

# Examining the Impact of Question Surface Features on Students' Answers to Constructed Response Questions in Biology

## Do photosynthesis question surface features influence student responses?

- Surface features of the question can influence how students respond (Ebert-May, Batzli, & Lim 2003, Nehm, Beggrow, Opfer, & Ha 2012)
- In the past, we have noticed interesting written and interview responses to different versions of the photosynthesis question from students
  - Ex. Corn is not green, does not undergo photosynthesis

### Research Questions

Does changing the surface features of the question stem result in significant changes to student responses?

- Does changing the species of plant in the question stem influence the concepts present in student responses?
- Does changing the order of prompts in the question influence the concepts present in student responses?
- Do students think that surface features are important to answering the question?

## Cross-over Question Design

### Photosynthesis Question

Each Spring, farmers plant about 5-10 kg of **SPECIES** per acre for commercial **SPECIES** production. By the Fall, this same acre of **SPECIES** will yield approximately 4-5 metric tons of dry harvested **SPECIES**. **ORDER OF PROMPTS**.

### Surface Feature Variables

**ORDER OF PROMPTS Process, where (PW):** Explain what process adds this huge increase in biomass and where the biomass comes from.  
**ORDER OF PROMPTS Where, process (WP):** Explain where this huge increase in biomass comes from and by what process.  
**SPECIES:** Corn or Peanut

- Question asked at a large Midwestern university
- Post instruction on metabolism; given in introductory biology course
- Given as a online homework, 322 out of 468 students responded

### Acknowledgements

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### References

- Ebert-May, D., Batzli, J., & Lim, H. (2003). Disciplinary Research Strategies for Assessment of Learning. *BioScience*, 53(12), 1221-1228. doi:10.1641/00063568(2003)053[1221:DRSFAO]2.0.CO;2
- Nehm, R. H., Beggrow, E. P., Opfer, J. E., & Ha, M. S. (2012). Reasoning About Natural Selection: Diagnosing Contextual Competency Using the ACORNS Instrument. *American Biology Teacher*, 74(2), 92-98. doi: DOI 10.1525/abt.2012.74.2.6

## No significant difference in content of student responses to four question versions

### Text analysis categories vs. photosynthesis question rubrics

- Text analysis categories have a finer grain size; represent all possible relevant ideas that we have seen in student writing
- PS rubrics have a larger grain size; represent specific concepts and misconceptions of interest for this constructed response question

### Research Questions A and B

- No significant difference in the content of student responses to versions of the question stem with different species or order of prompts

### Implication

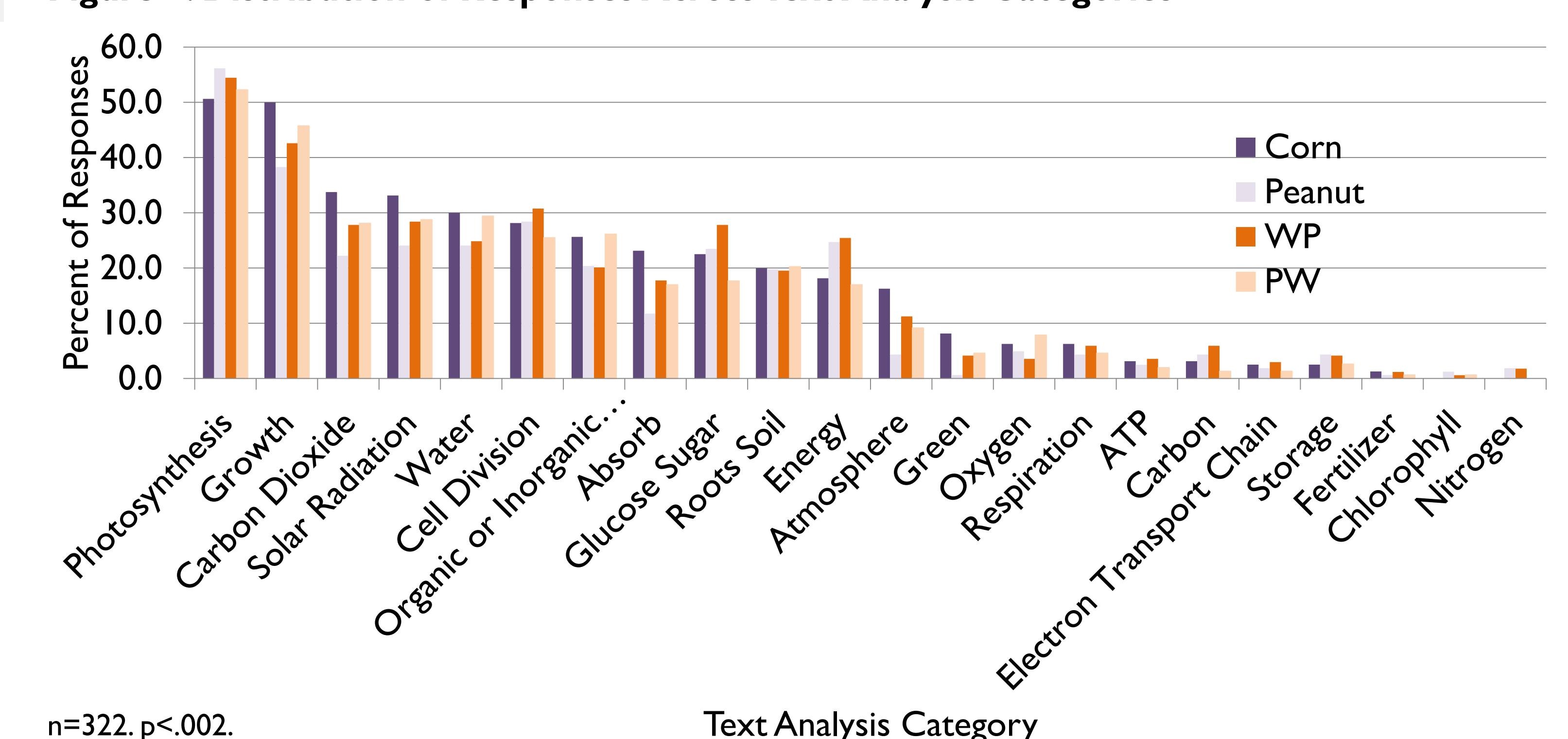
- These versions of the question with different surface features can be used interchangeably without expecting to see a significant difference in the content of student responses

Table 1. Photosynthesis Question Rubric

| Rubric                  | Examples  | Corn <sup>a</sup> | Peanut <sup>b</sup> | WP <sup>c</sup> | PW <sup>d</sup> |
|-------------------------|---|-------------------|---------------------|-----------------|-----------------|
| Correct Process         | Photosynthesis, Calvin Cycle                            | 53%               | 59%                 | 57%             | 55%             |
| Incorrect Process       | Light reactions alone, respiration, cell division, etc. | 39%               | 35%                 | 36%             | 39%             |
| Correct Source          | CO <sub>2</sub> , carbon from the atmosphere            | 36%               | 23%                 | 30%             | 29%             |
| Incorrect Source        | Sunlight as mass, oxygen, ATP, etc.                     | 21%               | 22%                 | 5%              | 9%              |
| Water as Source         | Water   | 6%                | 7%                  | 25%             | 29%             |
| Nutrients from the Soil | Nutrients from the soil, minerals, fertilizer, etc.     | 29%               | 24%                 | 17%             | 26%             |
| Correct Product         | Glucose, sugar  | 23%               | 20%                 | 26%             | 16%             |
| Incorrect Product       | CO <sub>2</sub> , ATP, energy                           | 6%                | 4%                  | 5%              | 5%              |

The analytic scoring rubric includes eight concepts and misconceptions; scored dichotomously based on presence or absence of each concept or misconception. Each response can fall into any number of bins. <sup>a</sup>n=160. <sup>b</sup>n=162. <sup>c</sup>n=147. <sup>d</sup>n=175.

Figure 1. Distribution of Responses Across Text Analysis Categories



| SPECIES     | ORDER OF PROMPTS    |                     | Totals |
|-------------|---------------------|---------------------|--------|
|             | Process, where (PW) | Where, process (WP) |        |
| Corn (CO)   | Version 1<br>n=83   | Version 2<br>n=77   | 160    |
| Peanut (PE) | Version 4<br>n=70   | Version 3<br>n=92   | 162    |
| Totals      | 153                 | 169                 | 322    |

## Students find prompts both important and confusing

### Research Question C

- Students thought the plant species were neither important nor confusing when answering the question
- Students thought the prompts were both important and confusing when answering the question

### Implication

- Question writers should pay close attention to the clarity of question prompts, because students are likely to be confused about what the prompts are asking

### Further Investigation

- More interviews focused on how students understand the question prompts

Table 2. Examples from Student Interviews: Important and Confusing Parts of Question Stem

| Important Parts of Question Stem   |
|--|
| <i>Explain what process adds this huge increase in biomass...</i> (8 students)<br>Student 8: "And process tells me it's not just like where does it come from, air? I mean, it's like a process, it has steps."  |
| <i>Explain where this huge increase in biomass comes from ...</i> (6 students)<br>Student 6: "It's relevant because it explains the next part of what the question is asking you to do; to tell you where the biomass comes from. That's what I thought was pretty relevant."  |
| Confusing Parts of Question Stem   |
| <i>Both prompts are asking for the same thing</i> (2 students)<br>Student 6: "I get the sense that when it's saying what process adds to the increase and where the biomass comes from, it's kind of talking about two different things and they're really like the same. It's discussing the same process. So I think that's where things can get kind of confusing." |
| <i>Explain what process adds this huge increase in biomass...</i> (3 students)<br>Student 7: "I guess it would be if they're asking for like one specific process here, it's just one thing, or if they're asking for just like whole steps of processes that leads to it. That would probably be it."   |

n=20.