Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

Classroom Compass

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HIGHLIGHTS

How Can Research on the Brain Inform Education?

In recent years educators have explored links between classroom teaching and emerging theories about how people learn. Exciting discoveries in neuroscience and continued developments in cognitive psychology have presented new ways of thinking about the brain—the human neurological structure and the attendant perceptions and emotions that contribute to learning. Explanations of how the brain works have used metaphors that vary from the computer (an information processor, creating, storing, and manipulating data) to a jungle (a somewhat chaotic, layered world of interwoven, interdependent neurological connections).

Scientists caution that the brain is complex and, while research has revealed some significant findings, there is no widespread agreement about their applicability to the general population or to education in particular. Nevertheless, brain research provides rich possibilities for education and reports of studies from this field have become popular topics in some educational journals. Enterprising organizations are translating these findings into professional development workshops and instructional programs to help teachers apply lessons from the research to classroom settings. References to several teaching models based on brain research are found on page 10, **Programs**.

Opportunities for Learning

Most neuroscientists believe that at birth the human brain has all the neurons it will ever have. Some connections, those that control such automatic functions as breathing and heartbeat, are in place at birth, but most of the individual's mental circuitry results from experiences that greet the newborn and continue, probably, throughout his or her life. How and when neural connections are made is a topic of debate. Some researchers believe the circuits are completed by age five or six. Other studies extend the period of development from birth to the later elementary school years. Still others argue that nerve connections can be modified throughout life with new connections forming perhaps even late in life. For educators who subscribe to the first view, programs and activities aimed at preschoolers (e.g., Head Start or Sesame Street) increase in

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How Can Research on the Brain Inform Education?
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importance. The second perception supports offering complex subjects much earlier in the curriculum than has been traditional. The third encourages efforts for lifelong learning.

The links between learning, the number of neural connections, or the time frame for development of those connections are not clearly understood. In the case of sight, evidence suggests that after a critical development period vision is severely stunted or fails altogether. For musical learning, some researchers have found that the longer someone plays an instrument the more cortex will be dedicated to controlling the finger movements needed to play it. Exposure to music and development of spatial reasoning (skills that can be transferred to mathematical understanding) seem to be connected.

These and other findings encourage educators and parents to expose very young children to a variety of learning experiences—providing blocks and beads to handle and observe, talking to the child, playing peek-a-boo. The *NCTM Curriculum and Evaluation Standards* encourage teachers of kindergartners to let students work with patterns; sort, count, and classify objects; use numbers in games; and explore geometric shapes and figures. It is not too early to engage such young children in discussions about patterns, beginning data analysis, sequencing, and number sense. The introduction of a second language is best attempted in these early years as well. In fact, some researchers look to the first year of life as the best "window of opportunity" for accelerated learning.

Emotions and the Mind

Educators may find the most useful information in research that focuses less on the physical and biochemical structure of the brain and more on the mind—a complex mix of thoughts, perceptions, feelings, and reasoning. Studies that explore the effects of attitudes and emotions on learning indicate that stress and constant fear, at any age, can circumvent the brain's normal circuits. A person's physical and emotional well-being are closely linked to the ability to think and to learn effectively. Emotionally stressful home or school environments are counterproductive to students' attempts to learn. While schools cannot control all the influences that impinge on a young person's sense of safety and well-being, classrooms and schools that build an atmosphere of trust and intellectual safety will enhance learning. Letting students talk about their feelings can help them build skills in listening to their classmates' comments. Finding ways to vent emotions productively can help students deal with inevitable instances of anger, fear, hurt, and tension in daily life.

Are You Left-Brained?

It is difficult to sort through all the information offered by brain and mind research and make wise choices for the classroom. One popularization of mind-based research, the hemisphericity theory, has attributed certain learning styles and preferences to dominance of the left or the right side of the brain. This dichotomy seems to explain observable differences among learners and designations of "left-brained" and "right-brained" have appeared in our popular culture. The original studies that supported the theory, however, involved severing (either through an accident or by surgery) the band of nerve fibers, the *corpus callosum*, that connects the two hemispheres. In a normal brain the two sides of the brain operate together, but with the connection severed, the two halves cannot communicate. The popular interpretation of the hemisphere explanation of personal learning styles ignored the complex, interactive reality of the two sides working together. While understanding the brain's hemispheres is undoubtedly relevant to education, children cannot be categorized as exclusively left-brained or right-brained learners.

Multiple Intelligences

Another popular interpretation of research on human learning is based on Howard Gardner's theory of multiple intelligences. First published in 1983, Gardner's *Frames of Mind* presented a vision of seven intelligences (linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal) that humans exhibit in unique and individual variations. An antidote to the narrow definition of intelligence as reflected in standardized test results, Gardner's theories have been embraced and transformed into curricular interpretations across the country. Many teachers instinctively respond to the notion that students learn and excel in a variety of ways, and believe that a classroom that offers an array of learning opportunities increases the likelihood of success for more students. Gardner himself, however, counsels against widespread application of his theory to every learning situation. All concepts do not lend themselves to every variation of Gardner's list and attempts to present every lesson in seven different modes pushes the theory beyond its practical usefulness. These profiles also should not be used as diagnostic indicators of a student's talents. Just as students are not fully right-brained or left-brained, they should not be defined by their predilection for one or more of Gardner's categories. The goal of education is to encourage the development of well-rounded individuals.

continued on page 10

Implications for Teaching

Recent Research Suggests	Teaching Suggestions
The brain performs many functions simultaneously. Learning is enhanced by a rich environment with a variety of stimuli.	• Present content through a variety of teaching strategies, such as physical activities, individual learning times, group interactions, artistic variations, and musical interpretations to help orchestrate student experiences.
Learning engages the entire physiology. Physical development, personal comfort, and emotional state affect the ability to learn.	• Be aware that children mature at different rates; chronological age may not reflect the student's readiness to learn. • Incorporate facets of health (stress management, nutrition, exercise) into the learning process.
The search for meaning is innate. The mind's natural curiosity can be engaged by complex and meaningful challenges.	• Strive to present lessons and activities that arouse the mind's search for meaning.
The brain is designed to perceive and generate patterns.	• Present information in context (real life science, thematic instruction) so the learner can identify patterns and connect with previous experiences.
Emotions and cognition cannot be separated. Emotions can be crucial to the storage and recall of information.	• Help build a classroom environment that promotes positive attitudes among students and teachers and about their work. • Encourage students to be aware of their feelings and how the emotional climate affects their learning.
Every brain simultaneously perceives and creates parts and wholes.	• Try to avoid isolating information from its context. This isolation makes learning more difficult. • Design activities that require full brain interaction and communication.
Learning involves both focused attention and peripheral perception.	• Place materials (posters, art, bulletin boards, music) outside the learner's immediate focus to influence learning. • Be aware that the teacher's enthusiasm, modeling, and coaching present important signals about the value of what is being learned.
Learning always involves conscious and unconscious processes.	• Use "hooks" or other motivational techniques to encourage personal connections. • Encourage "active processing" through reflection and metacognition to help students consciously review their learning.
We have at least two types of memory: spatial, which registers our daily experience, and rote learning, which deals with facts and skills in isolation.	• Separating information and skills from prior experience forces the learner to depend on rote memory. • Try to avoid an emphasis on rote learning; it ignores the learner's personal side and probably interferes with subsequent development of understanding.
The brain understands best when facts and skills are embedded in natural spatial memory.	• Use techniques that create or mimic real world experiences and use varied senses. Examples include demonstrations, projects, metaphor, and integration of content areas that embed ideas in genuine experience.
Learning is enhanced by challenge and inhibited by threat.	• Try to create an atmosphere of "relaxed alertness" that is low in threat and high in challenge.
Each brain is unique. The brain's structure is actually changed by learning.	• Use multifaceted teaching strategies to attract individual interests and let students express their auditory, visual, tactile, or emotional preferences.

Caine, R.N., Caine, G. (October 1990). "Understanding a Brain Based Approach to Learning and Teaching." *Educational Leadership* 48, 2: 66-70. (Excerpts). Adapted by permission of the Association for Supervision and Curriculum Development.

Number Sense and Mathematics Communication in Elementary School

from the *NCTM Standards*

Number Sense and Numeration:

In grades K–4, the mathematics curriculum should include whole number concepts and skills so that students can understand our numeration system by relating counting, grouping, and place-value concepts.

Children must understand numbers if they are to make sense of the ways numbers are used in their everyday world. They need to use numbers to quantify, to identify location, to identify a specific object in a collection, to name, and to measure. Furthermore, an understanding of place value is crucial for later work with number and computation.

Prior to formal instruction on place value, the meanings children have for larger numbers are typically based on counting by ones and the "one more than" relationship between consecutive numbers. Since place-value meanings grow out of grouping experiences, counting knowledge should be integrated with meanings based on grouping. Children are then able to use and make sense of procedures for comparing, ordering, rounding, and operating with larger numbers.

Mathematics as Communication:

In grades K–4, the study of mathematics should include numerous opportunities for communication so that students can reflect on and clarify their thinking about mathematical ideas and situations.

Mathematics can be thought of as a language that must be meaningful if students are to communicate mathematically and apply mathematics productively. Communication plays an important role in helping children construct links between their informal, intuitive notions and the abstract language and symbolism of mathematics; it also plays a key role in helping children make important connections among physical, pictorial, graphic, symbolic, verbal, and mental representations of mathematical ideas. When children see that one representation, such as an equation, can describe many situations, they begin to understand the power of mathematics; when they realize that some ways of representing a problem are more helpful than others, they begin to understand the flexibility and usefulness of mathematics.

Young children learn language through verbal communication; it is important, therefore, to provide opportunities for them to "talk mathematics." Interacting with classmates helps children construct knowledge, learn other ways to think about ideas, and clarify their own thinking. Writing about mathematics, such as describing how a problem was solved, also helps students clarify their thinking and develop deeper understanding. Reading children's literature about mathematics, and eventually text material, is also an important aspect of communication that needs more emphasis in the K–4 curriculum.

Learning psychologist Howard Gardner proposed that each learner reflects his or her unique combination of intellectual strengths and weaknesses. Gardner's theory of seven intelligences (linguistic, mathematical, spatial, musical, intrapersonal, interpersonal, bodily-kinesthetic) has inspired many educators to present content in a variety of ways so individual students' learning preferences might be awakened and connected to their intellectual strengths.

The place value activities presented here suggest alternatives to traditional textbook problem solving. These activities are designed to be used during a mathematics lesson, but the concepts could be incorporated across the curriculum: setting up a model bank in a social studies class, reading a counting story in language arts, emphasizing the mathematics of measurement in science. Embedding the ideas in a variety of contexts will give different learners more opportunities for understanding.

Place Value for Elementary Students

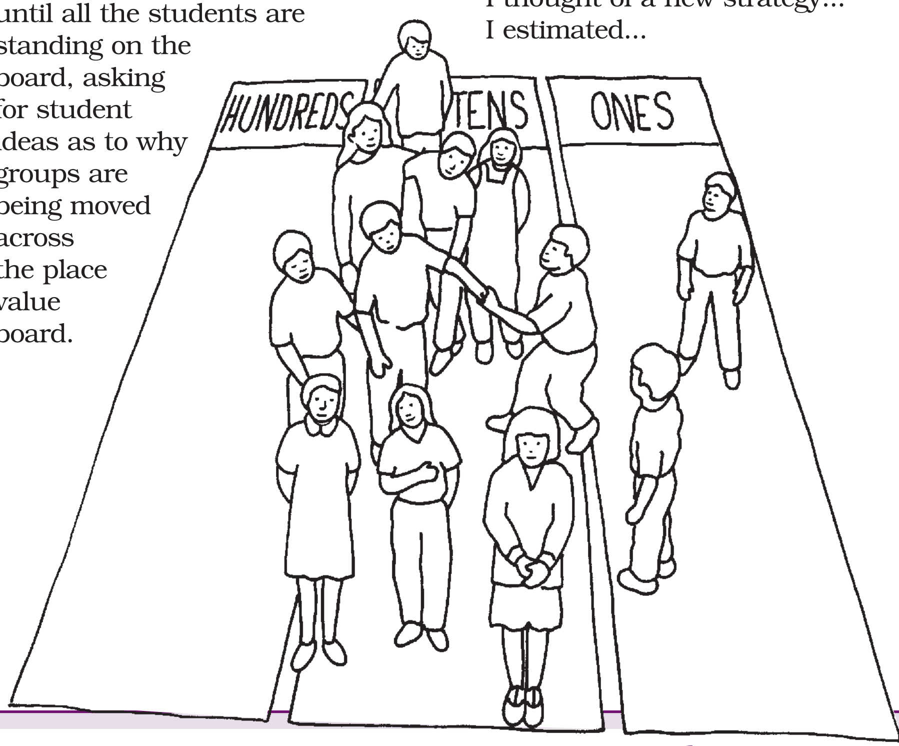
These activities reinforce students' understanding by using rhythm, physical action, and introspection.

Physical Action: The Place Value Board

Use a sheet of butcher paper to create a large place value board and place it on the floor. With a large die, roll a number and have that many students stand in the ones column. Ask the students why they are standing in that column. How many more students could we place in that column?

Roll the die again and add that many more students to the ones area. Ask: are there enough students now to make a group of ten? If yes, have ten students link their arms and move to the tens place. Anyone left stays in the ones area. Ask: why have we moved this group to the ten's place? Will someone tell something about the number represented on the place value board? Does that correspond to the number of children standing at the place value board?

Continue to roll the die until all the students are standing on the board, asking for student ideas as to why groups are being moved across the place value board.



Introspection: The Math Journal

While mathematical conversations among students are essential for understanding, a journal provides another avenue that may appeal to the introspective, linguistically oriented learner. Students should write as mathematicians, clearly communicating each idea, theory, or step to solving a problem. They may use this writing time for exploration, reflection, or explanation. Let the students respond to such questions as

Something I learned today...
I found the right tool to...
I saw a pattern...
Something I didn't understand...
Something easy...
I predicted...
Math is easy when...
Something in math I'd like to learn...
My plan for tomorrow is...
Skills that I enjoyed learning...
I found...I made a connection...
I thought of a new strategy...
I estimated...

Music: That's a Rap!

Introduce this spoken song to the students after they have worked with the concept of place value. If you do not feel comfortable demonstrating your rap skills, let student volunteers assist you. (Sunglasses and baseball caps help set the mood.)

Place Value Rap

The number of digits
in our system is ten.
You will learn their value
if you just begin.
There's a zero,
there's a one, two, three, four,
five, six, seven, eight, nine,
no more.
Every digit has a value
on its face;
And each digit has
a value in its place.
Two can be two ones or
two can be two tens.
Either way it's two,
the value just depends
On where you put it,
On where you put it.
The value just depends on
where you put it.
Two tens are twenty and
two ones are two.
When you use
the proper place
it's easy to do.

With this inspiration, your students may want to experiment with their own math raps.

These activities appear in *Celebrating Multiple Intelligences: Teaching for Success*, written by the faculty at New City School in St Louis, Missouri. Available from The Bookshelf, 4301 Connecticut Ave. N.W., Suite 432, Washington, DC 20008. 1-800-346-1834.

AN ACTIVITY FOR UPPER LEVEL STUDENTS

Learning a Maze

How do we learn? A simple path through a maze provides a way to measure one kind of learning using the sense of touch.

This activity guides middle school or secondary students in exploring one part of the complex process of learning. Some schools have had success in teaching students about how the brain and mind work so they can actively and consciously take part in their own learning.

Our senses play an important part in learning. The brain's work begins with the messages it receives through the senses from the outside world. Neural connections form as experience and data provide the building blocks for understanding. Sight is usually the primary sense for navigation—how can we tell where to go if we can't see the path? In this activity, however, students measure the trial-and-error learning that occurs when sight is restricted and they must rely primarily on touch. The first attempt to complete the maze is reinforced by two more trials, letting the navigator accumulate experience and learn the path.

Constructing the Maze

What is a maze? Let the students discuss their ideas about mazes, perhaps supported with photographs or drawings of mazes. Students then take about 10 minutes to create a maze from 12 stick-on mailing label strips and two stickers. The start and end points of the path are marked by the stickers—use stickers that are distinct from the strips so they will provide a different tactile sensation. Protect each student's maze construction from others' eyes by standing a manila folder (or a tall book) around each work area.

Running the Maze

Student pairs learn each other's mazes using only their fingertips to find their way. First, one person will attempt the other person's maze, blindfolded, while the partner times the run. Each student gets three timed trials on each maze; completion rates are recorded on a record sheet (see above, right). After one has completed the three attempts, the students switch roles.

Talking About It

At the completion of the timed trials the students can reflect on their experience. Possible questions include

- What evidence did you have that you were learning?
- Were you able to shorten your completion time? Were there portions of the maze you learned well and others that were still difficult?
- Was timing the trials a good way to measure learning? Could you learn more about the maze but not improve your completion time?
- What is learning?
- What are some other skills you have learned through trial and error?

Extension

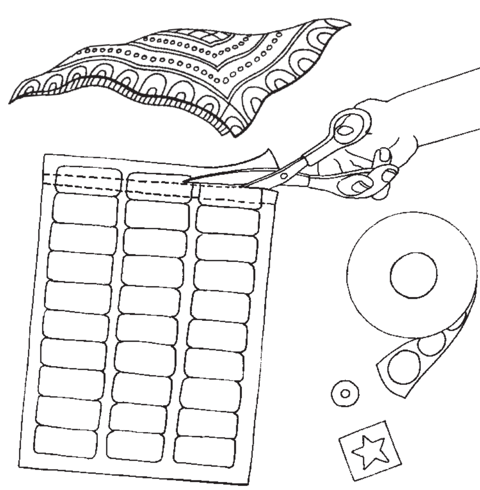
Save the mazes and data sheets for future trials. Have the students predict how the passage of time will affect their learning. Test their long-term memory by retracing the same mazes at a later time (one week, one month, etc.). How accurate were their predictions?

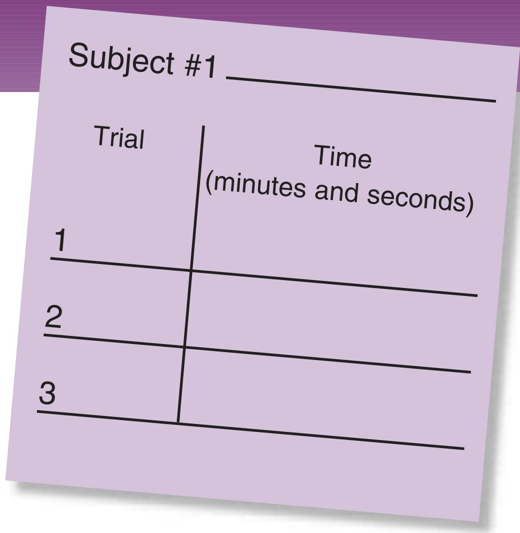
You will need:

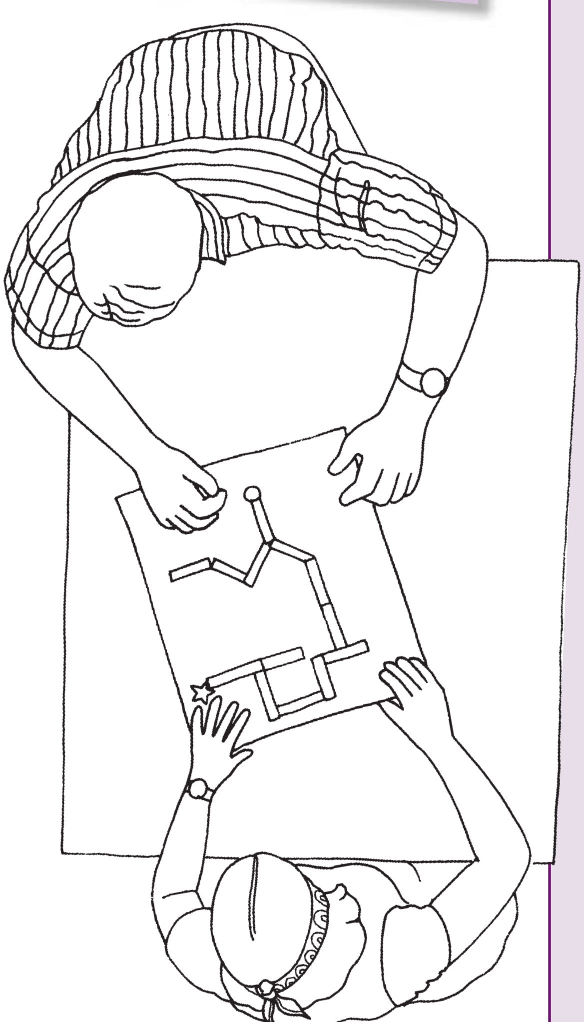
Stick-on mailing labels, 30 labels a page. To conserve your materials budget, cut the mailing labels into three thin strips. Use labels with rounded corners for easy removal.

Each student will need:
- Twelve mailing label strips
- Two stickers
- One manila folder
- One sheet of construction paper

Each student pair needs:
- One blindfold
- One minute/second timer







This activity is shortened, modified, and adapted from *Learning About Learning*, a 10-session teacher's guide in the Great Explorations in Math and Science series from the Lawrence Hall of Science at the University of California at Berkeley. See page 8 for further information.

The Ways We Learn

from *Benchmarks for Science Literacy*

There are multiple reasons for studying how people learn. By learning about how people learn, students may be able to learn more effectively themselves and to know what difficulties they may face. Also, knowing about the limitations of human learning can help people to anticipate problems (their own and those of others) in learning how to teach children better.

Kindergarten through Grade 2

This level is the time to be sure that all children know that they can learn almost anything they want to. Children are most interested in learning about their surroundings. They should be encouraged to notice how they learn by asking them how they learned something in the past or how they might learn to do something new or by having them teach a skill to someone else.

Grades 3 through 5

As children's self-awareness increases, they want to know more about their personal capabilities, what they might be able to do and know. They should be given many opportunities to explore areas of personal interest and develop new skills. By the end of 5th grade, students should know

- Human beings can use the memory of their past experiences to make judgments about new situations.
- Learning means using what one already knows to make sense out of new experiences or information, not just storing the new information in one's head.

Grades 6 through 8

Emphasis should now be placed on how to figure out what learning has taken place as a consequence of studying something. Students can design various tests and administer them to individuals and groups as practice for longer studies of learning. They can investigate different ways of learning different things and compare the results they get.

By the end of the 8th grade, students should know that

- The level of skill a person can reach in any particular activity depends on innate abilities, the amount of practice, and the use of appropriate learning technologies.
- Learning often results from two perceptions or actions occurring at about the same time. The more often the same combination occurs, the stronger the mental connection between them is likely to be.

Grades 9 through 12

Now is the time to consider some explanations of how learning takes place. Claims of sophisticated learning by other animals, such as language in lower primates, can be considered in light of available evidence.

By the end of the 12th grade, students should know that

- The expectations, moods, and prior experiences of human beings can affect how they interpret new perceptions or ideas. People tend to ignore evidence that challenges their beliefs and to accept evidence that supports them.
- Human thinking involves the interaction of ideas, and ideas about ideas. People can produce many associations internally without receiving information from their senses.

This excerpt is from Chapter 6, "The Human Organism: Learning" in *Benchmarks for Science Literacy* (1993), reprinted with permission from the Oxford University Press.

Resources and Opportunities

Mathematical Fun

Recommended for grades 3–6, *Logical Journey of the Zoombinis* is a mathematics CD-ROM for Macintosh or Windows.

A traveling band of Zoombinis, whimsical blue creatures with intriguing hair and eye variations, works its way through a series of mathematically puzzling adventures in its quest for a new homeland. Developers at TERC, an educational research and development center in Cambridge, MA, note that in its mathematical structure a Zoombini is similar to a record in a database, a base-5 number, and other mathematical objects such as a vector. The logical journey challenges the user to analyze data, apply logic, develop sets, categorize by characteristic, and think in mathematically relevant ways. Basically, however, the game is fun. The CD-ROM can be purchased by itself, in a lab pack, or in a school edition that includes a teacher's guide, tutorials, lesson plans, and transparencies.

For price and ordering information, contact:

Broderbund
PO Box 6125
Novato, CA 94948-6125
1-800-474-8840

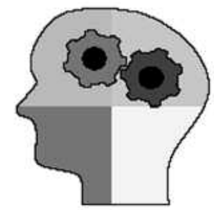
Workshops by Satellite and on the Internet

A series of eight workshops for K–12 science teachers are being broadcast over a satellite television channel beginning in late February. The project is a joint effort of the Annenberg/CPB Math & Science Project, the Smithsonian Institution, and Harvard University. The programs will include video clips of science classrooms and be augmented by Internet discussion sessions. Topics will include preparing to teach science, assessing student understanding, classroom management, and creating a context for learning. All workshops are offered free to anyone who can receive the digital Digicipher2/MPeg2 signal. Programs can also be taped, duplicated, and rebroadcast for educational use. Teachers can earn college credit and certificates of participation from Colorado State University. For more information contact:

Annenberg/CPB Channel
c/o MCET
One Kendall Square
Bldg. 1500
Cambridge, MA 02139-1562
1-800-556-4376

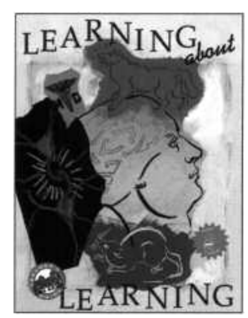
or visit the Web site at:
http://www.learner.org/k12/acpbtv

Brain Food



Want your students to know more about the brain? Take a look at **http://weber.u.washington.edu:80/~chudler/whoi.html**, the Neuroscience for Kids Web page. This is a nice collection of experiments, puzzles, resources, facts, and illustrations for elementary and secondary students and teachers created by Eric Chudler, an assistant professor in the University of Washington's Department of Anesthesiology. The page includes some gems—two brain recipes (one from flour, one from potato flakes) that when mixed in a plastic bag result in models reflecting the consistency and weight of a human brain. Also offered are puzzles to test the memory, and a nifty Connect the Dots exercise that illustrates the complexity of multiple neural connections.

More GEMS



The GEMS guide *Learning About Learning* for grades 6–8 presents 10 sessions designed to help students gain insight into their own learning. Students take the role of investigative scientists as they explore such concepts as health and safety, product testing, animal behavior, ethics, the nervous system, and the brain. A condensed version of one activity from this guide, "Learning a Maze," is presented on page 6. For price and ordering information contact:

GEMS (Great Explorations in Math & Science)
Lawrence Hall of Science
University of California
Berkeley, CA 94720-5200
1-510-642-7771

TIMSS

Mathematics and science educators are looking carefully at *Pursuing Excellence*, a summary of the first results from the Third International Mathematics and Science Study (TIMSS), an ambitious effort that examined a half million students in 41 countries during the 1995 school year. *Pursuing Excellence*, provides a detailed interpretation of TIMSS results, which placed U.S. eighth graders below the international average in mathematics and above the average in science. U.S. students' scores were not significantly different from those of English or German students in either subject. The results, which include comparisons of teaching methods, curricula, time spent in class, student homework loads, after-school activities and many other variables, provides a fascinating and complex picture. Full text of *Pursuing Excellence* is available on the Web site **www.ed.gov/NCES/timss** or from the U.S. Department of Education at **1-202-219-1395**.

For a more detailed examination of the science and mathematics results, two reports, *Science Achievement in the Middle School Years* and *Mathematics Achievement in the Middle School Years*, are available. These books include sample assessment questions as well as selected information about students' backgrounds, and classroom practices in teaching science and mathematics. The books cost $30 each. For ordering information contact:

TIMSS International Study Center
Center for the Study of Testing Evaluation, and Educational Policy
Campion Hall
School of Education
Boston College
Chestnut Hill, MA 02167
Call 1-617-552-4521

or view their Web site at: http://wwwcsteep.bc.edu/timss

S C I M A S T

Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

The Eisenhower SCIMAST project supports science and mathematics education in five states with a combination of training, technical assistance, networking, and information resources. Eisenhower SCIMAST is funded by the U.S. Department of Education's National Eisenhower Program to serve educators in Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. Eisenhower SCIMAST works in partnership with the Eisenhower National Clearinghouse, a national resource center dedicated to increasing the availability and the quality of information about instructional resources for science and mathematics educators. As part of that effort, Eisenhower SCIMAST has a resource/demonstration center open to visitors Monday through Friday, 8:00 A.M. to 5:00 P.M. The center houses a multimedia collection of science and mathematics instructional materials for grades K–12. It is located on the fourth floor of the Southwest Educational Development Laboratory, 211 East Seventh Street, Austin, Texas 78701. The center also has a toll-free number, **1-800-201-7435**, that provides callers in the five-state region information on multimedia and print instructional materials, assessment tools, and successful strategies for mathematics and science instruction.

Eisenhower Southwest Consortium for the Improvement of Mathematics and Science Teaching

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Environments for Learning

Recommended educational approaches, then, consist primarily of trying to maintain a relaxed, focused atmosphere that offers options for learning in individually satisfying ways. The old paradigm of students as empty vessels waiting to be filled with knowledge has given way to the constructivist belief that students continuously build understandings based on their prior experiences and new information. The idea of a fixed intelligence has given way to a more flexible perception of gradual intellectual development dependent on external stimulation.

Gerald Edelman, chairman of the Department of Neurobiology at Scripps Research Institute and 1972 recipient of the Nobel Prize for Physiology, offers a view of the brain that could influence the future classroom. Edelman's vision of the brain as a jungle in which systems interact continuously in a chaotic fashion suggests that learners would thrive in an environment that provides many sensory, cultural, and problem layers. These ideas suggest that students have a natural inclination to learn, understand, and grow. Surround students with a variety of instructional opportunities and they will make the connections for learning.

For More Information

Caine, R. N., and G. Caine (1991). *Making connections: Teaching and the human brain*. Alexandria, VA: Association for Supervision and Curriculum Development.
In addition to addressing several assumptions that teachers hold about education and citing facts and theories about the human brain, the authors discuss twelve principles of brain-based learning and the implications of those principles for educators. They directly challenge the simplification of learning into left- and right-brained modes.

Edelman, G.M. (1992). *Bright air, brilliant fire: On the matter of the mind*. New York: Basic.
Gerald M. Edelman, a Nobel Prize recipient, uses the metaphor of the jungle to describe the workings of the brain and explicitly rejects the metaphor of the brain as a computer. Using the ideas of evolutionary morphology and selection, he portrays the brain as a multilayered representation full of loops and layers.

Eisner, E. W. (1997). Cognition and representation; A way to pursue the American dream. *Phi Delta Kappan* 78, 5: 348–353.
An introduction to a special section on cognition and representation, this article sets out some of the ideas that will follow in the articles in the section and emphasizes the role of culture in processing representation and forming minds.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York: Basic.
Gardner describes natural learners, normal children who develop a vast array of intuitive understandings about their world even before they enter school.

Sylwester, R. (1994, Oct.). How emotions affect learning. *Educational Leadership*: 60-65.
Emotion plays an important part in learning and schools need to focus on metacognitive activities that allow students to identify and deal with their own emotions and those of others. Emotionally stressful environments can inhibit learning.

Programs Based On Research On Learning and the Brain

Fennema, E., T. Carpenter, and M. Loef Franke (1992). *CGI: Cognitively guided instruction*. University of Wisconsin-Madison: Wisconsin Center for Education Research. (1025 West Johnson Street, Madison, WI 53706/ 1-608-263-4200)

Kovalik, S., Olsen, K. D. (1994). *Integrated thematic instruction: The model*. Kent, WA: Susan Kovalik, & Associates.

McCarthy, B. (1987). *The 4Mat system: Teaching to learning styles with right/left mode techniques*. Barrington IL: EXCEL.

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Mathematics and Science Education Resources From the ENC

Resources for science and mathematics educators come from classrooms, research studies, through commercial publishers,and the community. The Eisenhower National Clearinghouse (ENC) provides links to many of these sources through its World Wide Web address at **http://www.enc.org**. From this collection of connections, you can find full text journal and research articles (in the Publications section); new web sites to explore (in the Digital Dozen offerings); connections to web-based sites with classroom-ready materials (under Lessons and Activities); and updates of issues of current interest to mathematics and science educators (see the Online Chalkboard). You can also use ENC's Resource Finder, a searchable catalog of more than 7000 science and mathematics instructional materials.

If you are not connected to the Internet but have a computer and a modem, you can use ENC's online services by dialing its toll-free number (**1-800-362-4448**) or you may dial **1-614-292-9040**. ENC also supports a reference staff that can help with mathematics and science education questions. The number for this service is **1-800-621-5785**.