How course design affects learning
Science of Learning
Best Practices for Teaching and Learning

Course design has a lasting consequence on learning. What we decide to cover or not cover in our courses, for instance, can influence the approach the student takes to learning. Courses that cover too much content leave little time and room for students to organize knowledge meaningfully. There is not enough time to cover concepts in depth. When breadth is emphasized over depth, the highly rich and contextualized mental frameworks that characterize deep understanding cannot be built.

Without connections, knowledge exists mostly in the context in which is learned. This leaves students with the inability to transfer concepts to novel situations. Therefore, structure your course so there is a greater emphasis on conceptual understanding rather than the amount to be covered. To accomplish this, start by thinking about the seminal concepts that you would like your students to be able to know and demonstrate by the end of the course.

This process is called backward design, and we will cover in depth during the session on creating a course and constructing a syllabus. Backward design leads to the prioritization of content, which will facilitate your ability to cover fewer concepts more deeply. Design assignments and assessments that emphasize deep understanding and encourage students to approach the subject as deep learners.

If during our lectures we emphasize conceptual understanding but our assignments and exams do not require students to think deeply, then our students will tend to approach the subject as surface learners. In the session on constructing effective problem sets on exam questions, we will demonstrate how to design questions that encourage deep learning and critical thinking skills.

Another useful strategy is to structure your course to provide lots of opportunities for knowledge to be acquired and transferred. You can do this in various ways, as discussed in the precession reading titled "Applying the science of learning" by Halpern and Hakel. One way is to vary the conditions under which learning takes place. And another is to facilitate retrieval.

Let's explore these two recommendations in more detail. When we vary the conditions in which learning takes place, students associate multiple retrieval cues with key ideas or concepts. This makes it easier for the information to be retrieved. The ability to retrieve the information and make use of it in a new scenario or application is called "knowledge transfer." Knowledge transfer is what we like our students to be able to do. Without it, our students will acquire knowledge that they are not able to apply to different or novel situations.

Nobel laureate Herbert Simon stated "The meaning of knowing has shifted from being able to remember and repeat information to being able to find and use it." We can change the conditions in which learning takes place through several methods. During class, use both verbal and audio visual representations of the same concept. Also, use diverse examples that illustrate a concept. A concept without examples is difficult to grasp.

Examples contextualize the concept and allow learners to be able to separate a concrete illustration, the example, with the enduring more abstract transferable concept. Let's say that

you explain a particular concept and then provide a single example to illustrate that concept. For the learner who is not an expert in the subject, there is no real difference between the concept and the example. The two tend to merge together in the learner's mind. The learner is often unable to separate the concept from the example.

One solution is to provide a second similar example, if an example is similar enough, there will be substantial overlap between the concept in example 1 and the concept plus example 2. This overlap is smaller than the concept in a single example, and the two examples serve to create the boundaries of the concept more clearly. It's even better to provide a third example that is distinct from the first two. This helps students differentiate the overlap between concept and examples. The concept stands out more clearly.

Another useful way to vary the conditions in which learning takes place is to provide students with opportunities to represent the information in an alternative format. For example, you can ask your students to describe and explain in words the concepts they have learned through mathematical equations, or vice versa, ask students to visually, through a diagram, represent descriptions of concepts, reactions, et cetera.

Learning and retrieving is enhanced when students are asked to retrieve and integrate information both verbally and visually. As we have previously mentioned, knowledge transfer is the consequence of understanding or deep learning, learning that is really understood and can be applied. As Halpern and Hakel reminds us in the "Applying the Science of Learning" precession reading, we need to always remember that we are teaching towards sometime in the future, when we will not be present, and preparing students for unpredictable real world tests that we will not be giving, instead of preparing them for the traditional midterm and final exams.

Long term retention and transfer can be achieved through retrieval and application. The strength of the memory traced or the connections in the brain made through the process of remembering and eliciting information become stronger each time a student is asked to retrieve the same information, particularly if they are asked to apply the information in new, novel ways.

There are many ways in which you can ask your students to retrieve information or concepts. One strategy you can use is to ask your students to explain to each other their answer to a question or problem. As we will see in the session on interactive teaching and active learning, this strategy can result in higher learning gains and increased student attention. Asking your students to respond to questions or solve problems on a particular concept, even after it has been taught, can also facilitate retrieval.

Spacing the retrieval opportunities so that the time interval between opportunities increases is preferable to constant retrieval for a short amount of time. Instead of always asking students to retrieve something right away, vary the time between presenting the concept and asking them to retrieve it. This allows for concepts to be integrated into existing frameworks more robustly, and for those connections to deepen over time.

As we have already mentioned, applying knowledge to new situations leads to transfer, whereas applying the learned knowledge to a similar situation only results in memorization. Therefore, don't just change a few variables within a problem, but instead provide your students with substantially different problems that illustrate the same concept.

Now that we have had time to explain strategies for implementing current theories on learning, think first on how you will implement at least two of the learning theories covered in the pre-session readings and in today's session. Then identify and describe specific activities or assignments that you would implement, and explain how they are supported by the research findings and learning theories.