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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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

2-Swada, et al, (2000)

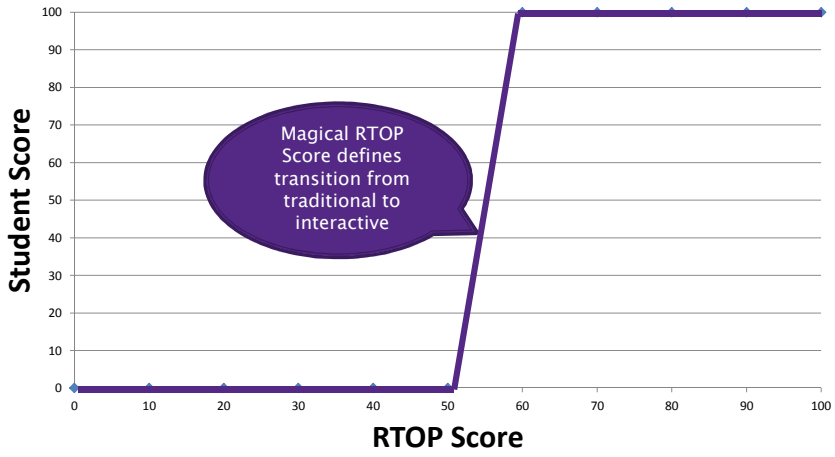
Quality of student reasoning

- 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

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)



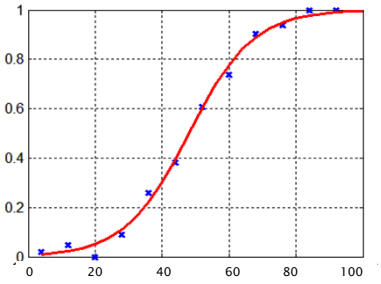
Logistic Regression

a, b: 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

$$Odds = \frac{Evidence}{No\ Evidence}$$

$$Odds\,Ratio = \frac{High\ RTOP\ Odds}{Low\ RTOP\ Odds}$$

Example of using simplified model

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

	Below Average RTOP	Above Average RTOP	Total
Evidence of proc ansv			
No-E process			
Total	449	381	730

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

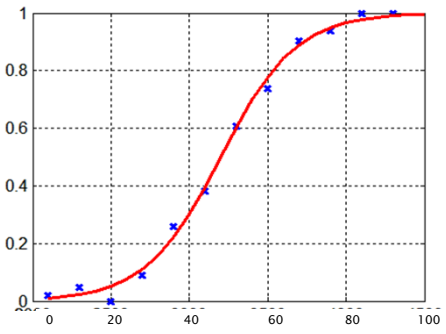
Cognitive Process	Odds ratio
Understand/Compare	1.84
Understand/Explain	1.00
Understand/Infer	1.42
Apply	1.30

Full Logistic Regression

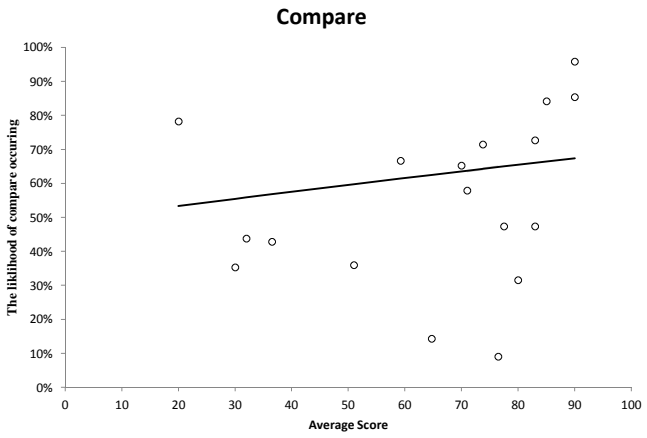
RTOP Score as independent variable vs.

- Compare-contrast
- Infer
- Explain
- Apply

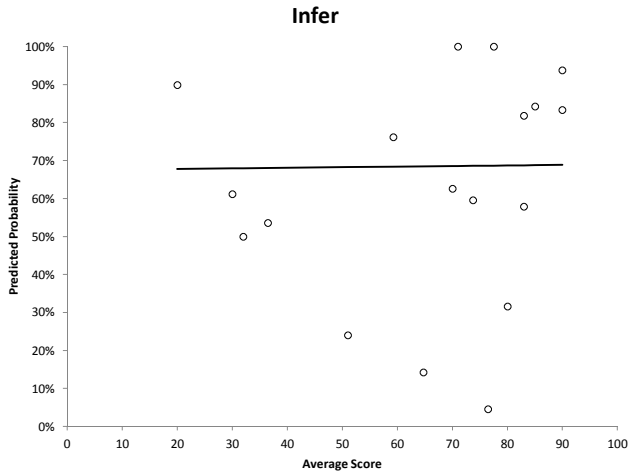
$$f(x) = \frac{1}{1 + e^{-(ax+b)}}$$



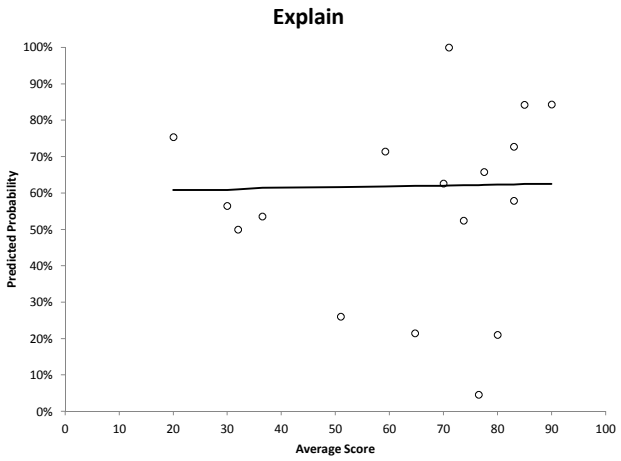
Compare vs. RTOP score



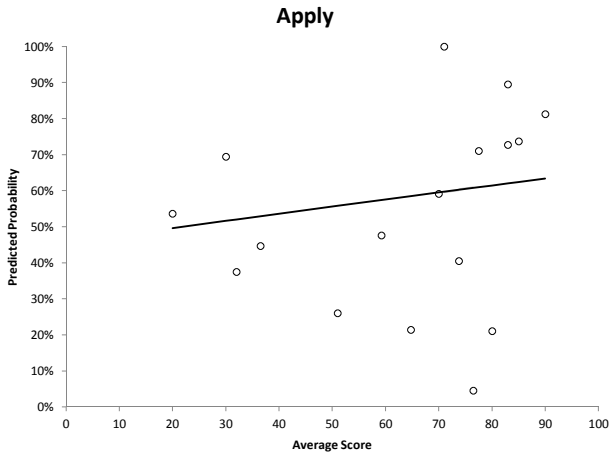
Infer vs. RTOP Score



Explain vs. RTOP Score



Apply vs. RTOP Score



Trends

Compare	As the RTOP score increases, the likelihood of the evidence for compare in student responses increases.
Infer	There is no relationship between the RTOP average score and evidence in student responses for inference
Explain	There is no relationship between evidence of students' ability to explain and the increase in RTOP average score
Apply	Likelihood of evidence in their responses of students' ability to apply slightly increases as the RTOP average score increases

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

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