

# The Brain



## Implications for Teaching and Learning

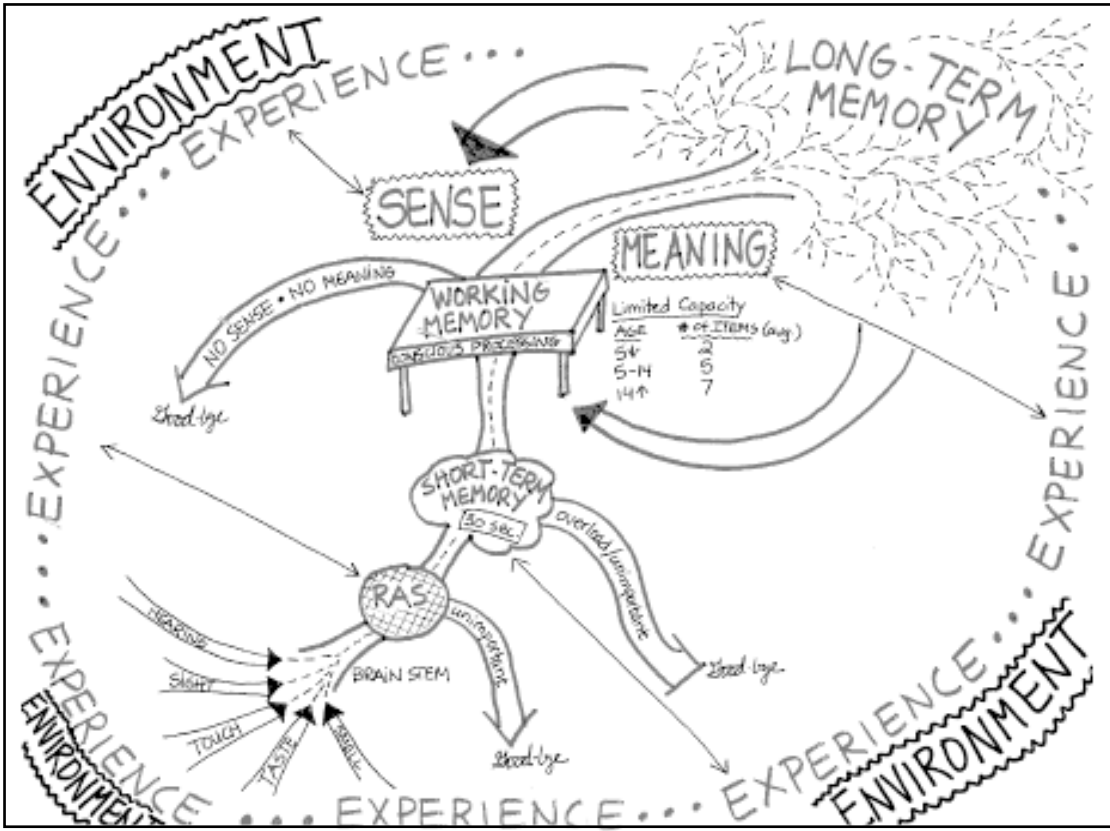
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# The Brain: Implications for Teaching and Learning

by Sue Bos

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ABOUT THE AUTHOR: Sue Bos is a veteran teacher at Guilford Central School in Vermont. She is currently teaching 7/8 Science. Community Works asked Sue to reflect on and compile her work investigating newer research on the brain. Her investigations are significant for their direct connections to her own classroom teaching. Several of the pieces included here originally appeared in *Community Works Journal*. Sue has also shared her work through professional development workshops and institutes for teachers.



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# **An Overview of Learning Implications from Current Research On the Brain**

*developed by Sue Bos*

▲ Learning experiences must make sense in order to allow new information to settle into existing brain patterns of knowledge

▲ Learning environments should be:

- sensually stimulating
- supplied with a variety of learning materials
- encouraging of active engagement with materials
- supportive of discourse and exchange between class members

▲ Teachers must attend to the emotional aspects of learning. The learning environment must be emotionally and physically safe.

▲ Students need training to develop appropriate attentional skills: how to focus attention and what to attend to

▲ The school day must provide for time to think, process, reflect and relax.

## **A Teacher's Thoughts on the Brain**

*by Sue Bos*

There has been an explosion in what we know about the brain in the last ten years, the 1990's --The Decade of the Brain. The brain is literally on our minds these days as more and more researchers share what they have been finding out about how our brains actually work. Advanced technology has allowed researchers to actually look inside the brain, examine the physical structure and monitor the activity that goes on there.

Two years ago it suddenly dawned on me that these brain researchers might be discovering things that would be useful for me to know. I'm a classroom teacher. My job is all about helping young students learn. I've been trained in learning theory and learning styles, curriculum development and assessment techniques, child development, human behavior, and classroom management. Little of my educational training, however, involved learning about the brain and how it works. Yet, the brain is where learning happens. The brain and how it functions is a pretty big piece of the learning puzzle that teachers try to put together successfully in the classroom.

Supported and encouraged by my participation in a professional development seminar class we run on-site at our school, I

set out to become better informed about the brain. I read a lot, wrote a lot, thought a lot, and shared my ideas with my peers. Through my research I developed a basic understanding of the brain and how it functions. I also and started noticing specific things I thought were critically important for my work in the classroom.

From my reading and notes I pulled together a core list of "Brain Givens", a selection of brain knowledge and facts that I feel are educationally relevant and therefore, important for an ordinary classroom teacher like me to know. From these givens I developed a correlating list of "Learning Implications", teaching practices I can employ in my classroom in ways that make the learning environment more "brain compatible" and allow for my students to better maximize their learning potential. *(See chart)*

I can't claim to be an expert on brain structure and function; new findings are emerging all the time and it can be hard to keep up. Some of the research results are confusing and tedious to wade through, but there are references out there that are accessible to the average person and they have important ideas to ponder. *(See resource list)*

My "Brain Givens" are intended to be useful generalizations. They mesh nicely with the knowledge and understandings I have developed over the years through experience in my classrooms; and for me they provide some solid, scientific justification for teaching practices that, until now, have felt merely instinctually "right". I use this knowledge structure as a guide, as I shape the physical and social and environment in the classroom, plan curriculum and activities and manage my class on a daily basis. I share them here in the hope that they might be useful for others engaged in the task of educating our children.

**Through my research I developed a basic understanding of the brain and how it functions. I also and started noticing specific things I thought were critically important for my work in the classroom.**



*Sue and her students explore local history in the cemetery*

## **Brain Givens and Learning Implications**

*by Sue Bos*

### **Our emotional and physical states are at the base of all learning.**

Aristotle was right when he said, “There is nothing in the intellect that has not been in the senses before.” Our senses serve as the conduit for getting information to the brain. As sensory input travels through the brain on its way to the cerebral cortex, it is affected and sometimes altered by its passage through the lower systems of the brain, systems that attend to our physical and emotional needs. All learning has at its core an emotional and physical basis. Students’ availability for learning is directly impacted by their emotional and physical well being. Sensory input is filtered by the brain stem and limbic system, before it gets to the cerebral cortex, where information processing and learning take place. Students who are sick, scared or emotionally hurting will not be able to maximize their learning potential.

Teachers must be aware of this and must work to ensure that the classroom is physically and emotionally safe. It should be understood that students and teachers will be treated with respect, care and dignity. The classroom should be a place where everyone feels safe, comfortable and securely supported. Teachers should demonstrate genuine caring and concern for the physical and emotional well-being of their students.

### **The brain is a pattern seeker and maker.**

The brain is a complex organ, made up of a network of neurons, through which the brain receives, processes and stores information. Physical neural networks are built, altered and maintained within the systems of the brain. These networks provide the structure for individual neural maps of meaning. In its quest for seeking and creating map patterns, the brain is constantly on the alert for new input that has some meaningful connection with information that is already established somewhere in the brain complex.

New learning and understandings need to find a secure place to take hold in the brain’s network, and this task is more easily accomplished when new information makes sense in some way. If there is something in a student’s past experiences that the new knowledge can be connected with in some way, then that new information will already have some meaning for the student. Active learning happens when we engage in new activities, building on past experiences, making connections and taking meaning from those activities and the connections that ultimately emerge.

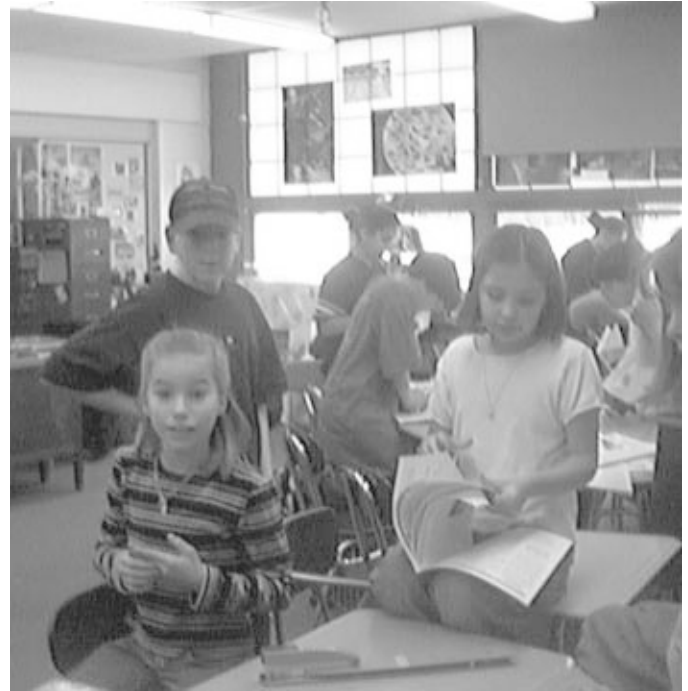
As teachers we need to provide our students with meaningful learning experiences. Work in the classroom should be thoughtful and purposeful, and students should have a clear understanding of the importance and underlying meaning of the work they do. Students should be aware of and understand the “givens” in the curriculum, but they should also be allowed some choice within those “givens” to whatever extent is possible. Meaning is inherent in those activities over which we have some choice.



**The brain is made of a network of connecting neurons.**

Humans are born with all the brain cells they will ever have. We don't get more, and can't make any more. Which is too bad, but not really a big problem, because, as important as individual neurons are, it is the connections between neurons that are clearly more important. Neural networking is what it's all about.

The brain is capable of building an infinite number of neural connections which can be used in the creation of neural network patterns and maps of meaning. The pathways themselves can be physically altered and enhanced to allow for a more efficient passage and processing of stimuli and information throughout the network. Neural connections are built, maintained and enhanced in environments that are sensually stimulating and thoughtfully and safely challenging. This is the Nurture part of the great Nature vs. Nurture debate, i.e.: which is more important, genetics or environmental influence. In brain development it looks like a nurturing environment has critical importance.



Streamlining of neural pathways has been shown to be facilitated by good physical health, and enriching and supportive environments. Enriched learning environments are sensually stimulating and are stocked with a variety of learning materials. They are places where students are encouraged to actively engage with materials, and are given frequent opportunities to interact with their peers.

**The brain needs time to build strong neural connections.**

Our brain needs time to process input and build the physical connections that are necessary for storage and processing of new information in the neural network. There is a physical process that occurs, and this process takes time. A constant barrage of input that demands neural attention with no break, will not allow the brain the time it needs to build useful and secure neural connections. New learning networks need time to develop and take hold.



As teachers we need to be mindful of this real and important need for processing time when planning our curriculum and learning activities and going about the business of running our classrooms on a daily basis. This time needs to be structured into the school day on a regular and reliable basis. What we do won't take hold if we don't allow time for the neural networks to get built.

For me, this means paying attention to the need for "down time" throughout the day and trying to hold to the theory of "less is more" in planning curriculum and activities. Lessons and activities focus closely on one or two core concepts, and what we do, we try to do thoroughly

and well. We focus our work around theme areas and do activities throughout the curriculum that reflect and enhance our theme.

Reflection opportunities are another way to facilitate and support the development of neural connections. Reflection allows for time to think over, reprocess and further develop our new knowledge and understandings. Opportunities for reflection can occur throughout the day at quiet structured times for thinking and writing, and during small and large group discussions and dialogues.

Misconnections and fuzzy understandings are more likely to occur if we rush our students, if we try to do too many things in too short a time. Students need time to reflect on their work and their learning. Teachers need to be vigilant about providing this time. We need to ensure that our students have regular reflective opportunities in the classroom.

### **The brain can pay conscious attention to only one thing at a time.**

The brain does an amazing job of managing the overwhelming amount of sensory input it is receiving all the time. Luckily, much of this work is accomplished on auto-pilot as the brain goes about its work of stimuli management and information processing and storage. Thinking activities, however, demand conscious attention from the brain. We do not think about things that we are not paying attention to. Attention is the first tier of thought. The problem is that the brain can only pay conscious attention to one thing at a time.



*Students work hard to be understood by a hearing impaired senior during an oral history project*

The ability to focus is extremely important for cognitive learning and students need help in developing their attentional skills. They need guidance in their selection of things to attend to, and they need training and opportunities to practice good habits of attention. We can not assume our students have these abilities.

In the classroom we can provide these opportunities. We can read aloud to our students, everyday, making listening a part of the curriculum and not an assumed student skill. We can focus curriculum around theme areas, where the given theme is attended to throughout the day in varied learning activities and subject areas. We can allow for student choice wherever it's feasible. That's fifty percent of the attention battle right there. Let them attend to something they already want to attend to.

### **Each brain is unique.**

While all human brains share the same basic physical structure and methods of operation, each brain is unique and different from every other brain. Genetic material that makes up the brain varies from person to person, and grows and develops following a schedule that is unique to each individual human being. We build our brains with what we have and according to our own personal timetable of development. Finally, we each bring our own diverse perspectives, emotions, memories and prior experiences to every environment and event we encounter in the world. All of these things work in concert to create individual human brains that are unlike any others.

We must always remember this, for these brains are in the bodies of the students in our classrooms. We must create environments and learning experiences that recognize, support, enhance and challenge a diversity of student interests, abilities and potentialities. It is, at times, a challenging and even daunting task, but one well worth taking on. We must celebrate, support and encourage the diversity of minds that are in our classrooms.



# CHART of Brain Givens and Learning Implications

by Sue Bos

## BRAIN GIVENS

1. The brain is a **PATTERN SEEKER**, made up of a network of neurons that provide the structure for individual neural maps of meaning. The brain is constantly on the alert for patterns as it processes and stores new information.

2. Although the number of neurons in the brain cannot increase, the network of **CONNECTIONS** between neurons can increase in number and alter physically to be more efficient. These changes have been shown to happen:

- \* in stimulating and enriching environments
- \* through active mental and physical engagement with materials.

3. The brain inputs information through the **SENSES** passing from the brainstem through the limbic system (the emotional control center) and then on to the neo-cortex. Emotions are at the base of all learning.

4. The brain can cognitively process and pay conscious **ATTENTION** to only 1 thing at a time.

5. The brain requires **TIME** to build and enhance the physical connections that are necessary to process input and transfer information from short-term memory to permanent long-term memory

6. **EVERY BRAIN IS UNIQUE.** Each brain is made up of its own unique genetic material and develops at its own individual pace. Each individual person has a collection of life experiences that are different from every person

## LEARNING IMPLICATIONS

1. Learning experiences must **MAKE SENSE** in order to allow new information to settle securely into existing brain patterns of knowledge. New learning experiences should facilitate connections to prior understandings and experiences, and should be meaningful to students.

2. **LEARNING ENVIRONMENTS** should be:

- \* sensually stimulating
- \* supplied with a variety of learning materials
- \* encouraging of active engagement with materials
- \* supportive of discourse and exchange between classmembers

3. Teachers must attend to the **EMOTIONAL ASPECTS** of learning. The learning environment must be emotionally and physically safe.

4. Students need **TRAINING** to develop successful attentional habits: **HOW** to focus attention and **WHAT** to attend to. Teachers cannot assume students have these abilities. These skills must be taught and nourished.

5. The school day must provide for **REST and REFLECTION**, time to think, process, reflect and relax.

6. **EVERY STUDENT IS UNIQUE.** Teachers should try to understand, celebrate and challenge the individuality of their students. Students should not be made to conform to teacher's programs. Educational programs should be structured to meet individual students' needs and abilities whenever this is possible.

## Mechanics of The Brain

by Sue Bos

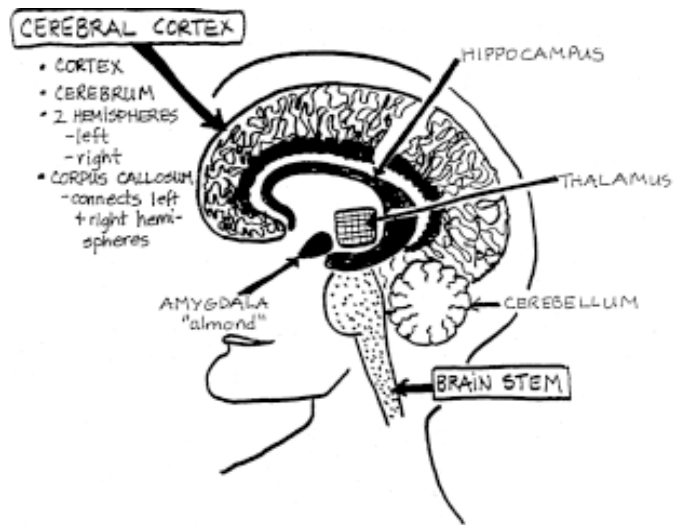
drawings by Anna Ruff

### The brain, an organ about the size of a grapefruit, is composed of 3 primary parts:

the brain stem or “reptilian brain”, the limbic system or “mammalian brain”, and the cerebral cortex, the “executive branch” of the brain. While it is easy to look at the brain by studying these three component parts and their functions, it is important to understand that the brain is a complex system. While certain areas of the brain are specialized for certain operations, all the component parts of the brain work together as an integrally related system.

All information enters the brain in the form of sensory input that is delivered to the brain via the spinal cord, the superhighway of the nervous system. Information enters the brain through the brain stem and travels through the limbic system on its way to the cerebral cortex. In the cerebral cortex the brain puts together and makes sense of

what the senses perceive. It is here that conscious thought and higher level learning happens. The brain stem and limbic system act as both filters and conduits for the sensory input, and, what happens in these parts of the brain as information is traveling through them, plays a significant role in determining what learning and thinking ultimately occurs in the cerebral cortex. It is important to understand how these systems function and impact sensory input in the learning process.



### The brain stem

the gateway to the brain, is where basic body functions for survival are handled. Breathing, heart rate and instinctual body responses are all regulated here. In addition to this vital role, the brain stem also serves as a kind of “town crier” to the higher parts of the brain. As sensory information enters the brain, the brain stem alerts the rest of the brain that information is coming through. The brain stem is the “alertness center” of the brain system. It tells the brain that it is time to pay attention.

### The limbic system

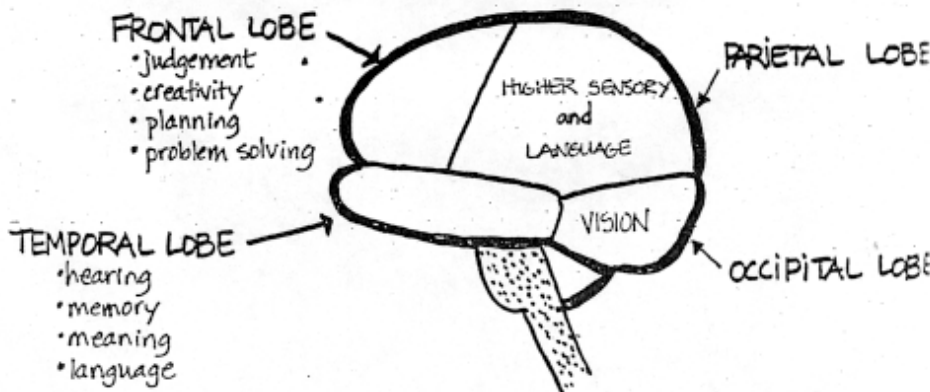
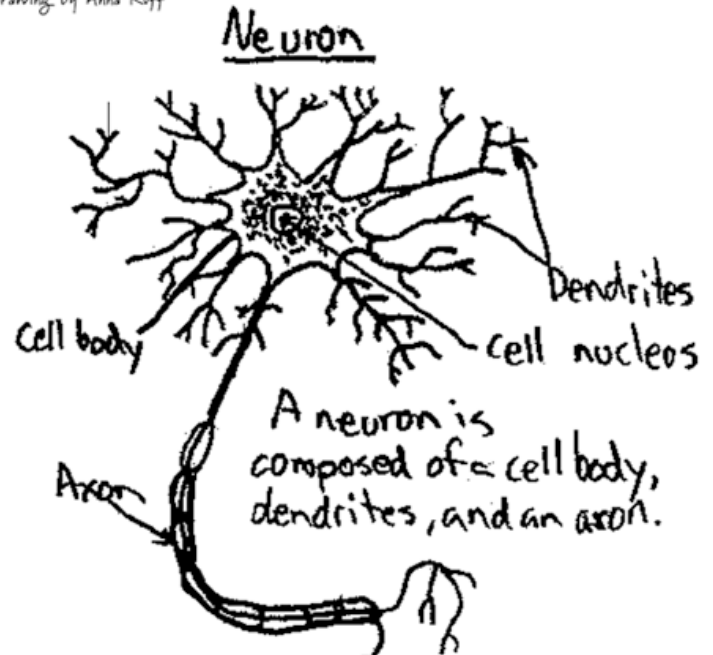
is where emotions step into the picture and play a significant role in the passage of sensory input through the brain. Operating as a climate control center and a mediator of emotions, the limbic system plays a primary role in determining exactly what pieces of incoming sensory stimuli the brain can and will pay attention to. Like the brain stem, no thinking happens here, but in its function as a determiner of what the brain pays attention to, the component parts of the lim-

bic system play a significant role in regulating memory and learning functions. The thalamus serves as a filter of sensory data by regulating emotions; the hippocampus is primarily concerned with memory and providing a meaningful context for our emotions; and the amygdala is concerned with connecting memory and emotion, a process of providing an emotional context for information and memory. Physical body functions which can be impacted by emotions are also regulated here. They include temperature, blood pressure, and blood sugar levels.

### The cerebral cortex

is where thinking happens. The cortex is the wrinkly outer layer of the brain, the “gray matter”. It is divided into two sections, each of which cover one of the two cerebral hemispheres. The left hemisphere controls the muscles on the right side of the body, and the right hemisphere controls the left side of the body. The left hemisphere is primarily concerned with detail, and logical, analytical and sequential functions, while the right hemisphere tends to focus on more creative, ar-

drawing by Anna Ruff



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tistic, whole picture functions. Both hemispheres are connected through the corpus collosum, a thick bundle of neurons that allows for efficient transfer of information from one hemisphere to the other. The hemispheres are further divided into four major areas or lobes: frontal, parietal, occipital and temporal. All four are specialized for certain brain functions such as problem-solving in the frontal lobes, sensory processing in the parietal lobe, visual processing the in occipital lobe, and hearing and language in the temporal lobe. These component parts of the cerebral cortex allow us to put together and comprehend what the senses perceive. This is where conscious thought and active learning take place.

## **The Brain and Service Learning**

*by Sue Bos*

As the last weeks of summer slip away, I find myself thinking more and more about the upcoming school year. It happens every year at this time; physically I'm still on vacation but my mind is on the year ahead. I find myself thinking, imagining and planning what this new class and new year might be like. I think about things we might do, themes we might focus on and activities we might participate in. I imagine what our physical space will look and feel like. I work to plan and shape a year of rich learning experiences for my students.

One of the things I know I want to do this year is to include service learning in a more central way in our class curriculum. The Vermont State Standards and our local district curriculum framework both recognize the value of service learning experiences and have included service learning in their guidelines. The elementary school I work in has long been a pioneer in bringing service learning projects into the classroom; and this year my principal has asked that all classroom teachers incorporate service learning in some way in their classrooms. These are all good reasons to include service learning in our work for the year; but the reason that appeals most to me is that service learning is compatible with the ways in which the brain learns.

Everything I do in the classroom, I try to do with an awareness of the discoveries neuroscientists are making about the brain and how we learn. It's important to me that what I do in the classroom be informed by what we now know about the brain and how it functions. If I want to do my best job as a teacher, I need to know as much as I can about what my students need to make the best use of their learning potential. Understanding the brain is where it starts.

**Service learning is an important step to take. It is an effective teaching strategy that meshes well with the way the brain works.**

The work of the brain is all about making connections. Information travels through the brain via neural pathways that are formed as individual neurons connect with each other. The ultimate goal is to have as many smooth and efficient neural networks as possible. Building the connections is the key. Service learning experiences offer many opportunities to build and enhance these neural networks. Service learning is all about connecting the learning in the classroom with the real world beyond the walls. Its about helping students see that there is a real and practical use for the things they are learning in school. Students connect the work they are doing now with its potential use in their future lives.

New connections between neurons in the brain are created when we have experiences we have never had before. As the brain strives to make sense of new and unfamiliar experiences, it looks for connections to things it is already familiar with. On a physical level this is accomplished through individual neurons branching out and building new connections with other neurons in the brain. Service learning offers students opportunities to meet new people, see new places and do new things. Participation in service learning projects can expose a student to people, things and ideas that they have had no experience with before. Through these activities students can broaden their horizons and foster the development of new neural connections in their brains.



Practice is essential to the maintenance and enhancement of neural pathways. The more times you do something, the better you get at what you're doing. Practicing helps streamline connections between neurons. This happens because those neural connections are getting physically stronger each time they are used. Service learning activities provide a useful way for students to practice the skills they are learning; it is the ultimate example of hands-on learning. A fifth grader can practice her oral reading skills when she regularly reads with her first grade reading partner. A sixth grade student can practice his computation skills and build on his understanding of numbers as he takes responsibility for the class book order. Students of all ages can fine-tune observation and data collection skills as they document headstones in a community cemetery. Service learning offers new and different ways to practice the skills that need to be learned in school.

The brain is constantly on the alert for new input that has some meaningful connection to information that is already established in the neural network. Experiences that have a meaningful context are more likely to find a secure place to take hold in the brain. Service learning activities are inherently meaningful. Students do things that need to be done. The purpose and meaning in their work is clearly visible; what they are doing is important and real.

Every person's brain shares a common basic structure, but each individual brain is unique. Our students have a combination of skills and talents that they bring to every learning experience, and it is important for us to be aware of what those special talents and skills are. Experiences beyond the classroom open up opportunities for students to demonstrate and share their varied skills and talents. Intelligences that aren't always visible in the more traditional school day, often come to light through engagement in service learning projects. As I discover the intelligences my students have I can use this knowledge to help guide their work and learning. Service learning can be a valuable tool to recognize, demonstrate and celebrate individual student's learning styles.



**We feel good when we do helpful things for other people, and service learning is about helping people.**

All learning has emotion at its core. While the full role of emotions in learning is only beginning to be understood, we do know that students learn best when they are physically and emotionally healthy. These basic needs for survival must be met before higher brain processing can occur. We also know that learning experiences that are associated with positive emotions are more likely to find secure attachments in the neural network. We feel good when we do helpful things for other people, and service learning is about helping people. But, service learning is also about learning. When we are learning while we are helping, we feel those positive emotions, and these feelings help our developing skills find a firm foothold in the brain. Service learning provides a positive emotional framework for learning.

In an ideal world all learning experiences would be connected, meaningful, novel, unique and emotionally pleasing. We know that all these things contribute in important ways to the development of the brain, so we should be shaping everything we do in our classrooms with these conditions in mind. In reality we know that this may not be possible right away, but it makes sense to start taking some steps in this direction. Service learning is an important step to take. It is an effective teaching strategy that meshes well with the way the brain works.

## **A Short List of Brain Research Resources**

*~Making Connections: Teaching and the Human Brain,*

Caine, Geoffrey, and Caine, Renate Nummela, ASCD, Alexandria, VA, 1991

*~Endangered Minds: Why Our Children Don't Think,*

Healy, Jane M., Simon and Schuster, New York, 1990

*~Brain-Based Learning,*

Jensen, Eric, Turning Point Publishing, Del Mar, CA, 1996

*~Inside the Brain: Revolutionary Discoveries of How the Mind Works,*

Kotulak, Ronald, Andrews McMeel Publishing, Kansas City, 1996

*~The Right Mind: Making Sense of the Hemispheres,*

Ornstein, Robert, Harcourt Brace and Co., New York, 1997

*~The Amazing Brain,*

Ornstein, Robert and Thompson, R., Houghton Mifflin, Boston, 1984

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