Exploring Students’ Patterns of Reasoning

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Introduction and Research Goal

- NSEUS\textsuperscript{1} (National Study of Education in Undergraduate Science) investigates the effect of interactive engagement teaching-learning strategies in treatment courses in compare to traditional courses.

- As a part of NSEUS, we are comparing students’ (Elementary Education majors) reasoning skills in a scientific context across disciplines (treatment and traditional courses).
Content Question Design

- Designed to elicit students’ reasoning patterns as they apply recently scientific concepts to a new context
- Structured with defined levels of abstraction
- Developed from concepts and procedures and the manner that these are cognitively processed
- Constructed to include a reasoning type such as cause-effect chain of reasoning, compare and contrast, analogical reasoning, etc
Bloom’s revised taxonomy for classifying the components of reasoning \(^1\)

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

1-Anderson et. al, 2001
Bloom’s revised taxonomy for classifying the components of reasoning, Cont.

<table>
<thead>
<tr>
<th>Table 2- Selection from Cognitive Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Remember</strong></td>
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<tr>
<td>Recognize (identify), Recall (retrieve from memory)</td>
</tr>
<tr>
<td><strong>Understand</strong></td>
</tr>
<tr>
<td>Interpret (paraphrase, change representation), Infer (draw logical conclusion), Classify (categorize), Compare and Contrast, Explain (construct cause and effect model)</td>
</tr>
<tr>
<td><strong>Apply</strong></td>
</tr>
<tr>
<td>Implement (apply a procedure to an unfamiliar task), Execute (apply a procedure to a familiar task)</td>
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Modification to Lawson’s definition to make it appropriate for physics contexts

Scientific Concepts

Descriptive

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

Hypothetical

Concepts indirectly observed by Measurement, or analogical model model e.g. magnetic field

Theoretical

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

2-Lawson et. al (2000)
Type of concept links

- One Concept-Level link
  - Descriptive
  - Hypothetical
  - Theoretical

- Cross Concept-Level link
  - Hypothetical
  - Theoretical

- Multi Concept-Level links
  - Descriptive
  - Hypothetical
  - Theoretical

3-Neiswandt & Bellemo 2009
Content questions
Structure and level of abstraction

- Concept construction and intellectual development proceeds from descriptive concepts toward theoretical concepts (Lawson et. al, 2000)

- The level of abstraction proceeds from one-concept level links toward multi-level links (Neiswandt, et. al 2009)

- The level of abstraction may increase if we move toward higher levels of cognitive processes and knowledge types in Bloom’s taxonomy (Anderson et. al, 2001)
Applying taxonomy and concept categorization to a content question

- Recently learned Concept
  Explain how the stability relates to the width of the base and the height of center of mass above the base? Explain in terms of forces and torques.

- Application to real life
  To protect against attacks the man takes on particular fighting stances. Explain why this fighting stance makes it difficult for opponents to knock him down?
Rubric

- Interpret students’ responses in terms of components of Bloom’s revised taxonomy
- Construct a framework by defining three levels of performance (*In-depth, developed, Naïve*) for each component of Bloom’s Taxonomy
- Identify students’ levels of performance for each component according to the definitions

4-Wiggins and J. McTighe (1998)
Example 1) Density (Active learning class)
A toy metal ship is floating in a container of distilled water. Explain why a metal ship can float.

Sample Answer:
“A larger surface area causes less force allowing it to float.
Distilled water has a high surface tension let it to float”.

- Factual knowledge: What other facts?

- Infer: The chain of cause and effect is not complete

- Doesn't Compare how and why

Conceptual schema

Response Frequency

- Factual
- Conceptual Schema
- Understand (Compare)
- Understand (Infer)
Example 2) Chemistry (Traditional Class)
In the winter time spreading salt on the road can melt ice. Explain how the chemical structure of salt affects the properties of the solution? And why sugar, does not have the same effect?
Conclusion

✓ We can compare students’ reasoning patterns as displayed on the responses by comparing the associated histograms.

✓ We can devise content questions with the same level of thought processes in different disciplines.

✓ We can find the weaknesses and strengths of students’ reasoning in our classification scheme (concept structure, type of knowledge or cognitive process).

✓ This method will allow the comparison of students’ responses and their reasoning across disciplines.
Thank you

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