Learning Theories: Pillars of Teacher Decision-Making

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In the last issue, I articulated the argument that learning "styles" are not the most valuable way to understand learners. Professor Daniel T. Willingham provides a brief, descript summary of this view at http://www.youtube.com/user/dbw8m#p/u/3/sIv9rz2NTUk. Yet, if learning "styles" do not sufficiently explain learning, how can we better conceptualize learning to inform our instruction?

First, we must clearly conceptualize "learning." While rote memorization has a place in education, it is clearly not the same as understanding. Yet, the prevailing message students receive is that memorization and understanding are synonymous. Learning is more productively viewed as the process whereby learners make meaning of new ideas and experiences through connection to their current conceptual framework. This view of learning emphasizes the role of students' mental activity in learning, and that learning goes beyond simple "information acquisition." As we shall see, understanding the similarities among all learners' mental activity provides powerful tools to make better instructional decisions while acknowledging students' unique conceptual frameworks and past experiences.

Well-established Learning Theories

Behavioral Learning Theory

Behavioral learning theory (BLT) treats the mind as a black box and focuses on changes in observable behaviors. Reflecting this, emphasis is placed on stimulus-response and the reinforcement or discouragement of particular behavior. BLT is attractive because of its simplicity, ability to explain phenomena, clear implications for pedagogical practice, and basis in controlled research (Collins, 2002). However, this narrow view of learning creates difficulty for understanding learners' reasoning and thinking – activities central to education and informed teacher decision-making (NRC, 2000).

Yet, in a very important sense, assessing learning does depend on noting learners' behavior. That is, the behavior of students (how they respond to questions, how they act in particular situations, etc.) is indicative of their deeper thinking. However, unlike behaviorism, cognitive learning theories attempt to more deeply explain the mental processes of learning. So, while BLT has an important role in perceiving student thinking, the use of BLT alongside cognitive theories that seek to understand students' mental processes is crucial for effective instruction.

Cognitive Learning Theories

Cognitive learning theories include constructivist learning theory (CLT), developmental learning theory (DLT) and social learning theory (SLT). Each of these theories emphasizes the role of active mental processing in learning. That is, cognitive theories focus on *how* students make meaning of new information and experience. However, the three emphasize different factors that affect the meaning-making process. Together they provide a far more comprehensive view of learning than any one alone does.

Constructivist Learning Theory

CLT emphasizes how the ideas and thinking learners already possess are used to assimilate and/or accommodate new information and experiences into conceptual frameworks (Slavin, 2003). That is, when learners encounter new information they will either make sense of the new stimuli within their current conceptual framework (assimilation) or add to their conceptual framework to make sense of incoming stimuli (accommodation). Assimilation fits new information within existing mental frameworks whereas accommodation requires addition to or modification of existing mental frameworks. Whether assimilated or accommodated, new knowledge must be somehow connected to or within existing frameworks to be deeply understood.

According to CLT, students enter classrooms with mental frameworks they have been building their entire life to make sense of experiences. Unfortunately, many of the conceptual frameworks students create contradict accepted scientific understanding. Common examples include incorrectly thinking that monthly moon phases result from shadows cast by Earth, or that the mass of growing plants and trees comes primarily from soil. These and other incorrect ideas have been erected and used because they make sense to the students. Consequently, students do not question these ideas and give them up reluctantly, if at all. Because students' prior ideas make so much sense to them, questioning and modifying those ideas can even elicit an emotional response.

Developmental Learning Theory

In addition to CLT's focus on the role of conceptual frameworks, developmental learning theory focuses on how prior experience and age affect students' ability to handle abstraction (Karplus, 1977). As students mature, they transition from being pre-operational to concrete operational to formal operational thinkers. Students who are concrete operational will struggle to think in hypothetical terms and will have trouble making predictions about events they have not already experienced. Those students who are more formal in their thinking will be able to apply previous experience to new situations as well as problems lacking concrete context.

The demarcation between concrete and formal thought is not clear-cut. Perhaps a continuum on which students move from being more concrete operational to more formal operational better illustrates the transition. Furthermore, students may be concrete operational in some areas while formal operational in others. Biological maturation as well as experience in a particular area will both affect the student's level of thought.

While very young children who are concrete operational are able to divide eight cookies equally among four playmates, they will likely struggle if asked to perform the same mathematical reasoning divorced from context. While the specific ability to divide the cookies has tremendous value, the ability to identify and perform the underlying mathematical operation (formal operational thought) is more useful in varied situations. Yet, until a child is developmentally mature enough to handle abstraction, teaching the mathematical concept will result in simple memorization rather than deep understanding that transfers to varied problems.

In addition to a continuum for student reasoning abilities, representations of concepts can require more or less abstract reasoning. Because manipulatives or direct observation of phenomenon requires less abstract reasoning, students are able to better mentally engage with these representations. Olson (2006) notes, "verbal explanation may be difficult for a child to understand, but when a more concrete representation (such as a picture or a real object) is used along with the explanation, the child has a greater likelihood of understanding" (p. 56). Not only must we consider how to more concretely represent concepts, we must also consider what representations best match particular concepts (Olson, 2006; Willingham, 2005). Students are not likely to gain accurate notions of kinetic molecular theory without seeing animations of particles in motion.

Social Learning Theory

Social learning theory adds to CLT and DLT by noting that knowledge is constructed via social interaction. Students' social environments help shape the framework on which concepts are built. Vygotsky's focus on the social environment brought attention to the role of other people in learning. Without the interactions of peers, parents and teachers, many students would not be encouraged to extend their range of understanding.

When conceptualizing students' range of understanding Vygotsky labeled the zone of proximal development (ZPD). This conceptualization of students' understanding level continues to emphasize the role of others in learning by noting that students can accomplish more difficult tasks with help from more knowledgeable peers or mentors. The ZPD is the range of a student's understanding that extends from problems or thinking they can do on their own to tasks they can accomplish with the aid of a more knowledgeable person.

Because social interaction occurs most commonly via language exchanges, we must carefully consider classroom language. Language must not be beyond students' ability to comprehend and must be scaffolded throughout concept development. If complex vocabulary is introduced too early, students will not have the necessary understanding to apply the vocabulary accurately, or may attach incorrect meaning to the new vocabulary. Of course language use considerations must consider students' developmental level and their conceptual frameworks, which will each be affected by students' social environment.

Cohesion of cognitive learning theories

To demonstrate the tremendous explanatory power of the cognitive learning theories let me provide an example. I remember one student who answered a question about why the poles of Earth are always cold by writing "poles are made of metal, and when you stick your tongue to metal it sticks because it is cold". This student's ideas demonstrate how each of the cognitive learning theories affects learning. The student's use of the word pole, and my use of the word pole were not the same (SLT). The student is clearly using their prior knowledge to interpret the question (CLT). Finally, the student seems to be struggling to understand that there is an imaginary spot we call the "poles" of the Earth where an imaginary line called the axis runs through (DLT). Each of these theories plays a part in understanding this student's struggles. Below I discuss how each of the theories can be used to inform instruction.

Using the Learning Theories to Inform Instruction

Using Behavioral Learning Theory

Every question I ask students serves as a stimulus to which students respond. When I show students a demonstration or discrepant event, the stimulus often results in responses of awe and hopefully evaluation of conceptual frameworks. Of course, I will likely have to provide further stimuli such as carefully worded questions to encourage students to think more deeply about what they have just observed. Additionally, BLT can inform classroom management. When two students are having a side conversation during classroom discussion, I move to stand near them. To the stimulus of my presence, students usually respond by ending their side conversation.

Using Constructivist Learning Theory

CLT's focus on student-created conceptual frameworks does not mean teachers have no role in student learning.

Science ideas are often counterintuitive, and students will rarely come to those ideas without teacher intervention that includes carefully scaffolded questions and information provided at just the right moment. Thinking that students must discover knowledge confuses a theory of learning with instruction itself. No matter how a student is exposed to new information, they will struggle to place the information into a previous or newly developed framework. Encouraging students to "discover" information versus telling students the information is a pedagogical decision, either way the *student* must incorporate the new information (NRC, 2000). CLT is powerful for explaining student struggles to understand; "discovery learning" wrongly removes the teacher's important role during instruction. Instead of thinking students are "on their own" in the learning process, we can use our knowledge of student thinking to directly confront their misconceptions, guide them on the road to accurate understanding, and make connections to their current conceptual frameworks.

Since students make meaning based on their previous understanding, two things must happen. First, students' previous knowledge needs to be identified through discussion or activities that encourage students to explain their initial thinking about concepts. Second, the learner needs to be actively mentally engaged with new information or activities that directly confront misconceptions and reflect accurate understanding. Teachers can encourage active mental engagement through open-ended questions that target students' naïve thinking and encourage the students to compare new experiences with old ideas. Students can be further encouraged to meaningfully engage by being asked to devise ways to test their own conceptual framework for accuracy (NRC, 2000).

Identifying previous conceptual frameworks and encouraging students to reflect on how new information fits or does not fit sounds easy enough. Yet students' inaccurate ideas are not always predictable and make intuitive sense to students so are very resistant to change. Simply telling students new information is likely not enough to induce long-term change in student conceptual frameworks (Rowe and Holland, 1990; Saunders, 1992). Instead, we must continually encourage students to mentally wrestle with new ideas/experiences through carefully chosen questions that elicit student explanation and probe the ways in which students assimilate new information within their conceptual frameworks.

Before encouraging active mental engagement with new information and incorporation of new information within frameworks we must consider when to provide new information. This decision ought not be taken lightly. Students will make meaning of new material based on their previous conceptual frameworks. If the learner's schema is greatly different from the new information, less of the information will be remembered, or it may be inaccurately assimilated into a previous conceptual framework (Champagne and Hornig, 1987). Only when students' conceptual frameworks will be strengthened, extended, or gaps filled should new information be given. If new information is given too early, the ideas will not be caught in the conceptual 'net' and the information will be doomed to "go in one ear and out the other."

Using Developmental Learning Theory

When confronting students' prior knowledge or misconceptions, we must consider our students' reasoning abilities based on their biological maturation. While Piaget's stages of cognitive development will not proceed identically for every student, we must realize that "cognitive development involves the gradual acquisition of strategies for remembering, understanding, and solving problems" (NRC, 2000 p. 80). Because younger students' cognitive abilities will not be as developed as older students we must work to match the reasoning demands of instruction to learners' level of mental development (Champagne and Hornig, 1987). For example, if students are not developmentally ready for deep understanding of mathematical relationships between variables, teaching these relationships will be unnecessarily frustrating for both teacher and students.

In addition to considering students' developmental level, we must also consider how the concept being taught is best represented (Olson, 2006; Willingham, 2005). Teaching about biological adaptation by only having students read about adaptations seems incomplete. While adaptation itself is not a complex idea and many students would be able to make sense of text, I would be left wondering why students were not observing organisms directly and contemplating the advantages of various adaptations. Not only would these concrete observations be easier to mentally engage with, they would likely be much more interesting to students.

If concrete representations are easier, we might ask why abstract learning is the goal. Importantly, abstract learning more effectively transfers to new situations than concrete learning based on specific examples (NRC, 2000). Fortunately, we can use different representations to scaffold students so that they might better understand abstract ideas. To build students to abstract reasoning, instruction ought to start with concrete experiences and familiar ideas. Once concepts have been explored concretely, abstract applications of concepts can be explored using more formal thought.

Rather than beginning instruction with textbook reading, students will be able to mentally engage more meaningfully with manipulation of materials or making observations related to new concepts. Unfortunately, some phenomena cannot be directly observed. In these cases, video or pictures will better encourage students to mentally wrestle with concepts before engaging with text. When starting instruction with more concrete representations, students are able to later make sense of text or formulas because they have prior experiences on which they can reflect.

To illustrate how DLT informs instruction, consider how I approach teaching students about the gas laws. I begin with concrete observations by having students reflect on phenomena such as inflating a balloon, cooling an inflated balloon with dry-ice/acetone, playing with empty syringes (without needles) and observing Cartesian divers. I increase the abstract reasoning expectations by helping students develop mental models of particle behavior and having them make drawings of the particles as well as showing them animated simulations of particle behavior at different temperatures and pressures. After students have a wealth of experience and have thought at length about how gas particles behave, I introduce the most abstract representation: mathematical formulas of the gas laws. Yet, I consistently ask students to reflect on how the mathematical relationships fit with the observations and ideas we had previously discussed. If students are able to visualize the behavior of particles and connect that behavior to mathematical formulas, they will more likely be able to transfer their knowledge to new situations.

Beyond informing our instructional planning, considering the implications of developmental learning theory can aid in helping struggling students. I remember one student who was struggling to understand why different amounts of the same material have the same density. Many students were able to understand that if the mass and volume both go up, the ratio of mass to volume stays the same. However, this student was not convinced. While I could have had the student do some example problems with numbers, their lack of mathematical reasoning would likely hinder their conceptual change. Instead, I invoked more concrete representations by having the student draw pictures of particles for two different amounts of water. The student said the particle pictures should be the same. Excellent! I then asked the student how density and particles are related. When the student was able to articulate the relationship I asked the student to look at the particle diagrams they had drawn and tell me how the two amounts of water compared with respect to density. At this point, the student was able to articulate that the amount of substance is not a determining factor of density.

Using Social Learning Theory

SLT emphasizes students' zone of proximal development (ZPD) and the role social interaction with others has in learning. Having students work at the leading edge of their ZPD encourages growth in understanding. If students work beyond their ZPD they will be too frustrated. If activities are too easy, students will not be encouraged to grow in understanding (Dixon-Krauss, 1996). Importantly, we must support students who are working at the edge of their ZPD. Without guidance from teachers or more knowledgeable peers students may not fully engage with the learning task.

To encourage support of peers and greater social interaction, teachers might have students work cooperatively. By working together students can push and support one another's learning. When students discuss their ideas with others, they are more likely to wrestle with how to best explain their thinking - resulting in deeper levels of mental engagement. This student-student interaction encourages a more cooperative learning environment and helps keep language used in the classroom within students cognitive grasp.

This cooperative atmosphere should be expanded to whole class discussions. Rather than lecture-based instruction, teachers should take the role of active facilitator in classroom discussions. When students share their ideas with the class they are using their own words and shared experiences to discuss ideas. Of course the teacher has an active role in the discussions: providing information, asking follow-up questions, maintaining focus, etc.

Class discussion has helped me work within various students' ZPD at the same time. While some students might be struggling to understand basic concepts, others might be at the point where they can apply the concept to new situations. In the case of students who are ready to apply concepts to new situations, I (the teacher) become the more knowledgeable person - pushing students to explain their thinking and connect new situations to old examples. When I ask these more advanced students to explain their thinking or connect their thinking to old ideas, they are acting as the more knowledgeable peer for other students who do not quite grasp the basic ideas that the advanced students are applying. These students who do not yet grasp initial concepts will benefit from hearing their peers explain ideas in more familiar words.

Building and strengthening conceptual frameworks - Scaffolding

The concept of scaffolding, or extending student understanding through supportive incremental steps, makes use of each of the cognitive learning theories. Instruction should start with the most concrete representations such as direct observation and build to more abstract representations such as text or verbal explanations (DLT). As each representation type is introduced time should be spent to help students connect new to previous representations so that abstract reasoning abilities and the conceptual framework are enhanced and extended gradually. Additionally, students' existing conceptual framework ought to be probed for possible connections to new material (CLT). Instead of introducing complex new ideas divorced from student thinking, instruction should start with student thinking and introduce supportive ideas before introducing complex ideas. Lastly, teachers' social interactions with students serve to guide and support student learning and keep students' within their ZPD (SLT). If students are asked to consider ideas beyond their cooperative abilities, they will be unable to make strong connections to their conceptual frameworks even with support.

Putting learning theory to work in real time

To further explore the power of learning theory, let me provide another example to illustrate the cohesive picture of learning that constructivist (CLT), developmental (DLT), social (SLT), and behavioral (BLT) learning theories can provide. This example will demonstrate how the learning theories might explain student struggles and inform teacher decisions in the act of teaching. This example does not represent all that goes into teaching a concept like density, but briefly summarizes key parts of instruction to highlight the role of all four learning theories in teacher decision-making.

Many students struggle to deeply understand density. By the time students reach my 8^{th} grade classroom they have likely heard the word density before (SLT) and have some experience with sinking and floating (CLT). Some students may have even memorized d = m/v, but may not have had the math reasoning yet to understand what “mass divided by volume” really means (DLT).

When beginning instruction on density, I ask students to respond to questions relating to how things sink and float (BLT). I base my follow-up questions and examples on student comments concerning sinking and floating (CLT). I show students examples of objects (DLT) that contradict their naïve thinking (CLT) such as a low mass paper clip that sinks, or a large volume object that floats. After discussing examples and student ideas concerning factors that affect floating/sinking, I have students discuss with their partners to create an explanation for why some objects float and others do not (SLT). After sharing ideas, the class collects mass, volume and floating data for many objects. Instead of having students look at raw numbers, I have the students graph mass vs. volume and mark on the graph which objects floated and which sank (DLT). Then we discuss how we might interpret the graph. During this discussion I have to help the students make meaning of the graph and put words to the observed trends (SLT). Once students seem to understand how mass and volume each affect sinking/floating differently I introduce the idea of density (DLT & CLT). While explaining the idea of density I hold up objects that have the same volume with different density or objects with the same mass and different density (DLT). After students have a sense of density, I introduce the most abstract representation of density, the formula (DLT). I encourage students to consider how the formula fits with their previous observations of floating and sinking objects and the graph they made. Encouraging this reflective thought will help the students connect the abstract mathematics to their prior conceptual frameworks (CLT). Throughout instruction, I am constantly probing students' thinking (CLT) through questions and reacting to their responses (BLT). I am also encouraging students to explain their ideas in their own words and discuss their thinking regularly with other students (SLT).

In the above example, notice how the learning theories complement and support one another. I cannot simply consider my students' developmental level, I must also consider what the students already think, or what experiences the students have had and those I must give them. Furthermore, I must consider how the content I am teaching is best represented as well as my students' zones of proximal development. Rather than being concerned with my students “learning style,” I will make much better use of my own mental effort and planning by considering students developmental stage, prior experience, initial conceptions and the manner in which the content is best represented.

Summary

We can better inform our instruction by considering the commonalities in human learning as expressed by learning theory. Instead of students not understanding text because they are “auditory learners” consider that perhaps the students do not understand the text because they do not have the appropriate background experience or abstract reasoning necessary to fully engage with the text. When we cater to students' preferences, as expressed by “learning style,” we do not help them become well-rounded learners with the flexibility to take on any challenge that comes their way. By helping students navigate learning hurdles through consideration of learning theory, we encourage our students to reflect on prior experience, attempt to represent concepts in new ways and discuss their thinking with peers – strategies that will serve them well throughout their lives. Imagine an employee who refuses to read a report for an important meeting because they are “kinesthetic learners!” Whether a kinesthetic, auditory or visual task, the cognitive learning theories help explain the process of learning within the mind. When discussing learning, we must realize that the process is the same, but the learner is different because of varied background, experience, biological maturation, etc. Because of their ability to explain and inform a wide range of learning situations, these well-established learning theories are powerful weapons of mass education!

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