Students’ Reasoning and the Level of Interactivity in Science Content Courses for Future Elementary Teachers

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National Study of Education in Undergraduate Science

Investigating

- Impact of types of delivery of undergraduate science content courses on elementary education majors
- How traditional vs. interactive undergraduate science courses for elementary education majors affect
  - Learning (pre-service)
  - Classroom practices (in-service)

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Collaborators

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- San Diego State University
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The overall study

- 20 universities
- Collect data from
  - Pre-service teachers & students
  - In-service teachers and classes
- Pre-service science content classes
  - Physics
  - Chemistry
  - Biology
  - Earth Science
- Different disciplines at different universities
- Large number of pedagogies
  - Many variations of “reformed” teaching–learning
Focus of our work

- Question: Do students learn differently from different pedagogies?
- Difficulty: Need to compare across disciplines.
- Difficulty: Need to study a large number of students in many different universities
- Solution: Analyze evidence of students’ reasoning as exhibited in their responses to written content questions.

Research Questions

- What is the relation between the quality of students’ reasoning as displayed on written content examination questions and the degree to which course is considered to be reformed?
  - How do we classify students’ reasoning based on their responses to written content questions?
  - How do we relate classified responses to the degree to which science instruction is reformed?
Measure the level of the reform

Reformed Teaching Observation Protocol (RTOP)
- Lesson design
- Propositional knowledge
- Procedural knowledge
- Classroom culture
- Teacher–Student relationship

Quality of student reasoning

- Analyze level of cognitive processes displayed in written responses
- Rubric based on Anderson, *et al.* variation on Bloom’s Taxonomy
- Limit the analysis to
  - Understand
    - Compare
    - Infer
    - Explain
  - Apply

2-Swada, et al. (2000)
Questions Developed & Analyzed

- Content:
  - Physics, Biology, Geology & Chemistry
- Data collected as final exam from ~ 900 students
- Qualitatively analyzed
  - Using rubric based on Bloom–Anderson
  - For evidence of cognitive processes

Analysis (in the ideal world)

Magical RTOP Score defines transition from traditional to interactive
**Logistic Regression**

- **\( \alpha, \beta \):** Coefficients that fit the regression model
- **\( x \):** RTOP scores
- **\( f(x) \):** Probability of evidence that certain component of taxonomy occurred

\[
f(x) = \frac{1}{1 + e^{-(ax+b)}}
\]

**Simplified version of logistic regression**

- Treat both variables as dichotomous
- RTOP divided into above and below average
  - Average for classes observed = 65.5
Odds Ratio

Odds that a student will show evidence of a cognitive process if he/she is in a higher than average RTOP class

\[
Odds = \frac{\text{Evidence}}{\text{No Evidence}}
\]

\[
Odds\ Ratio = \frac{\text{High RTOP Odds}}{\text{Low RTOP Odds}}
\]

Example of using simplified model

- Number of students in each of the four groups for the cognitive process *Apply*

<table>
<thead>
<tr>
<th>Evidence of process</th>
<th>Below Average RTOP</th>
<th>Above Average RTOP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Evidence</td>
<td>449</td>
<td>381</td>
<td>730</td>
</tr>
</tbody>
</table>

A student in a higher than average RTOP class is 1.3 times more likely to show evidence of using apply than one in a low RTOP class.

Average RTOP = 65.5
Odds ratio = 1.30
Odds Ratio Using Simplified Logistic Regression

<table>
<thead>
<tr>
<th>Cognitive Process</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand/Compare</td>
<td>1.84</td>
</tr>
<tr>
<td>Understand/Explain</td>
<td>1.00</td>
</tr>
<tr>
<td>Understand/Infer</td>
<td>1.42</td>
</tr>
<tr>
<td>Apply</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Full Logistic Regression

RTOP Score as independent variable vs.
- Compare–contrast
- Infer
- Explain
- Apply

\[ f(x) = \frac{1}{1 + e^{-(ax+b)}} \]
The likelihood of compare occurring:

Compare vs. RTOP score

Infer vs. RTOP Score
Explain vs. RTOP Score

Apply vs. RTOP Score
Trends

<table>
<thead>
<tr>
<th>Compare</th>
<th>As the RTOP score increases, the likelihood of the evidence for compare in student responses increases.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infer</td>
<td>There is no relationship between the RTOP average score and evidence in student responses for inference</td>
</tr>
<tr>
<td>Explain</td>
<td>There is no relationship between evidence of students’ ability to explain and the increase in RTOP average score</td>
</tr>
<tr>
<td>Apply</td>
<td>Likelihood of evidence in their responses of students’ ability to apply slightly increases as the RTOP average score increases</td>
</tr>
</tbody>
</table>

Summary of Qualitative Analysis

- Created a protocol to develop content questions with same level of thought processes in different disciplines
- Developed a rubric to classify evidence of students’ reasoning based on written responses to content questions
Summary of Quantitative Analysis

- Evidence of cognitive process depends on RTOP in the favor of higher RTOP scores for some but not all processes
- Other results show similar patterns
- But some traits decrease with higher RTOP component scores

http://nseus.org/