Concept Maps to Address Misconceptions in Introductory Science Courses

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Teaching and Learning Science Concepts and Addressing Misconceptions

• Why it matters
• Which concepts
• How to address
• Improve teaching
Why

• Previous research demonstrates that one of the issues with embedded misconceptions is that students struggle with comprehension of the relationship between abstract topics, such as photosynthesis and respiration or pollination and double fertilization in plants.

• Concept maps have the potential to provide scaffolding that can address and remediate mistaken understandings.

• As teaching tools, concept maps illustrate the relationship between concepts and vocabulary.
Concept Maps as Learning and Assessment Tools

• Developed by Novak and Gowin (1984)
• Illustrations of the relationship between concepts can:
  – Demonstrate higher level of understanding of conceptual knowledge
  – Develop learning skills
  – Detect common misconceptions retained by students
Detecting and Addressing Misconceptions

• First detected misconceptions via previous survey (Orvis and Espinoza, 2014)
  – Used misconceptions and student responses to create assessment and study tool (assessment)
  – Also further uncovered misconceptions
    • More specific to material taught in course
Students lack understanding of photosynthesis and respiration as two interconnected processes -

• lack of knowledge about how photosynthesis and cellular respiration are connected;

• difficulties contextualizing photosynthesis and respiration at a biochemical level

• difficulties relating oxygen and carbon dioxide gas exchange to photosynthesis and cellular respiration;

• lack of knowledge about plants being producers of their own food (Brown & Schwartz, 2009)
Misconceptions Detected – Related to Photosynthesis and Respiration as Taught in HORT 101

- Photosynthesis gives energy
- Plants use $\text{CO}_2$ during respiration
- Respiration reaction is opposite to photosynthesis
- Respiration happens in the dark and photosynthesis in the light

(Orvis and Espinoza, 2014)
Implications from prior work:

• More frequent assessments help students keep up on reviewing materials and repeated exposure improves learning

• Visuals as part of activities and assessments are important

• Concept maps are a useful tool for this large science course:
  – content delivery combined with a semi-structured concept map assessment/activity to improve instruction

• Simplification of topics by instructors leads to mistakes and misconceptions – use caution
Lecture Activity (5): Flowering, Pollination and Seed Development

In this sheet, you can see a concept map (diagram) that represents the process of pollination which occurs after flowering and helps the seeds develop. In this activity you are asked to relate the concept of: (1) flowering to temperature, photoperiod and fertilization; (2) pollination to pollen dispersal, hand-on pollination and pollen germination; (3) seed development to double fertilization, embryo development and endosperm tissue.

Localize these concepts (numbers) in the diagram:

1. Double fertilization  
2. Seed development  
3. Pollen germination  
4. Hand-pollination  
5. Pollen dispersal  
6. Pollen tube growth  
7. Flowering  
8. Nutrition (fertilizer)  
9. Temperature  
10. Photoperiod  
11. Endosperm tissue  
12. Embryo development

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Lecture Activity:
Interpretation of a Concept Map: Photosynthesis and Respiration in a Plant Cell

In this sheet, you can see a concept map (diagram) that represents photosynthesis and respiration. Concepts maps are tools to interconnect concepts. In this activity you are asked to relate the concept of photosynthesis to oxygen (O₂), carbon dioxide (CO₂), water (H₂O), carbohydrates, and light to the processes of photosynthesis and respiration in plants. Please, complete the following diagram with the molecules in the box below. Each color means a different molecule.

1. Oxygen (O₂) - blue
2. Carbon dioxide (CO₂) - black
3. Water (H₂O) - light blue
4. Carbohydrates - purple
5. Light - orange
Example - Concept: Seed germination requires these factors

1. Amino acids
2. Bark
3. Endosperm
4. Flowering
5. Germination
6. Hormones
7. Imbibition
8. Lipid/Fat
9. Photosynthesis
10. Radicle
11. Respiration
12. Root
13. Seed coat
14. Sugar
15. Temperature
16. Vascular System

Factors that break down food

- Starch
- Sugar
- Protein

water breaks down the

helps to build the

First Leaf
Methods

• Large science service course (n=140+), mixed majors and non-majors, with lab
  – Online hybrid and face to face sections
• Both sections utilized concept map activities developed by the authors
  – Activities are grounded in constructivist theory
• This study focused on implementation of activities with hybrid group
Results – performance measures

• Online sections show strong correlation for grades and participation in concept map activities
  – Five activities that utilized concept maps in some form (semi-structured)
  – Pearson $r$ correlation between participation in online activities and final grade in course = strong
    • 0.7362 (percentage points earned activities vs total points grade percentage)
    • 0.7537 (number of activities completed vs total points grade percentage)
Results – student feedback

• Spring semester 2017, hybrid course (n=39)
• 22 responses on pollination/fertilization activity through optional (for extra credit) discussion board post
  – All state activity was helpful/useful/like it
  – Several indicate that initially the activity was confusing, however it was clarified after viewing the content video
Results - student feedback

- So, looking at this the first time I was just so confused because this class is little difficult for me and I really don't understand anything about horticulture but going through it the second time I felt much better about what I was learning and actually started to understand a little bit.

- I found the activity to be useful. Try to solve it first I was very unsuccessful, but as a visual and kinesthetic learning going through the activity a second time really helped the information to stick.

- I did not know a lot of the answers to begin with, but I do believe I learned a lot and it helped a lot once I went over it again during the lecture.
Conclusions

- Students indicated that the inclusion of the concept maps (semi-structured, with visuals) in the course helped them conceptualize the terms they learn in lecture,
  - they appreciated being able to organize concepts and vocabulary visually.
- Overall inclusion of concept maps as learning tools in a large science course has proven to be an effective manner in which to improve student learning of complex topics.
- Lack of discussion among students a challenge for hybrid group, and instructor.
Recommendations

• Adding additional concept map activities for topics not yet covered by existing activities.
  – For example, Plant improvement, environment influences on plant growth

• Assess specific concept learning

• Improve capacity for discussion among hybrid students online

• Develop online laboratory activities that will support learning for both face to face and hybrid sections
  – For example, 3-D imaging dissection and identification of flower structure
Questions?