from the ERS Supporting Good Teaching Series

What Research Tells Us About How Children Learn

Understanding more about how people learn can help teachers harness the mental energy present in all their students. This overview presents some key findings of cognitive research on human learning, touches on what instructional approaches are compatible with our growing understanding of how the brain works, and provides some tips on how to incorporate this information into your teaching.

Key Findings of the Research on Human Learning

The brain searches for meaning.

"Whatever else we are as human beings, we have an innate desire for meaning," says Parnell (1996, 50). Learners of all ages discover meaning by making connections.

Recent cognitive research tells us that the need for developing connections is rooted in the basic functioning of the brain itself. An individual brain cell may be connected to 10,000 or more other brain cells. In simplified terms, each brain cell receives messages from other cells and decides to pass each message along depending on the amount of electrical charge behind the message. When it finds little or no connection, the message may be discarded. Every time a person experiences something that "connects" with a previous experience, that experience tends to "stick," and something is learned (Parnell 1996). In the classroom, this means that teachers should help students to actively make connections:

- Build curricula around what students already know. If facts are presented as part of a larger picture and associated with past learning, the brain is more likely to remember them (Bruer 1997).
- Create meaning by linking information to real-life experience. When possible, connect information to other personal associations (Jensen 1996).
- Give students choices about what they learn so that they can choose what is most relevant to them.
- Use meaning-making activities such as journal writing. For example, at the end of a lesson, students would write down what they learned, how the learning relates to what they already know, and how they can use this information in the future (Sousa 1998).
- Embed learning in everyday activities. For instance, students practice language skills by making signs for an event.

"Successful learning depends on whether, and how well or how much, learning experiences bring into play the brain's inner resources and the rules of how the brain learns" (Smilkstein 2003, 94)

Issues in the ***Supporting Good Teaching Series*** are designed to help teachers successfully address challenges present in every classroom. Each of the issues includes a synthesis of research, best practice, and questions intended to encourage teacher self-reflection as well as discussion among school staff members.

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- Use stories, complex themes, and metaphors to link information and understanding.
- Create interdisciplinary curricula, or find times when it is possible to address one topic across disciplines.

> "Teachers spend about 90 percent of their planning time devising lessons so students will *understand* the learning objective (i.e., make sense of it). But to convince a learner's brain to persist with that objective, teachers need to be more mindful of helping students establish *meaning*" (Sousa 2003, 26).

Meaning is also created by identifying "patterns." The brain resists assimilating isolated bits of information; it prefers to integrate information by recognizing and incorporating patterns (Caine and Caine 1995; Della Neve, Hart, and Thomas 1986). What can teachers do in the classroom to take advantage of the brain's preference for patterns?

- Present a variety of material that initially seems unconnected, then model ways of making connections—for example, by webbing or talking out loud about the reasons why and how certain pieces are joined.
- Encourage students to talk about material in an unstructured way, discovering on their own how each piece of the puzzle fits into something larger and how the connections that are made might vary from student to student (Jensen 1996).

The brain is a complex system.

The brain is a system of thoughts, emotions, imagination, and physiology that constantly exchanges information with its environment. As a "parallel processor," the brain is able to perform many functions simultaneously (Caine and Caine 1994). Information broken up into small chunks, with supplied answers at every turn, does not take advantage of such complexity (Nadis 1993). What are the implications for teaching and learning? Teachers should:

- *Allow learning to follow its own course.* Recognize that the brain does not always take logical steps down one path, but can go down a hundred paths simultaneously. With varied experiences, students make connections, extract patterns, and retain

Making Learning Last

"Attaching sense and meaning to new learning can occur only if the learner has adequate time to process and reprocess it. This continuous reprocessing is called rehearsal and is a critical component in the transference of information from working memory to long-term storage. Two major factors should be considered in evaluating rehearsal: the amount of time devoted to it . . . and the type of rehearsal [rote or elaborative] carried out.... [Rote rehearsal] is used when learners need to remember and store information exactly as it entered working memory…. By contrast, elaborative rehearsal is used when . . . it is important to associate new learnings with prior learnings to detect relationships" (Sousa 2003, 27-28).

Sousa also describes another key finding from research about the brain and learning—the stages of memory:

> Immediate memory is the ability to hold on to items, from a few seconds to about a minute, to accomplish a particular task…. The task is often completed subconsciously and the memory of it quickly fades…. However, [with practice], there is a high probability that the information will move to the conscious processor—working memory. Working memory is the ability to hold items long enough to consciously process and reflect on them and to carry out related activities during the processing, which can take from minutes to hours…. Long-term memory is the ability to store information in a permanent form for months, years, and even for a lifetime…. [In classrooms], permanent storage is most likely to occur when the learning makes sense and has meaning (2003, 23-25).

information in different ways (Della Neve, Hart, and Thomas 1986).

- *Realize that it takes some students longer to make connections.* Instructional planning should provide opportunities for some students to have this extra time, while still maintaining a sense of coherence (Caine and Caine 1995).

Some Ways to Provide More Time for Learning

- Use review through application regularly. Some concepts take 24 repetitions before mastery.
- Incorporate time for reflection into everyday classroom practices. It allows students' brains to develop meaning and personal relevance from the concepts introduced by the teacher.
- Integrate one subject's concepts into other academic areas. It makes sense to the brain and frees up time for high-level thinking and thorough application of the skills in lessons.
- Use the 20-2-20 rule. Re-explain within 20 minutes, review and apply within 2 days, and reflect upon and further apply within 20 days (Erlauer 2003, 96).

There are many ways to be intelligent.

Intelligence is multifaceted, with traditional IQ tests measuring only some aspects of it. Howard Gardner has identified eight basic types of intelligence: verbal/linguistic, musical/rhythmic, naturalist, logical/mathematical, visual/spatial, bodily/kinesthetic, interpersonal, and intrapersonal (Sousa 2003). This understanding suggests that teachers should:

- *Consider more than one type of intelligence when planning instruction.* For example, when teachers link music to math or visual art to biology, they are more likely to tap into the many ways that students learn.
- *Promote self-directed learning in which students ask researchable questions;* identify varied resources; and initiate, implement, and bring closure to a learning activity. Regardless of the focus—studying the nesting habits of local birds or solving a mock crime—these projects draw on numerous intelligences (Campbell 1997).
- *Teach students about the theory of multiple intelligences,* and then ask them to think about which intelligences they use during different activities (Greenhawk 1997).
- *Provide choices* so that students can pursue individual interests using individual strengths.

Ask not how smart is the child, but how is the child smart?"

(Howard Gardner in Sousa 2003, 35).

Learning is an emotional activity.

Emotions often serve as a link for retrieving information and enhancing long-term memory. "The more personal meaning a learner experiences in conjunction with any material to be learned, the greater the retention and application will be" (Greenleaf 2003). If we recall an event from years ago, most often there is some emotion attached to it (McClanahan 1998). In general, how a person feels in a learning situation determines the amount of attention he or she devotes to it—and increased attention is more likely to result in learning and retention (Sousa 1998). How can teachers use this knowledge to improve instruction? They can:

- Create a comfortable, nonthreatening climate. Anything that students might interpret as punitive, critical, or threatening may act as a barrier to learning (Della Neve, Hart, and Thomas 1986).
- Engage students personally through the use of journals, discussion, sharing, and reflection. If there is a significant current event that may have personal meaning for the students, ask them to talk or write about it.
- Use theater and drama—ideal forums to engage the emotions.

Learning is a social activity.

Learning is heavily influenced by the interaction of the individual with the larger social environment. Our minds respond to interaction with others, in part because these situations often engage emotions, as discussed earlier. What are the implications for the classroom? Teachers can:

- Create a classroom atmosphere in which students interact comfortably and see themselves as part of a learning community.
- Look for opportunities for students to work in small-group settings.
- Use peer tutoring.

To decrease stress for students and so decrease a barrier to learning:

- Set clear classroom rules with predetermined consequences.
- Speak respectfully to students, address them by name, get to know them as individuals, and make each person feel special.
- Use rubrics for assignments so that students know the exact expectations for earning specific grades.
- Smile, have fun teaching, and show a sense of humor (Erlauer 2003, 20).

Metacognitive skills enhance learning.

Successful students do more than acquire knowledge of facts and concepts. They have an awareness of how they are learning and use it to monitor their own thought processes and to change their approach to fit the situation or activity (Bruer 1997). Some researchers argue that "teaching thinking skills, learning strategies, problem solving, and creativity can make a difference as fundamental as how the brain itself works" (Languis 1998, 46). Metacognition involves being aware of one's strengths and weaknesses as a learner. What are the implications for teaching?

- Teachers should realize that, for some students, weak metacognitive skills can act as a barrier to learning—but that these skills can be taught.
- Involve students in discussions of their learning process and problem-solving strategies. By listening to students think out loud, teachers can better recognize what specific understanding a student is missing, and then help the student obtain it (Bruer 1997).

Practices Supported by Cognitive Research

Many current instructional approaches are compatible with our growing understanding of how the human brain works. Several examples are highlighted here.

Thematic, Integrated Curriculum

There are many ways to organize learning around common themes, and cognitive research clearly supports the integrative approach. Specifically, it creates the expectation in students that there are connections to be made: connections with upcoming ideas in the same course, with other courses, and with out-of-school settings (Perkins 1991). This process takes advantage of the mind's continual search for meaning.

Given describes the brain's learning systems—emotional, social, cognitive, physical, and reflective—and suggests that teachers act as "talent scouts" to help students identify strengths and so develop their reflective learning system. This system:

> considers personal achievements and failures and asks what worked, what didn't, and what needs improvement.... That is, children can learn to ask themselves, "Did I learn best when listening compared to reading, or handling information, or when working with others versus working alone?" Although the reflective learning system is the last to develop biologically, it . . . [acts] as the brain's executive officer.... Without explicit instruction in self-monitoring and performance analysis, however, this system can go dreadfully underdeveloped (2002, 8-9).

Cooperative Learning

Much research has suggested that cooperative learning can be effective; our knowledge of cognitive research suggests why. Working in groups can fulfill the human need for social interaction and can cultivate emotional responses in students. In addition, each student's role in contributing to the group and working toward a common goal creates a powerful purpose for individual learning (Jensen 1998, 33).

Block Scheduling

Longer teaching periods offer opportunities to provide the experiences compatible with the complex nature of the brain. Teachers have time to introduce a new topic with "hooking" activities that stimulate questions in each student. More time is also available to make connections to real concerns, leading to higher levels of student motivation (Fitzgerald 1996). In addition, several different instructional approaches can be used in one period, calling on a variety of intelligences.

The Learning Cycle Approach

Research demonstrates that this popular approach in science instruction "(exploration, invention, and application) results in higher content achievement, improved thinking skills, and better attitudes toward science" (Gabel 2004, 204). Our new understandings of how the mind works help to explain its success.

During the first phase of the Learning Cycle Approach, students explore new materials and ideas with minimal guidance, raising questions about the phenomena being explored and identifying patterns of regularity—two practices that reflect the brain's quest for meaning. In the invention phase, terms and concepts are introduced that explain the patterns discovered in the exploration phase. In the application phase, students apply the terms and concepts to new situations—thus learning to generalize in a broader context, and once again nurturing the brain's need to construct meaning (Klosowski 1998).

Teaching Higher-Order Thinking Skills

The human brain's capacity to act as a parallel processor and function on many levels at once helps to explain why providing opportunities for higher-order thinking is an important instructional approach. Asking thought-provoking questions or requiring students to explain their reasoning can encourage learners to make connections between past and new learning, create new neural pathways, strengthen existing pathways, and increase the likelihood that the new learning will be consolidated and stored for future retrieval (Sousa 1998).

Nummela and Rosengren explain that traditional methods of teaching are similar to giving students a single route to reach a destination, whereas teaching methods that take advantage of the brain's capacity for complex problem-solving are more similar to giving students a map offering many possible routes to reach a destination. Route learning is quicker, and easier to test, but "contains far less information than maps" (1988, 85).

Putting It All Together in the Classroom

Research has much to tell us about how children learn and what instructional methods are most effective. Yet, teachers still face the task of constructing classroom environments that take advantage of this knowledge. Fogarty (1998) suggests eight guidelines for the "intelligence-friendly" classroom:

Restructuring Prior Knowledge

Sometimes existing knowledge can stand in the way of understanding new information. For example, in the area of mathematics, many children make mistakes when they use fractions because they use rules that apply to natural numbers only. Similarly, in the physical sciences, students form various misconceptions. The idea that the Earth is round like a pancake or like a sphere flattened on the top happens because it reconciles the scientific information that the Earth is round, with the intuitive belief that it is flat and that people live upon its top. Such misconceptions do not apply only in young children. They are common in high school and college students as well.

While such misconceptions are often the case in the learning of science and mathematics, the problem can apply to all subject-matter areas.

In the classroom

What can teachers do to facilitate understanding of counter-intuitive information?

- Teachers need to be aware that students have prior beliefs and incomplete understandings that can conflict with what is being taught.
- It is important to create the circumstances where alternative beliefs and explanations can be externalized and expressed.
- Teachers need to build on the existing ideas of students and slowly lead them to more mature understandings. Ignoring prior beliefs can lead to the formation of misconceptions.
- Students must be provided with observations and experiments that have the potential of showing to them that some of their beliefs can be wrong. Examples from the history of science can be used for this purpose.
- Explanations must be presented with clarity and, when possible, exemplified with models.
- Students must be given enough time to restructure their prior conceptions. In order to do this, it is better to design curricula that deal with fewer topics in greater depth than attempting to cover many topics in a superficial manner (excerpted from Vosniadou 2001).

- *Establish a safe emotional climate.* In such a climate, risk-taking is the norm, and students feel that wrong answers are as much a part of learning as right answers. Specific strategies include tapping into the emotional intelligences of the learners and organizing diverse small-group work.
- *Create a rich learning environment*. Use presentations of science equipment, art supplies, or computers designed to stimulate curiosity. Create "mini-environments" that facilitate a variety of activities, including one-on-one interactions between students and between the teacher and the student, quiet reflection, and learning centers. Sensory input—music, print materials, visually appealing bulletin boards—can also engage students' interest.
- *Teach the mind-tools and skills of life.* These run the gamut from communication skills necessary in any social environment to skills needed to program computers. Specific skills might include critical thinking (prioritizing, comparing, and judging); creative thinking (inferring, predicting, and generalizing); social skills (team leadership and conflict resolution); technological skills (keyboarding and searching the Internet); visual skills (painting and sculpting); and performance arts (dancing and acting).
- *Develop the skillfulness of the learner.* Student skills are developed through mediation, practice, coaching, and rehearsal. Skill development occurs through formal teaching structures—such as direct instruction—as well as through independent readings and research and the dialogue of peer coaching and mentoring.
- *Challenge students with hands-on learning opportunities.* These would include lab-like situations and other real-life experiences that invite the learner to become an integral part of the process.
- *Involve many facets of intelligence.* It is not necessary to include all eight intelligences in every lesson, but teachers might reasonably try to incorporate several different ways of understanding in any given assignment. For example, working on a classroom newspaper requires that students interview (interpersonal), write (verbal), design and lay out (visual), and critique (logical).
- *Transfer learning from the public arena to the personal.* Through reflection, make learning meaningful and relevant. Possible tools for reflection include reading-response journals, in which the reader writes a personal, immediate response to what has been read; and learning logs, which record thoughts, comments, and questions prior to or following an experience.
- *Balance traditional assessment measures with portfolios and performance assessments.* In addition to letter grades, use portfolio assessments (on collections of students' best work) and performance assessments (on speeches, presentations, plays, concerts, etc.).

Generally speaking, "[t]eachers can help students learn more effectively if they create opportunities for students to relate the curriculum to their personal lives, provide an environment that reveals multiple meanings of material, and allow students to see the dynamic nature of information" (Slavkin 2003).

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Questions for Discussion and Reflection

- Brainstorm some ways to integrate small-group settings or peer tutoring into your lesson plans and teaching methods. Discuss them with your fellow teachers.
- Reflect on the methods that you use to teach a particular concept or lesson. How might you alter this method to encourage higher-order thinking skills and stimulate your student's capacity for complex problem solving? Think back to the road map analogy discussed in the text.
- Take a closer look at the guidelines by Fogarty presented on page 6. Is your classroom "intelligence friendly"? Share some ideas about how to do this with your colleagues.

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Higher Order Thinking Skills (NT-#5209)

Defines higher-order thinking skills and describes how to teach these skills to students, including such groups as at-risk students.

Multiple Intelligences (NT-#5130)

Covers programs, curricula, teaching methods, and research results applicable to the eight intelligences identified by Harvard psychologist Howard Gardner.

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