

Exploring Students' Patterns Of Reasoning

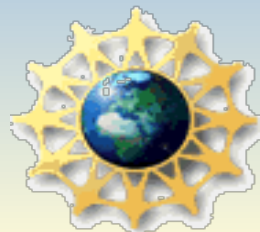
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Introduction to NSEUS¹

- Impact of reformed undergraduate science courses on student outcomes
 - Reformed \Rightarrow Interactive engagement strategies with Elementary education majors
- Comparing reasoning skills (reformed vs. traditional courses) across scientific disciplines

¹National Study of Education in Undergraduate Science

Assessment Tool

- Open-ended content questions
- Predetermined cognitive load, knowledge type
- Focus on reasoning, not on correct answer
- Assess whether they can apply newly learned concept to a new context

Bloom's Revised Taxonomy for Classifying Components of Reasoning²

Knowledge Dimension

Factual knowledge	Knowledge of elements and essential facts
Conceptual knowledge	Knowledge of classification ,principles , theories and structures, Conceptual schema
Procedural knowledge	Knowledge of subject-specific skills, algorithms, techniques, methods and procedures

²Anderson et. al, 2001

Bloom's Revised Taxonomy for Classifying Components of Reasoning²

Cognitive Dimension

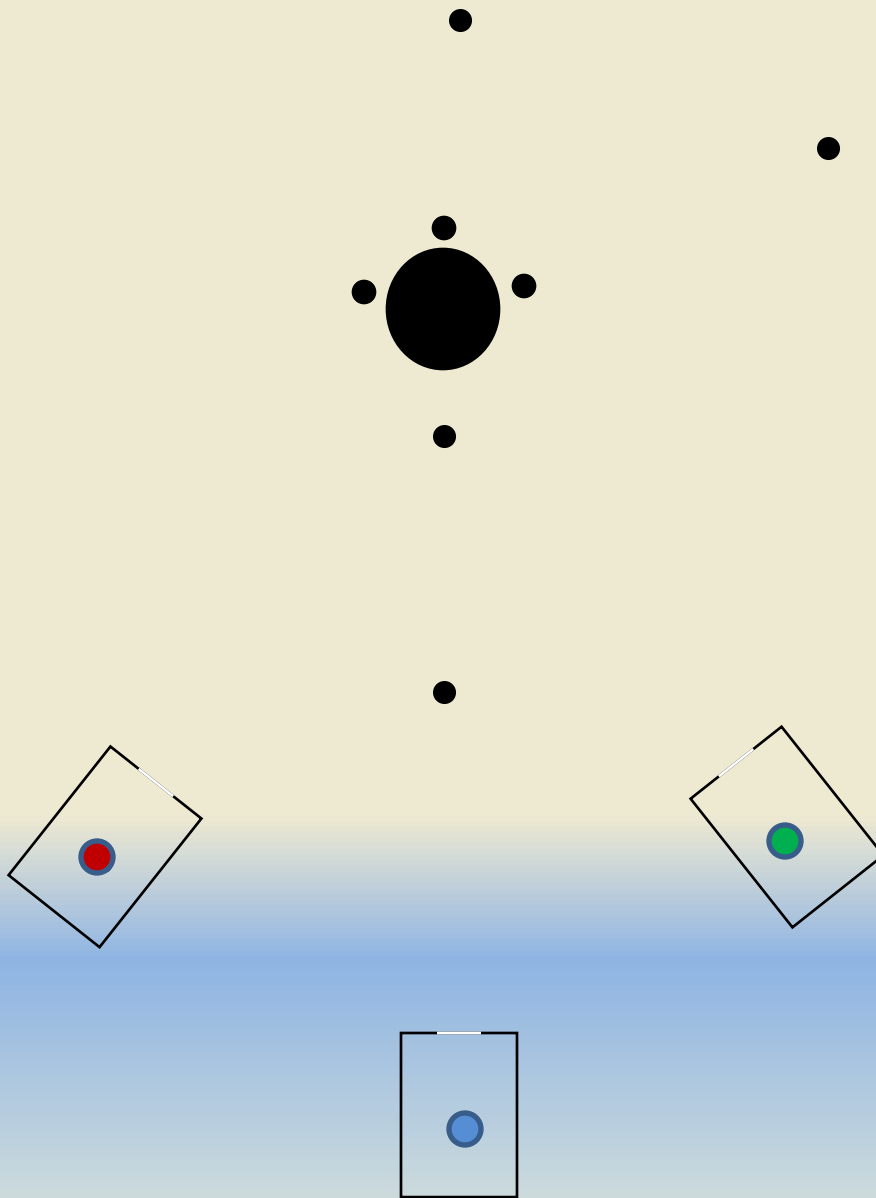
Remember	Recognize (identify), Recall (retrieve from memory)
Understand	Interpret (paraphrase, change representation), Infer (draw logical conclusion), Classify (categorize), Compare and Contrast, Explain (construct cause and effect model)
Apply	Implement (apply a procedure to an unfamiliar task), Execute (apply a procedure to a familiar task)

²Anderson et. al, 2001

Example Question⁴

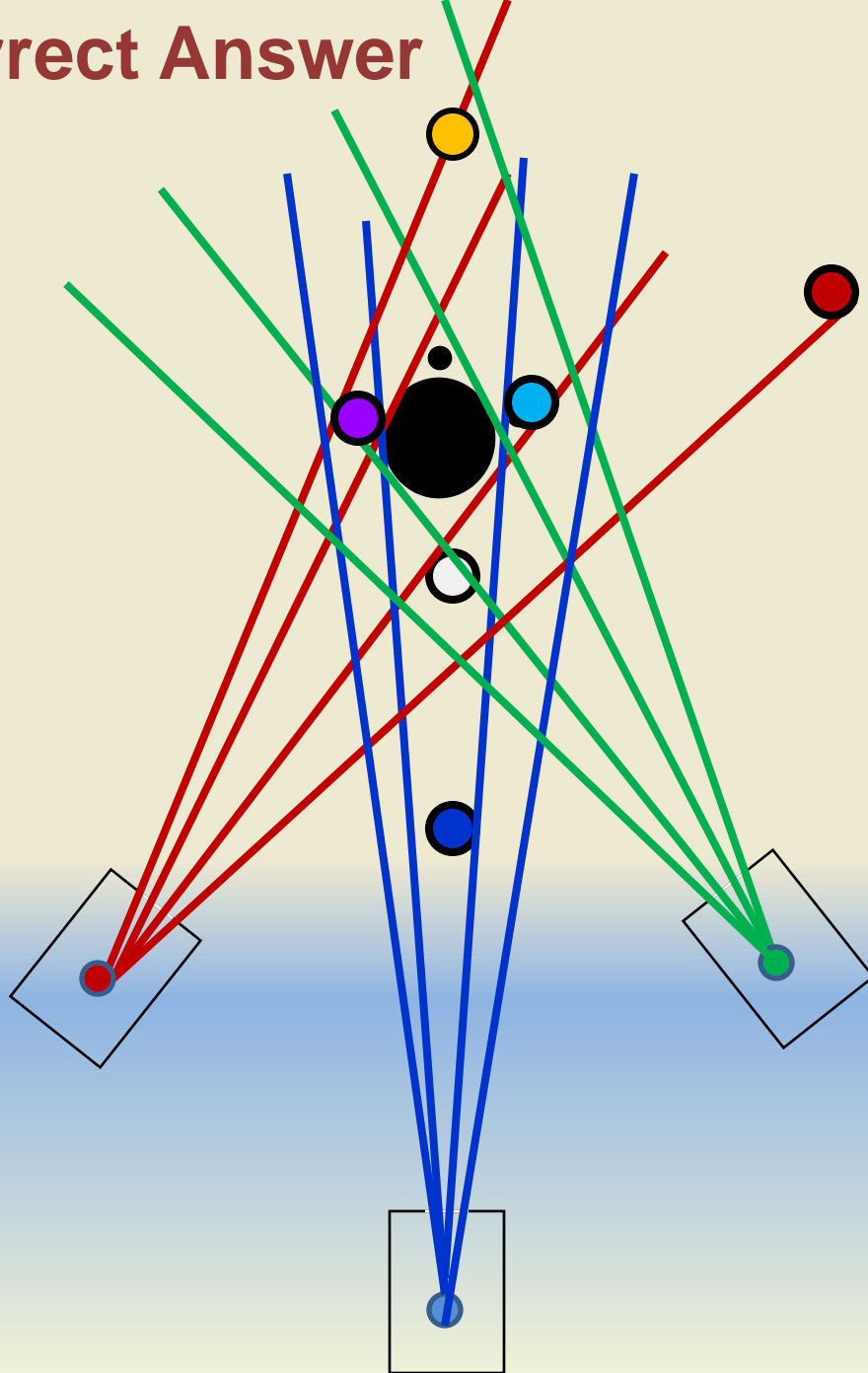
Three light sources are placed on a piece of white paper on top of a table. One of the light sources produces a red beam, another blue, and a third green as shown. The beams are aimed toward a vertical rod that blocks light. The beam of light from each light source falls on both the rod and on the white paper on the table. (You may treat the light bulbs as point sources of light.)

At each labeled point what color will you see? Explain your answer.



⁴Adapted from *Physics by Inquiry* (McDermott, 1996)

Correct Answer



Example Question

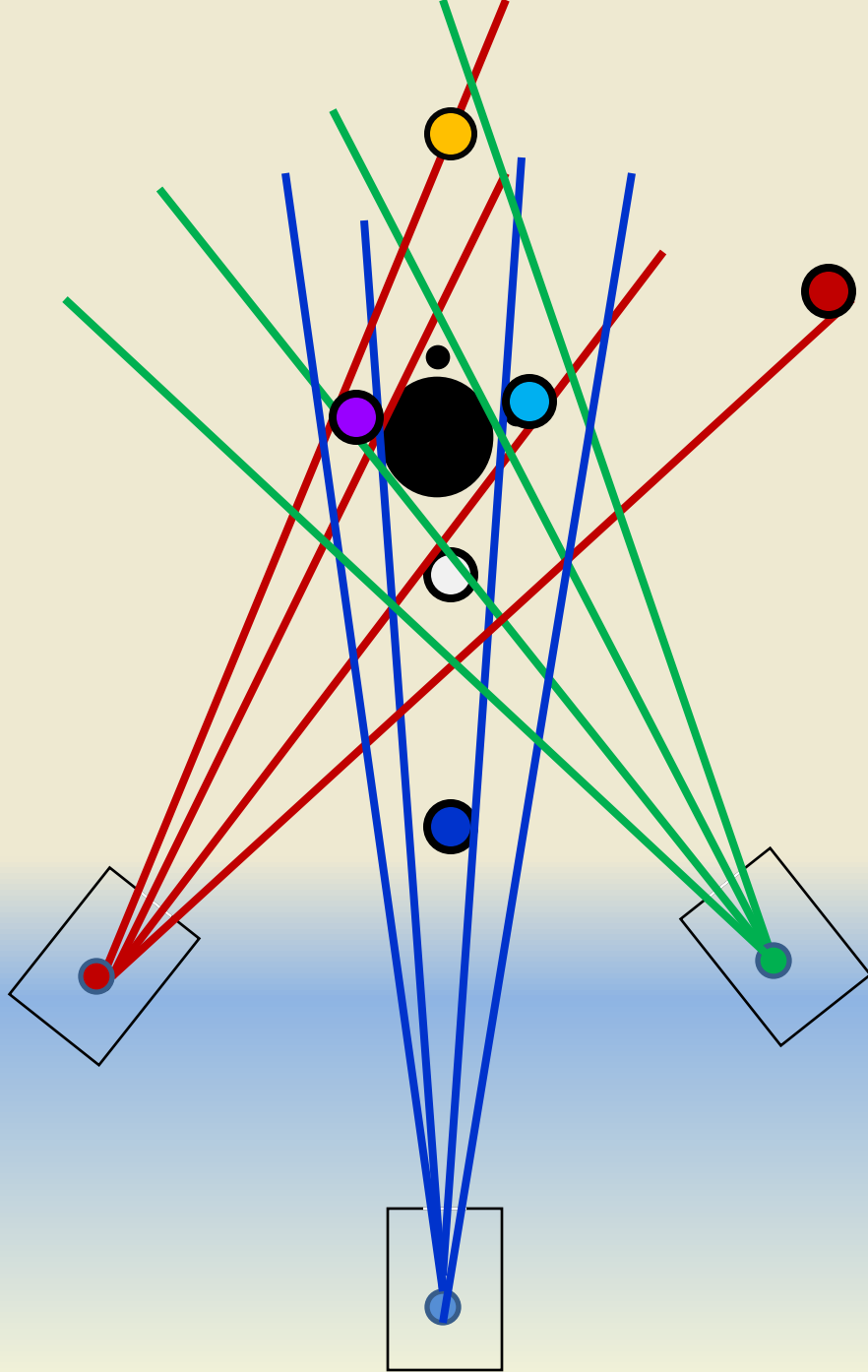
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Rubric for Analyzing Content Questions

- Interpret students' responses in terms of the components of revised Bloom's taxonomy
- Define three levels³ of performance for each component of Bloom's Taxonomy
 - *In-depth,*
 - *Developed,*
 - *Naïve*
- Identify students' levels of performance for each component according to definitions developed by us

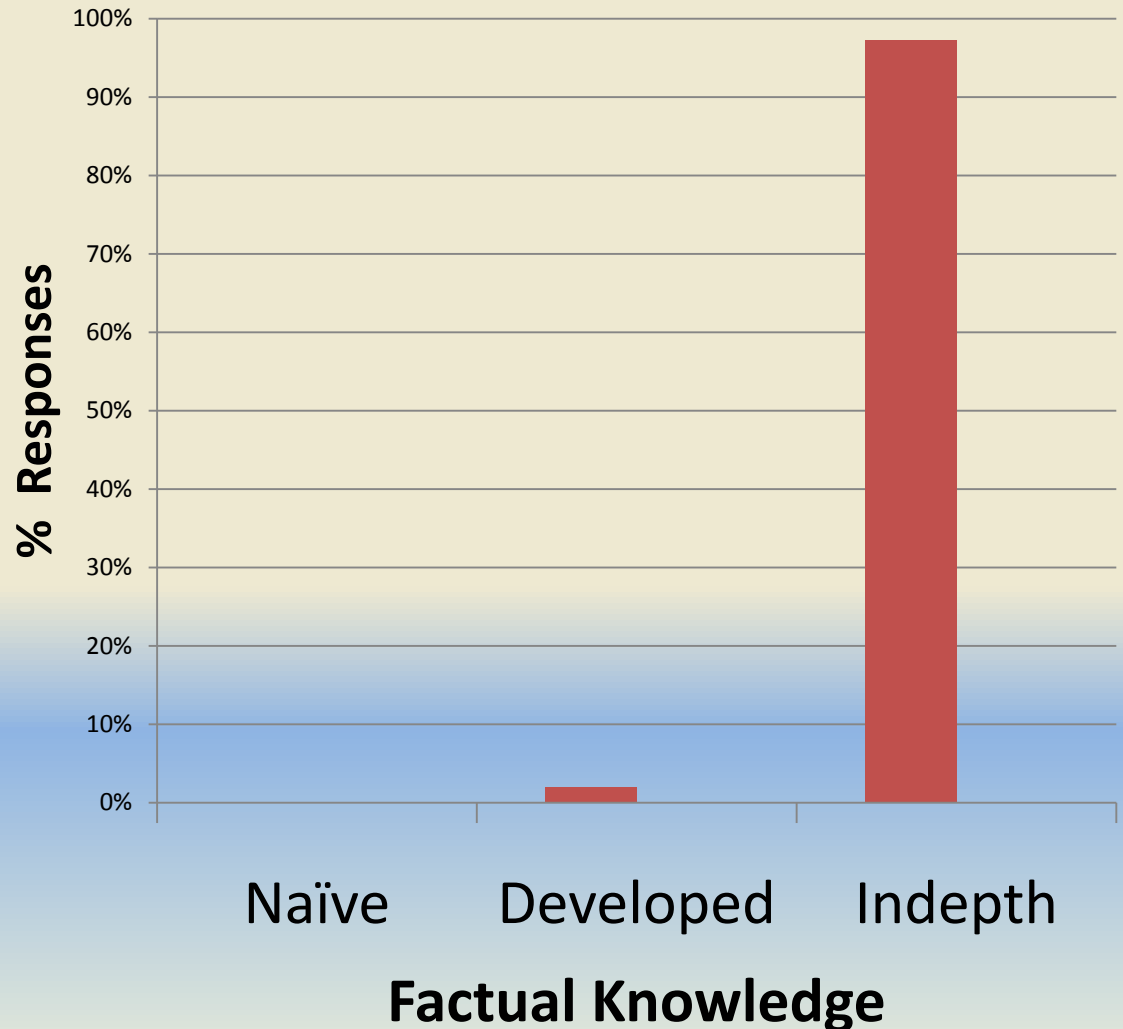
³Wiggins and J. McTighe (1998)



- Almost all students managed to find yellow, magenta, cyan and white without sketching the rays
- All of the students marked the red point as green or white
 - “More green than any color because it is closer”*
- 90% of students marked blue point as white, 10% marked it blue or pale blue;
 - “because blue is closer”*
- 31% marked black point as yellow

Factual Knowledge

Students appeared to be mainly using factual knowledge: combination of two primary colors is secondary color.



Conceptual Schema

Developed Level:

Reasoning:

There are shadowed and illuminated areas for each light source.

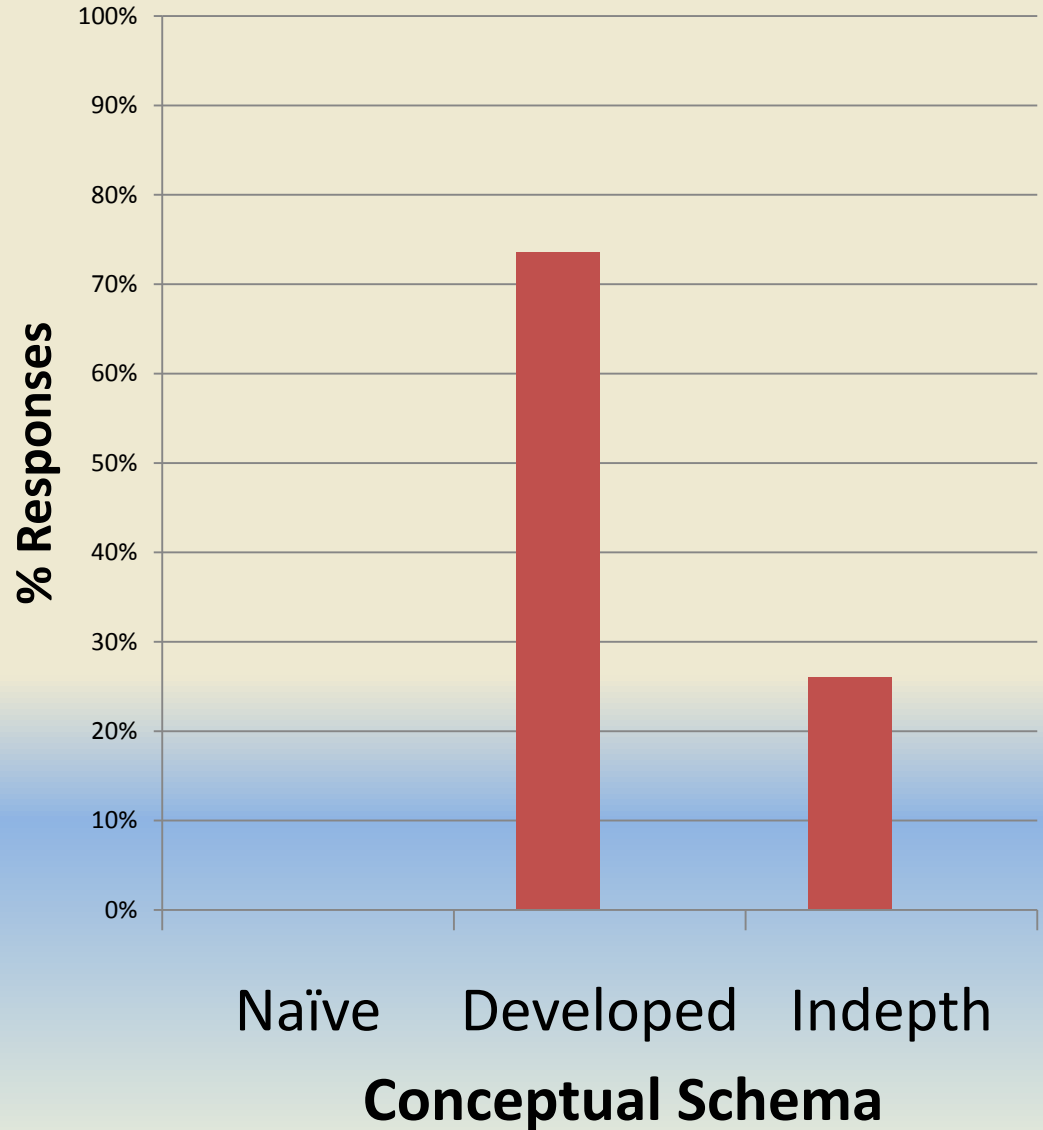
In-depth Level:

Reasoning:

There are shadowed and illuminated areas for each light source

+

Color at a point is the combination of colors received from different sources illuminating that point



Procedural Knowledge

Naïve

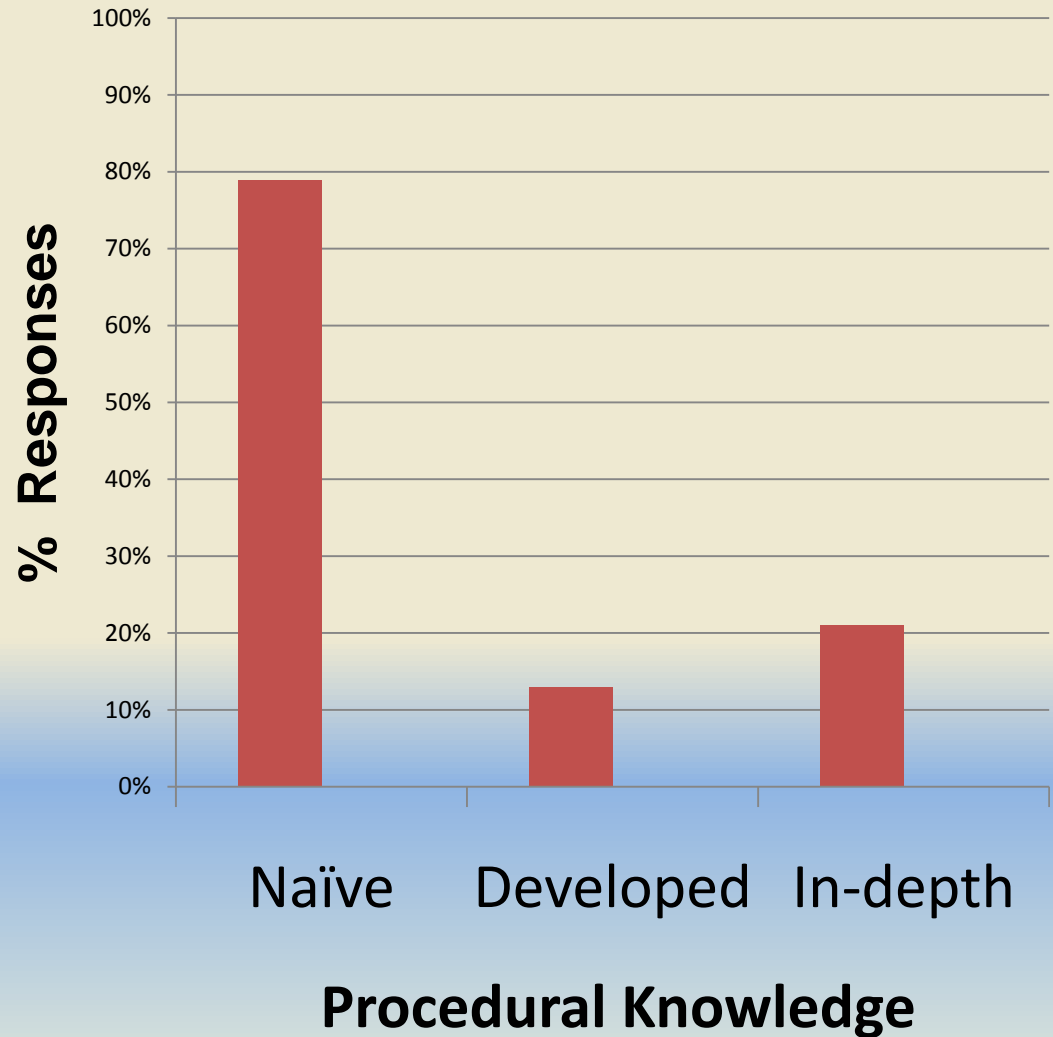
Did not sketch any ray diagrams

Developed

Sketch diagrams but *did not* separate shadowed and illuminated regions

In-depth

Sketch diagrams *and* separated shadowed and illuminated regions



Conclusions

- ✓ We have demonstrated that we can...
 - ✓ Devise content questions with predetermined level of thought processes.
 - ✓ Create a rubric that categorizes different levels of reasoning.
 - ✓ Diagnose weaknesses and strengths of students' reasoning as per our rubric
- ✓ We find that students' performance declines when higher levels of knowledge are required
- ✓ This strategy currently used in NSEUS project to compare students' reasoning patterns across classes & disciplines

Thank you
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