Review of Online Module

Week 1: Principles of Learning, Part 1

Module 1: Prior Knowledge, Mental Models and Knowledge Organization

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Learning goals of the online module

1. Describe examples of ways students' prior knowledge, particularly their misconceptions, shape how they make sense of new information
2. Describe differences between the ways experts and novices mentally organize their knowledge and how those differences affect problem solving ability
3. Identify teaching strategies that
    a. surface or activate students' prior knowledge
    b. help students develop more robust knowledge organizations

Description of main activities of online module

Online Videos

- Student Misconceptions in Physics Part 1 [06:47] - Vanderbilt physics professor, Dr. Shane Hutson discusses the misconceptions students can bring into his physics courses. He also addresses where these misconceptions come from and how this can influence student learning.
- The Importance of Mental Models [05:59] - Dr. Derek Bruff from Vanderbilt University discusses how mental models that students carry into a new course can influence their perception of new information. He then stresses the importance of addressing these erroneous mental models in order to provide students with an accurate mental representation of the concepts they will cover in the course.
- Cataloging Student Misconceptions [03:19] - Dr. Michele DiPietro from Kennesaw State University explores examples of student misconceptions in several areas of study.
- Categories of Student Misconceptions [09:36] - Dr. Michele DiPietro from Kennesaw State University and Dr. Derek Bruff from Vanderbilt University introduce several categories that allow us to classify student misconceptions. He also arranges these categories in terms of the easiest to the hardest to address while providing examples of each.
- Activating Prior Knowledge [09:00] - Dr. Michele DiPietro from Kennesaw State University discusses the concept of activating prior knowledge to efficiently convey a concept. He presents several example questions to demonstrate the importance of activating prior knowledge.
- How to Activate Prior Knowledge [06:37] - Dr. Derek Bruff from Vanderbilt University discusses effective methods for surfacing and activating prior knowledge. These methods include: peer instruction, analogies, and even the timing and use of demonstrations in lectures.

- Students Misconceptions in Physics Part 2 [09:53] - Dr. Shane Hutson from Vanderbilt University discusses how he identifies and addresses student misconceptions in his physics courses. He provides examples of effective techniques he uses in the classroom including, how he utilizes clickers and peer instruction to surface and then address some of the common misconceptions he encounters his courses.
- The Big Picture in Genetics [09:58] - Dr. Kathy Friedman from Vanderbilt University and Dr. Jennifer Osterhage from the University of Kentucky discuss their experiences in teaching genetics courses. They introduce the idea of using concept maps to identify the level and organization of student understanding as well as the importance of synthesizing information rather than simple memorization.
- Building Adaptive Expertise [04:53] - Dr. Derek Bruff from Vanderbilt University identifies the differences in conceptual understanding between a novice and an expert in a given field of study while introducing and discussing the distinction between routine expertise and adaptive expertise.
- The Role of Knowledge Organization [04:03] - Dr. Michele DiPietro from Kennesaw State University identifies different types of knowledge organization. He also provides an in depth discussion of the differences in knowledge organization between novices and experts.
- Knowledge Organization Research [09:52] - Dr. Michele DiPietro from Kennesaw State University introduces several studies that provide insight into how knowledge organization differs between novices and experts. He goes on to address why knowledge organization is important and identifies effective methods helping students organize knowledge in the most useful ways.
- Helping Students See the Big Picture [06:10] - Dr. Derek Bruff from Vanderbilt University provides an in depth discussion of strategies educators can use to help students consolidate and synthesize facts. The result is student development of an accurate and complete conceptual understanding of a topic.
- The Big Picture in Genetics Part 2 [10:01] - Dr. Kathy Friedman from Vanderbilt University and Dr. Jennifer Osterhage from the University of Kentucky discuss the methods and organizational tools they use in their genetics courses to effectively convey complex concepts to their students.

Online Discussion Questions

- Misconceptions, Part 1 – What misconceptions might students have about a topic in your discipline? Consider misconceptions that are relatively easy to resolve, as well as ones that are much harder to address. If you know of educational research on misconceptions in your discipline, please share references.
- Misconceptions, Part 2 – Select one of the misconceptions identified by your peers in Part 1 of this activity. Using the categories of misconceptions named by Michele DiPietro (proposition level misconceptions, flawed mental models, ontological miscategorizations, embedded beliefs),

categorize the misconception identified by your peer. Why this category? Why do you think students hold this misconception?

- The Flipped Classroom – The flipped classroom is an approach to course design that is growing in popularity with STEM instructors. In the flipped classroom, students receive their first exposure to a new topic before class, typically through a textbook or explanatory video. This frees time during class for more active learning—the kind of practice and feedback we discuss in this module. This structure can be very effective, given the value of practice and feedback, but it often runs counter to the idea of creating "times for telling," since it puts the "telling" first in the learning sequence. How do you reconcile this tension?
- Memorization – Sometimes students and instructors view learning as a process of presenting information (that's the instructor's job) and memorizing that information (that's the students' job). There's strong evidence that deep learning requires much more than memorization, and yet memorization is still a focus of much of undergraduate STEM education. In what ways has memorization been important to your own experiences as a STEM learner? In what ways has memorization alone been insufficient?
- Knowledge Visualizations – Concept maps can be tools for helping students develop more robust knowledge organizations. As described here, concept maps are fairly freeform, but many disciplines have formalized ways of visualizing knowledge organizations. For instance, paleontologists use cladograms to organize relationships among species. (Here's one example, and here's an explanation of cladograms.) Share an example of a formalized knowledge visualization from your field. How might you use such a visualization in your teaching? How might students find the visualization challenging?
- Takeaways – Given the principles and practices discussed this week, what are your takeaways? That is, how might you apply these principles and practices in your teaching context?

Activities for the MCLC In-person Sessions

Module 1: Prior Knowledge, Mental Models and Knowledge Organization

Learning goals for MCLC in-person sessions

1. Develop a more concrete understanding of this week's key concepts (prior knowledge, knowledge organizations), including how they apply in particular teaching contexts.
2. Interrogate one's own mental model about how learning works and what makes teaching effective.

	Student Activity/Discussion	**Facilitator Notes**
Warm-up	Free Write: How have you experienced this week's learning principles in your own STEM education? Describe a particular learning experience in which one of the principles was evident. (For example, you might describe how your prior knowledge influenced your understanding of a key concept in a first-year chemistry course, or you might share a moment when you saw the "big picture" in an upper-level biology course.) Have two or three participants share their stories with the group. Then make the point mentioned in the "Facilitator Notes."	It's a little risky to let our own experiences as learners inform our teaching practices—our students often experience learning very differently than we did—but some personal reflection can be useful for understanding important learning principles.
Activity #1	Show a portion of the classic "Private Universe" video[1]. Timecode 0:45 through 3:00 works well. Ask participants to speculate as to why the students and faculty shown in the video might have the "exaggerated ellipse" mental model of the Earth's orbit around the Sun, given where they are in their education. Is it possible that the students shown in the video were never assessed on their understanding of the Earth's orbit? What kind of assessment might have surfaced their flawed mental model?	We've started this course with a discussion of mental models for a good reason: It's incredibly easy to assume that students understand STEM concepts better than they actually do! The "Private Universe" video makes this point well. Be prepared to talk a bit about formative assessment here. Conversations about the "Private Universe" video naturally lead to questions about surfacing students' mental models. Formative

[1] Available here: http://www.learner.org/vod/vod_window.html?pid=9.

	Discuss: Why is it important that STEM educators have an understanding of mental models and their roles in learning?	assessment will be a central topic next week in the course.
Activity #2	Show a video clip of an expert tackling some problem or topic. Maybe a TED Talk, like Roman Mars' talk on flag design[2] or Scott McCloud's talk on the visual language of comics[3], or, even better, the "Cerulean Sweater" scene from *The Devil Wears Prada*[4]. Discuss: What was the speaker in this clip able to do, as an expert in their field, that a novice would not be able to do? What kind of knowledge organization might the speaker have that would allow them to tackle hard problems? Think-Pair-Share: Have participants shift contexts to their own disciplines. What aspects of the "big picture" might novices in their discipline struggle to see? What teaching approaches might help students see the "big picture"? Give participants a minute or two to consider the first question on their own, then have them work in small groups to address both questions. For the "share" portion, ask participants to share with the big group an interesting idea they heard from a peer within their small group. Takeaway: Students aren't going to see the "big picture" right away. Often, it takes an iterative approach. We can speed that process up by making our knowledge organizations visible to students, and by actively assisting them in constructing their own.	It can be helpful to observe experts in action in disciplines very different from our own. This can clarify differences between experts and novices (experts notice patterns that novices miss, experts can recall information quickly, experts have robust knowledge organizations, and so on) that we can then apply to our own teaching. When discussing knowledge organizations, it may be useful to identify different types of knowledge (examples, principles, arguments), different structures (hierarchical, sequenced, nonlinear), and different scales (micro, macro, mega). Concept maps are one useful strategy for helping students develop knowledge organizations. They're rather informal, however. Most disciplines have formalized way of visualizing complex relationships. See the course discussion forums for examples. You might share a few with your group, if they don't come up during the conversation naturally.
Activity #3	For a slightly more "meta" approach, work through these discussion questions as a whole group. 1. What were the most common approaches to teaching you experienced as an	One of the reasons we included faculty interviews in the module is that we wanted to share a few examples of how faculty have changed their approaches to teaching over time—how they fixed

[2] Available here: http://is.gd/ZP72iO. Try starting just after the 13-minute mark.
[3] Available here: http://is.gd/R17Vr1. Try starting just before the 8-minute mark.
[4] Search for it on YouTube. You'll probably find it.

	undergraduate? Why do you think these approaches were (are) so common? 2. Think back to when you started to consider how you would teach. (Maybe this was ten years ago, maybe this was last week.) Did you expect to teach as you were taught? Or did you want to take a different approach? Why? Given what you know now (especially what you've learned in this unit), what "rookie mistakes" can you see yourself making as a teacher if you're not careful? How might you avoid these "rookie mistakes"?	their "rookie mistakes" as they developed more sophisticated understandings of how learning works. The discussion questions here are intended to surface potential "rookie mistakes" and help participants see that they need to make them. Often these mistakes are made because we teach how we were taught, instead of leveraging research on teaching and learning!
Wrap-up	Looking ahead to the rest of the course, what would you like to learn about? In particular, do you have suggestions for discussion forum topics for this or future weeks of the course?	Anyone participating in the MOOC can add a new thread in an existing forum or sub-forum. However, we are inviting MOOC-supported learning communities to suggest new sub-forums, each of which might generate multiple threads of discussion. This is your opportunity to generate discussion across the entire MOOC on a topic of interest to your local learning community. What sub-forums should we add?