Beyond Multiple Choice: Heterogeneous Thinking About Photosynthesis is Revealed by Automated Analysis of Student Writing

Casey Lyons, Shauna Jones, Mark Urban-Lurain, John Merrill

Multiple Choice Data
(BS111, FS09, EX2, N=381)

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?

- 7.7% A: Absorption of mineral substances from roots
- 12.7% B: Absorption of org. sub from soil via roots
- 59.4% C: Incorporation of CO2 gas from atmosphere into molecules by green leaves
- 7.7% D: Incorporation of H2O from soil into molecules by green leaves
- 12.7% E: Absorption of solar radiation into the leaf

How do the Categories Relate to Open-Ended Responses?

Substance
- Biomass is increased due to the absorption of organic substances from the soil

Roots and Soil
- The maple seeds have drawn nutrients from the ground, mainly organic, and used it as food to grow

CO2 and Photosynthesis
- This huge increase in biomass comes from photosynthesis. The carbon taken from CO2 is incorporated into the plant, increasing its biomass. Some minerals from the soil, taken in by the roots would account for a very small portion of the biomass increase.

Water
- The huge increase in the biomass of the corn comes from all that is involved in allowing the corn to grow. Water and nutrients are taken up and aid in the growth of the corn. The water and light energy allow for photosynthesis to occur in the plant and aids in the growth of the corn as well.

Solar Radiation
- The increase of biomass is because of the absorption of solar radiation into the leaf, which allows for photosynthesis to occur which in turn, allows the corn plants to yield energy to absorb nutrients from the soil and thrive.

Conclusions
- Students can pick an answer out of a group
- Students written answers lack confidence
- These assessments tell two very different stories
- Misconceptions prevalent
  - Often co-exist with correct ideas leading to heterogeneous answers

Moving Forward
- Develop an expert rater scoring rubric that will be informative to instructors
- Use the lexical analysis data to predict expert ratings
- Challenges:
  - Wording of the question
  - Trade-off between holistic scoring and heterogeneity of student responses

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