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

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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?

A. Does changing the species of plant in the question stem influence the concepts present in student responses?
B. Does changing the order of prompts in the question stem influence the concepts present in student responses?
C. 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 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 what process.

SPECIES: Corn or Peanut

Table 1. Photosynthesis Question Rubric

| Rubric | Examples | Corn | Peanut | WP | PW
|--------|----------|------|--------|----|----
| Correct Process | Photosynthesis, Calvin Cycle | 53% | 59% | 57% | 55%
| Incorrect Process | Light reactions alone, respiration, cell division, etc. | 39% | 35% | 36% | 39%
| Correct Source | CO2, 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 | CO2, 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.

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

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<td>Explain what process adds this huge increase in biomass… (8 students)</td>
<td>Student 8: “And process tells me it’s not just where does it come from, air? I mean, it’s like a process, it has steps.”</td>
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<td>Student 9: “Where does this huge increase in biomass come from…” (6 students)</td>
<td>Explain where this huge increase in biomass comes from.</td>
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<td>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.”</td>
<td>Explaining what process adds this huge increase in biomass… (3 students)</td>
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<td>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.”</td>
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References

Surveys, interviews, and rubrics used in the study are available online at www.msu.edu/~aacr.

Figure 1. Distribution of Responses Across Text Analysis Categories

Students find prompts both important and confusing

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