept link	D-D

Question development - 2nd level of complexity

Question 2:
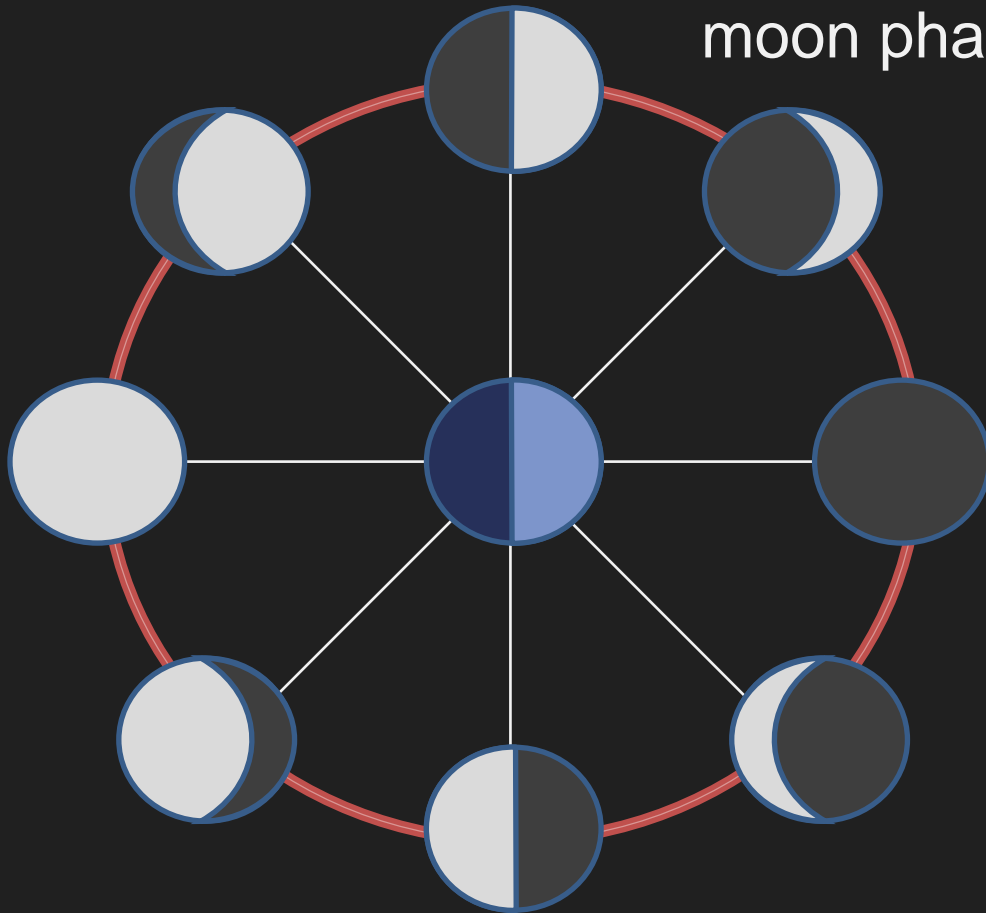 Describe the pattern of moon phases in a lunar cycle.

Type of knowledge	Conceptual Schema
Cognitive process	Compare
Concept link	D-H

Question development - 3rd level of complexity

Question 3:
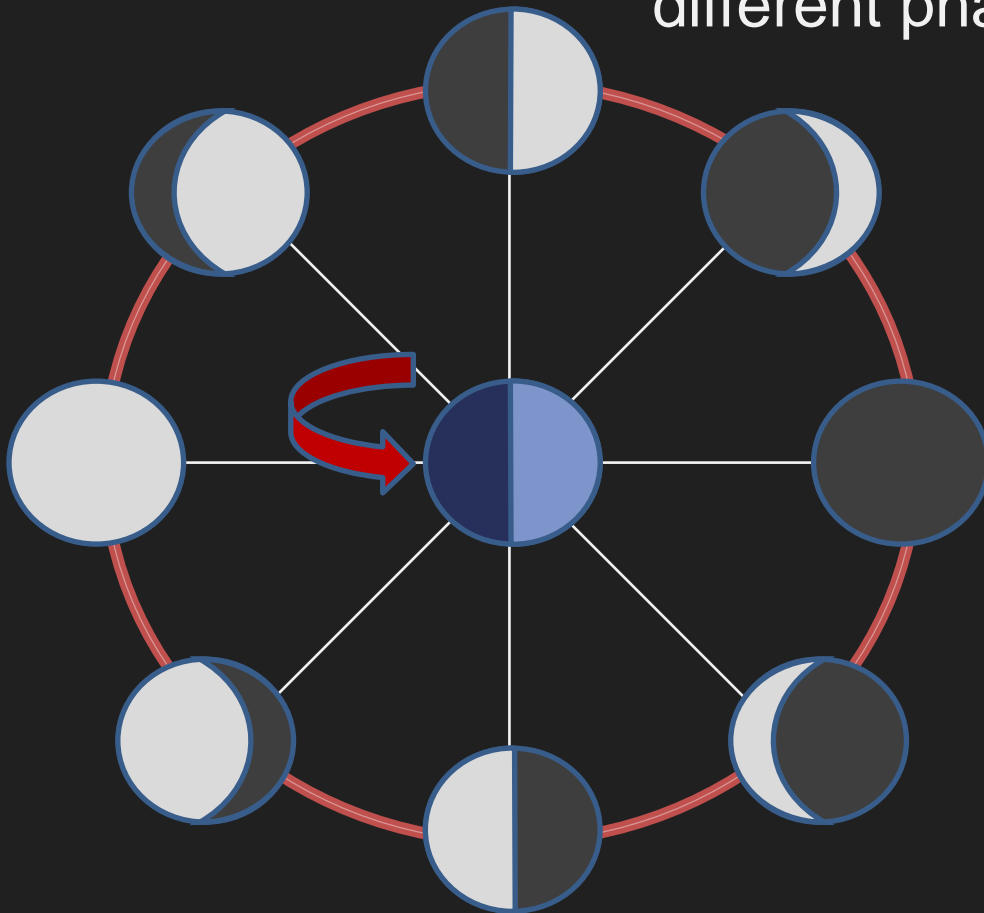 Why do sunlit portions change for the moon phases?

Type of knowledge	Conceptual Schema /Procedural
Cognitive process	Change representation/ apply
Concept link	D-H-H

Question development - 4ᵗʰ level of complexity

Question 4:
 Find the moon rise/set times for the different phases of the moon.

Type of knowledge	Conceptual Schema/ Procedural/ Classification
Cognitive process	Change representation/ Compare/apply
Concept link	H-H-H

Rubric-Analyze students' Responses

Factual	Poor Performance
	Developed
	In-depth
Conceptual	Poor Performance
	Developed
	In-depth
Procedural	Poor Performance
	Developed
	In-depth

Compare	Poor Performance
	Developed
	In-depth
Infer	Poor Performance
	Developed
	In-depth
Apply	Poor Performance
	Developed
	In-depth

Reform N=38

Fraction of responses (y-axis: 0% to 100%)

Porcedural Knowledge (x-axis: Poor Performance, Developed, Indepth)
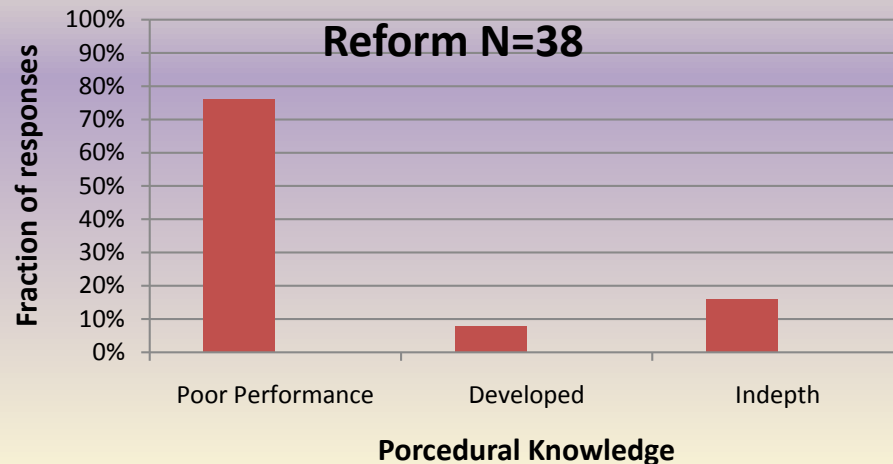
Application

- Impact of reformed undergraduate science courses on student outcomes
  - Reformed $\Rightarrow$ Inquiry oriented strategies with elementary education majors

- Comparing reasoning skills (reformed vs. traditional courses) across scientific disciplines

National **S**tudy of **E**ducation in **U**ndergraduate **S**cience

13

Thank you

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Please see my poster (7.30-8.15)