Exploring Students’ Patterns Of Reasoning

Mojgan Matloob, Sytil Murphy & Dean Zollman
Kansas State University

Cynthia Sunal & Dennis Sunal
University of Alabama

Cheryl Mason
San Diego State University

Supported by National Science Foundation Grant ESI-055494
Introduction to NSEUS¹

- Impact of reformed undergraduate science courses on student outcomes
  - Reformed $\implies$ 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 Reasoning

## Knowledge Dimension

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual knowledge</td>
<td>Knowledge of elements and essential facts</td>
</tr>
<tr>
<td>Conceptual knowledge</td>
<td>Knowledge of classification, principles, theories and structures, Conceptual schema</td>
</tr>
<tr>
<td>Procedural knowledge</td>
<td>Knowledge of subject-specific skills, algorithms, techniques, methods and procedures</td>
</tr>
</tbody>
</table>

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\(^2\text{Anderson et. al, 2001}\)
Bloom’s Revised Taxonomy for Classifying Components of Reasoning<sup>2</sup>

Cognitive Dimension

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

<sup>2</sup>Anderson et. al, 2001
Example Question

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. (Your may treat the light bulbs as points sources of light.) At each labeled point what color will you see? Explain your answer.

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4Adapted from Physics by Inquiry (McDermott, 1996)
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At each label point what color you will see? Explain your answer.
Rubric for Analyzing Content Questions

- Interpret students’ responses in terms of the components of revised Bloom’s taxonomy
- Define three levels\(^3\) 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

\(^3\)Wiggins 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.
Students appeared to be mainly using factual knowledge: combination of two primary colors is secondary color.
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

mojgan@phys.ksu.edu