Introduction: Use of constructed responses

- Students have complex ideas
- One limitation of multiple choice questions is the forced selection of a single idea
- Having students create their own explanations may better reveal their complex ideas
Introduction: Conceptual Change

- Students build new ideas upon existing knowledge
- This makes conceptual change difficult in that incorrect ideas are not easily replaced
Research Question

- How can we better reveal and understand students’ complex ideas?
  - When students construct their own answer, more likely to reveal a mix of ideas.
  - Impossible to analyze all students’ submissions in very large courses.
  - Can computer help?
    - **Lexical analysis** allows the processing of large numbers of student responses to reveal *common patterns of ideas*. 
Why Research Photosynthesis?

- Photosynthesis a complex biological process
  - energy transformations
  - molecular rearrangements
  - structure/function relationships

- Existing diagnostic questions and research into student difficulties
Methods

- Exam data from introductory cell biology course (n=391)
- Each student received one MC DQC and one constructed response
- Used 2 versions of the DQC questions that allowed a cross-over design
- Lexical analysis by SPSS Text Analytics for Surveys
Q. A mature maple tree can have a mass of 1 ton or more (dry biomass, after removing water), yet it starts from a seed that weighs less than 1 gram. Which of the following contributes most to this huge increase in biomass?

A. Absorption of mineral substances from root (7.7%)
B. Absorption of organic substances from soil via roots (12.7%)
C. **Incorporation of CO2 gas from atmosphere into molecules by green leaves (59.4%)**
D. Incorporation of H2O from soil into molecules by green leaves (7.7%)
E. Absorption of solar radiation into the leaf (12.7%)

A similar question stem using corn and same distractors was also used
A mature maple tree can have a mass of 1 ton or more (dry biomass, after removing the water), yet it starts from a seed that weighs less than 1 gram. **Explain this huge increase in biomass.**
Lexical Analysis

19. the huge increase in biomass is due to the intake of CO₂ to use in the production of sugars during photosynthesis. The sugars are then stored and increase the biomass.

21. the plant used CO₂ from the air and sunlight to produce sugar, which is used to build structures within the plant. This process is repeated over many years.

10. the increase in biomass to the fall is resulting from the storage of the products it held from photosynthesis. During all the photosynthesis in the summer starting from sunlight into the light reactions the H₂O and CO₂ it took in created sugar and O₂. By storing the sugar and water from photosynthesis it was able to increase in biomass.

22. The huge increase in biomass from the seed has weight less than 1 gram is due to all of the organic molecules it takes in during the tree’s lifetime, the tree takes in CO₂ from the air and takes in H₂O from the ground with its roots. More of that is contained inside the maple tree so that it can use it to do work.

24. through photosynthesis the tree will gain CO₂ to produce O₂ but in this reaction, as long as this tree is not of a photosyncs.

26. Any Mention of CO₂ Glucose/Sugar Photosynthesis

22. CO₂ from Air Any Mention of CO₂ Glucose/Sugar Solar Radiation


12. CO₂ from Air Roots/Soil Any Mention of CO₂ Substance Water
Frequencies of concepts expressed in Constructed Responses

<table>
<thead>
<tr>
<th>Category</th>
<th>Bar</th>
<th>Selection %</th>
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<tr>
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<tr>
<td>Any Mention of CO2</td>
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<td>Seeds</td>
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<td>Energy Molecules/Electric Potential</td>
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Students’ explanations reveal a more complex picture than multiple choice

- Concepts in constructed response coded by MC choice

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<td>Seeds</td>
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MC Selection
- A. Minerals
- B. Organic substances
- C. CO₂
- D. H₂O
- E. Light
MC Selection vs. CR Categories

- Any Mention of CO2
- Photosynthesis
- Glucose/Sugar
- Water
- Substance
- Solar Radiation
- CO2 from Air
- Energy Mols/EectrTranp
- Seeds
- Cell Rep/Energy/Matter
- Energy
- Carbon
- Roots/Soil
- Oxygen
- Respiration
- No Answer/No Exam
Students’ concept heterogeneity revealed through written explanations
Conclusions

- Lexical analysis can reveal patterns of concepts present in large number of responses
- Students have complex and heterogeneous ideas
- Constructed response provides a unique view of this complexity that can be missed by multiple choice items
Conclusions

- Nothing particularly unique about analyzing student writing, *per se*
- Ability to accurately analyze LARGE numbers quickly at low cost *is unique*
- Formative feedback to instructor about patterns of ideas of whole class allows *rapid instructional response* (JiTT)
- Even reading lots of responses would be unlikely to reveal these patterns in responses – exceptional research tool
Next Steps

- Use lexical categories as predictors of human scoring
  - Different rubric types
- Creation and implementation of DQC-type instrument as opposed to questions
Acknowledgements

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  - Automated Analysis of Constructed Response (AACR) Group
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Visit our group webpage: aacr.crcstl.msu.edu