Connecting Brain Research and Differentiation of Instruction: Implications for Teaching and Learning

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Introduction

Through the advent of current medical technology in brain scanning such as MRI (Magnetic Resonance Imaging) and PET (Position Emission Tomography), scientists in the past decade have been able to examine patterns of thinking, learning, attending and remembering in the human brain. This area of neuroscience studies the formation of cellular development in various brain areas. As a result, this current research has important implications for the field of education and is known as Brain-Based Education. Researchers Renate and Geoffrey Caine have listed twelve principles from brain science that can be linked to educational practices. These principles are:

1. The brain is a complex adaptive system.
2. The brain is a social brain.
3. The search for meaning is innate.
4. The search for meaning occurs through patterning.
5. Emotions are critical for patterning.
6. The brain processes parts and wholes simultaneously.
7. Learning involves both focused attention and peripheral perception.
8. Learning always involves conscious and unconscious processes.
9. We have at least two different types of memory: a spatial memory system and a set of systems for rote learning.
10. We understand and remember best when facts and skills are embedded in natural, spatial memory.
11. We learn best through active involvement.
12. Learning is enhanced by challenge and inhibited by threat. (Caine and Caine, 1994)

Educational application of these principles is evident in the following two examples: Research by Dehaene (1997) found that early mathematical abilities, when tracked by fMRI scanning, can be identified and developed by correlating brain mechanisms with basic numerical skills such as symbol recognition, naming ability and estimation of magnitude. The researcher hypothesized that with the combination of educational psychology and neuroscience, educational programs may be developed that could help children with atypically developed mathematical skills.

A second example of the application of brain research to educational practices was shown by Sousa (1997) who studied basic visual and language processes through the use of fMRI. Using brain scans before and after a particular educational intervention, Sousa was able to see the relationship between brain-based measurement and educational intervention programs that emphasized improvement in reading skills.

Neuropsychologists such as Davis (2001), Kolb (2000), and Wilson (2001) have shown that activity in the prefrontal cortex is where memory, attention and inhibition are altered as a result
of synaptic pruning. Because of this fact, these researchers believe that certain strategies and methods when applied in the classroom can cause significant improvement to these brain functions. It is important to note than an “improvement” in inhibition refers in this instance to the brain’s ability to eliminate distracters when it does not want to pay attention. In the next section, the direct application of this research to the curriculum and instructional program will be discussed.

The Brain Compatible Curriculum
According to educational theorist, Patricia Wolfe, three important levels of learning exist. These are: Concrete Experience, Symbolic Learning and Abstract Learning. Most parents and teachers of young children notice that children construct knowledge from their experiences. From early childhood observations, parents see that children are active learners--that is, they simply do not wait to respond to stimuli, they act upon their environment and explore it with a natural curiosity and wonder.

The prominent child psychologist, Jean Piaget, wrote that all of children’s learning is organized into schemes. These schemes provided ways for children to categorize the things they learned. Since children have different environments in which to learn, each child’s learning will be different and, in like manner, individualized.

To maximize the learning potential of each child, therefore, the learning environment and, in formal schooling- the curriculum- should allow for individual growth and exploration. In other words, to be compatible with what has been learned through brain research, the learning environment and the curriculum should be structured loosely enough to allow the growth process to take place.

Symbolic Learning
A second aspect of brain research deals with Symbolic Learning. In this stage, the child uses symbols to represent real objects. This is the connection of a picture (and later) a word, to represent an object. During the age period of 7-11 years, the child’s vocabulary increases greatly as the number of symbols multiply. An important factor in the multiplication of these symbols is the use of the five senses. As the mind captures sensory data, these data are associated with symbols and the representation of an object is complete.

In this respect, the school curriculum should allow for as much learning through the five senses as possible. If learning is restricted to just one sense (listening) or two senses (listening and seeing), the brain is restricted in its capacity to learn. According to David Sousa, author of How The Brain Learns, “A brain-compatible curriculum framework must be based on the way today’s students learn best. It should offer variety, challenge and choices for students.” (Sousa.1995)

Abstract Learning
Throughout the years of 11-14, the individual enters into Piaget’s formal operations stage. The person is now capable of thinking logically and abstractly and has reached a level where he or she can think much like an adult. This learner may create hypothetical events, imaginary possibilities and abstract propositions and should be able to solve problems containing the need for hypothetical reasoning. Many students at this level actually enjoy the challenge of employing higher order thinking skills of analysis, synthesis and evaluation.
Psychologist, Benjamin Bloom organized a sequence of learning which he called the Taxonomy of Educational Objectives. In this taxonomy, Bloom arranged educational tasks from the lowest to the highest. Lower levels of learning involved acquisition of knowledge and basic comprehension of that knowledge. Next, Bloom called for application (or experiential learning) and then moved to the higher levels of analysis, synthesis and evaluation. It will be noted that these higher order levels of learning called for divergent thinking, individual interpretation and abstract thinking.

Unfortunately, many schools’ curricula focus only on the lower levels of the taxonomy. Since some of the reasons are due to time constraints, the difficulty of assessing the higher levels and increased emphasis on accountability for students’ learning basic material. Due to this type of education, however, the brain’s capacity to expand learning into the abstract realm can be delayed or, in some cases, deterred.

In order to allow the brain to “blossom” into the region of abstract learning, the curriculum must contain opportunities for students to stretch their minds and develop powers of reasoning and higher order thinking. Without these opportunities, a generation of students could be produced who are simply rote learners with no power to think or reason beyond the textbook or the teacher’s lesson.

The Differentiated Curriculum

Most curricula in use at the present time are organized on the time-honored “one size fits all” principle. For decades, educators have assumed that all children have the same needs and learn in the same way. Unfortunately, this is not true. Researchers such as John Dewey, Jean Piaget and Jerome Bruner have shown that children learn in different ways and in different modalities.

With the current emphasis on standards-based education and data-driven instruction in schools, many educators feel compelled to produce high test scores on achievement tests in order to satisfy demands from state officials, school boards and the public in general. While this endeavor has succeeded in many cases, it would appear that learning has taken a back seat to “preparing for the test”.

When this concern arises, a question also surfaces- “Does learning have to be sacrificed in order to achieve high test scores?”. The answer to this question is “No”- but it does carry an important caveat. Learning can be achieved in a high-stakes arena but it takes careful planning and an extended amount of time on the part of the principle and the classroom teacher. This is where the concept of the DIFFERENTIATED CURRICULUM comes into play.

The ordinary curriculum can be transformed into a differentiated curriculum by adding four distinct components- Critical Thinking, Creative Thinking, Project-Based Learning and Interdisciplinary Planning. These aspects will be discussed one at a time:

- **Critical Thinking**- When students learn to analyze information and break it into its constituent elements they are able to gain a deeper understanding of ideas. Contrary to popular beliefs, ALL children are able to think critically if afforded the opportunity. In fact, most children ALREADY think critically in their choice of clothing, music and selection of friends. Classroom teachers and curriculum developers can use this innate ability of students, therefore, in applying it in a school situation. This entails challenging students to think critically about subjects by comparing and contrasting ideas, providing reasoning for their thinking, evaluating ideas and situations and thinking independently. Unfortunately, these
processes must be fostered early in their education before habits of rote learning and memorization retard their critical thinking ability.

- **Creative Thinking**- Creative thinking is what children need to learn in order to become problem solvers and innovators. Creativity is what sets apart those who are book-smart from those who are innovators, inventors and designers. Educators can foster creative thinking by building certain activities into the curriculum and teachers’ daily lessons. These activities enable the student to apply ideas to different contexts, create exciting products, develop stories and personal narratives, to use their imaginations to answer mind-boggling questions and to think of unique ideas and innovative ways to solve problems.

- **Project Based Learning**- Project based learning (PBL) involves students in a model that encourages them to engage in learning activities that are long-term, interdisciplinary, and integrated with real-world issues and practices. The focus is a shift from short, isolated lessons where students have 40 minutes of math instruction followed by 40 minutes of science followed by 40 minutes of reading. In PBL students are using their skills and knowledge in a variety of subject to solve problems and/or to created products. With a project-based curriculum students feel “connected” to what they are doing. They experience a sense of ownership and responsibility. As a summative experience, students are encouraged to share their products with their classmates. This gives the child a sense of accomplishment and pride that far outweighs any worksheet or test.

- **Interdisciplinary Planning**- In current curricula, school subjects are arranged into tightly compressed bodies of knowledge such as math, science, history, language and literature. These subjects are commonly taught in time periods of 30-45 minutes (depending on the grade level) without any relationship to one another. Students, therefore, are left with the task of determining the relationship by themselves. Needless to say, most students fail to do this. Brain research has shown that information in our brains is organized in schematic structures. These structures are made up of connected bits of information and serve as a framework for the knowledge we acquire. When a learner’s knowledge is connected it is much more likely that they will apply the prior knowledge to a wide variety of new situations. They will acquire information in a way that is more accessible and will be better able to relate it to previously acquired knowledge. With interdisciplinary planning, students learn about patterns in math, science, social studies, and even literature. Because of this, they are much more likely to “see” these patterns when they encounter new situations. Since patterns are not only studied in math, they are able to make the connection and gain the understanding that patterns can be found in many areas of their lives.

**Differentiated Instruction**

Unfortunately, the curriculum does not teach itself and it is incumbent on the principal and the classroom teacher to transfer the differentiated curriculum to the classroom. This can be done in three ways. First, by adjusting the content. The content of that is being taught must go beyond the content of the standardized test. While this may seem risky at first, in the long run it will prove beneficial and will increase students’ learning. Secondly, it is necessary to adjust the process of teaching. Teachers must move from drill and practice, from memorization and rote
learning to the development of critical thinking and creativity. This, of course, involves additional time and planning and calls for a different set of skill in the classroom teacher. As mentioned previously, however, increased benefits will follow.

Finally, (and perhaps most difficult) the desired product must be adjusted. Instead of mastering material for the short-term goal of scoring well on a test, the product of teaching must involve long-term goals of life-long learning and application of knowledge in real life challenges.

At first, these suggestions may seem to pose an indomitable task requiring a Herculean effort. This is not necessarily so. Following are eight ways that the classroom teacher can apply the principles of differentiated instruction:

1. Flexible Grouping- In a self-contained classroom, teachers can group students according to their readiness, interests and learning styles. In this way, teachers will be teaching to the students’ strengths and increased learning cannot help but occur.

2. Providing Learning Centers- Instead of compressing learning into separate subjects, various learning centers can be constructed in the classroom that provide integrated learning of interdisciplinary subjects. Another approach may be to have the teacher deign different centers for different subjects and have small groups rotate from center to center.

3. Developing Independent Contracts- These can act as individual agreements between a student and a teacher and serve as a guide for what the students need to learn. In many cases, students, teachers and even parents may choose to sign the contracts.

4. Adjusting Questions- Teachers adjust questions in class and homework assignments based on the individual student’s readiness, interests and learning profile. Teachers may vary questions from a basic understanding to more advanced levels for each student.

5. Thematic Units- For upper grade students, teachers can use units that incorporate information from various disciplines integrated into a broad based theme. This will allow students to connect learning to the real world and see links among disciplines.

6. Compacting- This involves tailoring the curriculum so that students do not have to repeat previously mastered material and are allowed to move on to more challenging activities. Compacting involves analyzing what the student has already learned previously and then building upon that knowledge.

7. Using Independent Study- Students who have mastered content and have a special interest may contract with a teacher for a self-directed project. This activity can also be arranged for small groups with similar interests.

8. Using Tiered Assignments- Tiered assignments are assignments designed at different levels of complexity according to students’ readiness levels. These assignments can also be used to meet the needs of at-risk students.

Quite naturally, the classroom teacher need not employ all of these suggestions. Using several of these techniques in conjunction with the regular instruction will improve learning by working toward the students’ strengths. As teachers well know, students are likely to enjoy learning when they are able to be successful. They are likely to be successful if they are learning in a way that is natural to them.
References


Davis, G., “There Is No four-Object Limit on Attention” Behavioral and Brain Science-2001

Dehaene, Stanislaus-*The Number Sense* - Oxford University Press 1999


Jensen, Eric- *Teaching With the Brain in Mind*-1998 Alexandria, Virginia-Association for Supervision and Curriculum Development

Kolb, B. “Experience and the Developing Brain” Education Canada 2000


Wolfe, Pat, “Applying Brain Research to Educational Practice,” Education Update 2001
Brain Target 1: The Emotional Climate While stress impedes learning, positive emotions contribute to long-term memory. The more intense the arousal of our amygdala, the stronger the informational imprint, which, in turn, enhances recall and learning. Presentation on theme: “Connecting Brain Research with Effective Teaching:” Presentation transcript: 1 Connecting Brain Research with Effective Teaching: The Brain-Targeted Teachingâ“¢ Model Dr. Mariale Hardiman Johns Hopkins University Roland Park Elementary/Middle School. Designing Instruction Objectives, Indirect Instruction, and Differentiation Adapted from required text: Effective Teaching Methods: Research-Based Practice.