The Science of Teaching and Learning

Until recently, it was not possible to understanding the brain processes involved in thinking and learning. Today, there is an extraordinary body of scientific work in regards to the human brain and the neural processes that occur during thinking and learning. The development of various theories about how the brain works has important implications for education, and new theories continue to evolve that lead educators to very different approaches to curriculum design, teaching, and assessment than what have been the traditional approaches until now (Bransford, 2000).

Many students often have limited opportunities to make sense of or understand topics because most curricula still emphasize memorization rather than comprehension. Textbooks are filled with facts that students are expected to memorize and most tests assess students' ability to remember them. Thirty years ago, educators saw little need to understand and use cognitive science theory in teaching. Today, cognitive researchers are spending more time with educators, testing and refining their theories in real classrooms where different settings and classroom interactions can influence the application of their theories. One of the hallmarks of the new science of learning is the emphasis on learning with understanding. When students are engaged in learning activities that helps them make sense of the information being presented, it is termed "active" learning.

The new science of learning recognizes the importance of knowing facts in thinking and problem solving, however, research that looks at 'expert knowledge vs. novice knowledge' clearly shows that "usable knowledge" is not merely a list of disconnected facts (Bransford, et.al., 2000). Expert knowledge is connected and organized around important concepts; it is "conditionalized" to specify the context in which it is applicable, and it supports understanding and transfer to other contexts rather than only the ability to remember facts. This finding is important as it stresses the importance of teaching within a context.

In the new science of learning, three major findings have a solid research base and implications for how we teach:

1. Students come into the classroom with preconceptions about the subject matter we are teaching. These preconceptions can either impede or enhance further learning. A critical feature of effective teaching involves eliciting preexisting understandings of the subject matter and provides opportunities for students to build upon or challenge their initial understanding. This can be done simply by questioning or surveying students prior to teaching. According to the constructivist theory of learning, learners must be able to connect new information to existing knowledge in order to construct understanding. Challenging misconceptions is necessary, although it is not easy. Research shows that even when students are presented with

situations that cannot be solved using their misconceptions, they still hold tightly to the initial under- standing (Bransford, et.al, 2000). The need to draw out and work with preexisting understandings that students bring with them is imperative for students to develop a deep understanding of the subject matter. This deeper understanding is necessary in order for students to be able to apply and transfer knowledge appropriately. The idea that students come into the classroom as empty vessels waiting to be filled with knowledge from the teacher must be replaced by the teacher making active inquiry into students' thinking. Teachers must develop classroom tasks and conditions through which students' thinking can be revealed. Read Jean Piaget's, "Theory of Cognitive Construction" on page 28 of this hand- book for further explanation of this occurrence.

2. To develop competence in an area, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas within a context or conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application. Students need to be presented information within a larger con- text. Some educators refer to this as "the bigger picture." Effective teaching requires the instructor to answer the question, "so what?" What does the information mean in the larger scope of things? For students, the question that is often asked is, "why are we learning this?" or "why do we have to take this course?" They are struggling to make a context or see a connection. It is very important that information is learned within a context or conceptual framework otherwise retrieval and application of new information is nearly impossible.

3. A "metacognitive" approach to instruction can help students learn how to keep track of their learning by defining learning goals and monitoring their progress in achieving them. In research where expert thinking was examined, it was found that experts monitor their understanding carefully. They make mental notes of when additional information is needed or when the new in- formation is inconsistent with what they already know or they at- tempt to make an analogy so that their understanding is deepened (Bransford, et.al., 2000). Research shows that students can be these taught meta-cognition strategies: to predict outcomes, explain to one's self in order to improve understanding, make notes of gaps in knowledge and comprehend why it is faulty, activate background knowledge and apportion time and memory (Palincsar and Brown, 1984). Because meta-cognition often happens as an internal conversation, many students may be unaware of its importance unless the processes are explicitly incorporated into instruction. Metacognitive strategies differ across disciplines therefore it is important that these strategies be taught within the discipline. For example, in History students might be asking themselves, "who wrote this document and how does it affect the interpretation of the events," whereas in Physics, the students might be monitoring their understanding of an underlying physical principle in order to interpret a phenomenon.

Integration of meta-cognitive strategies within disciplined based learning can enhance student achievement and develop in students the ability to learn independently.

Bransford, J. D., et. al. (2000). *How People Learn: Brain, Mind, Experience, and School.* National Research Council, Washington DC.

Palincsar, A.S., and A.L. Brown (1984). Reciprocal teaching of comprehension monitoring activities. *Cognition and Instruction* 1:117-175.

Essential Components for Effective Teaching and Learning

Although learning is a complex process, in its most basic form, there are some processes that must take place in order for learning to occur. The learner must be attentive, must be able to connect the information to prior knowledge and understanding, and finally, the learner must draw appropriate conclusions.

Attention:

The first thing an instructor must do is to gain the attention of the learner. This is not a joke or a shout at the beginning of class, this is the need for the learner to see relevance and meaning in learning the information being presented. This relevance and meaning must go beyond taking and passing the course for degree completion. The learner must be able to personally connect course content in meaningful and relevant ways. The instructor must be able to convince students that the effort they put forth in learning the course material will be worthwhile. Often, topics can be approached by presenting a real life scenario or problem for which the information can be utilized to solve the problem.

Processing Information:

Because learners must process new information repeatedly, in a variety of ways, before they can master it, instruction should include a mixture of written words, visuals, audio, manipulative, action, and practice with the content that students are expected to master. It is best to focus the instruction on a few major concepts that are learned deeply rather than teaching many concepts superficially. All learners will compare new information with previous experiences and knowledge. Effective instructors will incorporate this into learning activities by giving the students an opportunity to reflect, compare, and question the new information. Small group discussions are effective for giving learners the opportunity to draw from past experience and knowledge and to make links to the new information being presented.

Conclusions and Understanding:

All learners have their own unique perspective and experiences, and this affects what knowledge they are able to retain and use. The instructor's role is to move learners through the new material in an orderly and organized manner, giving them classroom opportunities to practice new skills and to draw their own conclusions. Learners experiment with and/or test new information before deciding if it is useful to them enough to make the effort to learn it. When instructors develop learning activities that encourage students to experiment and use information to draw their own conclusions, students see the relevance in learning the material.

(Chapters 7 and 9, *Teaching at Delaware State University, A Guide for Faculty, Academic Staff and Teaching Assistants 2015-16,* Center for Teaching and Learning)