# 2. Key Principles of Student Learning

 In this Deans for Impact white paper, education-school leaders summarize insights from cognitive science about optimal student learning in classrooms, with practical implications for day-to-day teaching.

How do students understand new content?

*• Students learn new ideas by linking them to ideas they already know.*

* A well-thought-out curriculum sequence builds foundational knowledge.
* Teachers should use analogies to link new learning to past knowledge, making the links explicit.

• *To learn and remember important information, students need to transfer it from short-term memory (which has quite limited capacity) to long-term memory.*

* Don’t present too much information at once.
* Make content explicit and carefully pace explanations.
* Worked examples are one way to avoid cognitive overload – displaying all the steps of a problem solution.
* Use multiple modalities to convey an idea – e.g., show a graphic while verbally describing the idea.

• *The mastery of new concepts happens in fits and starts, not through a fixed sequence of age-related stages.*

* Teachers shouldn’t withhold information from students because it’s “developmentally inappropriate;” the most important consideration in deciding if students are ready to learn something is whether they have mastered the prerequisites.

How do students learn and retain new information?

• *Information is often retrieved from memory as it was originally remembered, so students should focus on meaning as they learn.*

* Emphasize the meaning of important-to-remember material by having students explain it or organize information in helpful ways.
* Use stories or mnemonics.

• *Practice is important to retaining new material, and some kinds of practice are more effective than others.*

* Retrieving information from memory strengthens the memory, which means that **low-stakes quizzes and self-tests build long-term retention.**
* Interleaving or mixing different types of material strengthens long-term memory – for example, doing addition, subtraction, multiplication, and division problems together.
* Spacing practice over weeks or months improves retention.

How do students solve problems?

• *Each subject area has a set of facts that, if committed to long-term memory, aids problem-solving by freeing working memory and illuminating contexts in which existing knowledge and skills can be applied.*

* Teach different sets of facts at different ages – for example, phonemic awareness and multiplication facts in the elementary grades

• *Effective feedback is essential to acquiring new knowledge and skills.*

* Good feedback is specific and clear.
* Good feedback is focused on the task rather than the student.
* Good feedback is explanatory and focused on improvement, versus merely verifying performance.

How does learning transfer to new situations inside and outside the classroom?

• *To transfer knowledge or skills, students need to understand the problem’s context and underlying structure.*

* Teachers must ensure that students have sufficient background knowledge to appreciate the context and structure of a problem.

• *Examples help us understand new ideas, especially if we see the unifying underlying concepts.*

* Teachers can have students compare examples with different surface structures and identify the underlying similarities – for example, finding the area of a table top and a soccer field.
* For multi-step problems, students can be asked to identify and label the steps required.
* Teachers can alternate concrete examples (word problems) and abstract representations (mathematical formulas).

What motivates students to learn?

• *Beliefs about intelligence are important predictors of student behavior in school.*

* Students are more motivated if they believe intelligence and ability can be improved through effective effort.
* Teachers can shape students’ beliefs about ability and intelligence by praising productive effort and strategies and other processes that are under students’ control, versus praising for being “smart” or “talented.”
* Teachers can prompt students to feel more in control of their learning by encouraging them to set specific learning improvement goals, versus performance goals.

• *Self-determined motivation (intrinsic interest and values) leads to better long-term outcomes than controlled motivation (rewards, punishments, or perceptions of self-worth).* Teachers control several factors related to reward and praise:

* Whether a task is one the student is already motivated to perform;
* Whether a reward is verbal or tangible;
* Whether a reward is expected or unexpected;
* Whether praise is offered for effort, completion, or quality of performance;
* Whether praise or reward occurs immediately or after a delay.

• *The ability to monitor their own thinking can help students identify what they do and don’t know, but people are often not the best judges of their own learning and understanding.*

* Teachers can engage students in tasks that allow them to reliably monitor their own learning – e.g., testing, self-testing, and explanation.

• *Students will be more motivated and successful in classrooms when they believe that they belong and are accepted.*

* Teachers can reassure students that doubts about belonging are common and will diminish over time.
* Teachers can encourage students to see critical feedback as a sign that others believe they are able to meet high standards.

What are common misconceptions about how students think and learn?

• *Teachers need to communicate that cognitive science has debunked these erroneous beliefs:*

* Students have distinct learning styles.
* People use either the right or the left side of their brains.
* Humans use only 10 percent of their brains.
* Novices and experts think in the same ways.
* Cognitive development progresses in a fixed progression of age-related stages.

“The Science of Learning” by Deans for Impact, 2015; the full report is available at

<http://deansforimpact.org/wp-content/uploads/2016/12/The_Science_of_Learning.pdf>

*Synopsis above from Marshall Memo 688, May 29, 2017.*