YALE NATIONAL INITIATIVE
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Curriculum Units by Fellows of the National Initiative
2009 Volume VI: The Brain in Health and Disease

Mathematics and the Brain: Easy as 1-2-3 Simple Like A-B-C

Curriculum Unit 09.06.03, published September 2009
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Overview

- The goal of learning is not just to acquire knowledge, but to be able
- to use that knowledge in a variety of different settings that students
- see as relevant.
- David A. Sousa

Students are often successful with computational problems, whereas they experience significant difficulty when required to solve and analyze multi-step word problems. Why does this occur? What brain functions are vital for students' successful comprehension of math concepts? What parts of the brain produce student achievement in mathematics? These are essential questions that were researched and evaluated throughout the curriculum unit.

My unit focuses on student process and application of math concepts rather than rote memorization. I want students to acquire the ability to approach math in a system of reflective inquiry. The foundation to achieve this objective is through student exploration of meta-cognition activities to help them critically reflect on their learning. To augment this exploration, this unit incorporates multiple intelligences and brain-based learning theories, because according to research it is imperative that we create classrooms that engage the whole brain. Students will learn strategies to complete a variety of multi-step word problems with concrete information on the brain functions that allow for this success. I believe that when students have an understanding of the brain's relationship to how they learn math, this knowledge should build confidence when they attempt to solve complex problems. Therefore, my goal is to offer students an in-depth explanation of how the brain works in processing mathematical operations.

The unit is intended for fifth through eighth grade students. The length of time required to complete the unit is approximately six-eight weeks. The lessons created for this unit provide students with the competence to explain and illustrate mathematical concepts as opposed to just simple application. The curriculum unit is aligned to the Pennsylvania State Standards for math, science, and literacy.

Rationale

Math is a critical skill that all students need to accomplish; at the minimum, proficiency is required in order to increase their chances of succeeding in our competitive technological/numerical world. A few statistics illustrate this point. In a Public Broadcasting System (PBS) Internet, article: "A deficiency in certain basic math skills is more limiting now than it once was. In 1970, only nine percent of all jobs were considered technical. Today, nearly one-third of all jobs are classified as technical; most require far more computing skills than many jobs of the past." [1] Some careers in math include an electrical engineer, accountant, drafter, actuary, financial analyst, computer software engineer, and others. A final point to emphasize with young people is that math and science are behind the operations of their devices they use everyday: MP3 player, computer, and cell phones, just to name a few. We know these technological tools are fundamental to the average youth's existence.

The research data and my teaching experience have compelled me to implement immediate action to improve student math achievement. For example, reports suggest that if students are deficient in mathematics in their early years they remain deficient in their later years. Moreover, I am distressed by Kathie Nunley's research, which found that lack of student motivation remains one of the major reasons students do not succeed in mathematics, or any other subject. Her research may explain why there are higher numbers of high school dropouts in urban cities across the United States. Startling statistics from PBS highlight the urgent need to improve math instruction. [2] Seventeen-year-olds with math disabilities have, on average, a fifth-grade level of math knowledge. Thirty-five percent of children with learning disabilities drop out of high school. Why is this happening? One reason is that students are bored and they have not found any intrinsic connections to what they are learning and how it impacts or improves their life. What is the solution? Nunley proposes that motivation exists when students identify the relationship between their behavior and the outcome. [3]

Student lack of engagement is one of the contributing factors influencing student achievement. Richard Schaar states a fundamental fact about student intellectual potential that dispels the myth that math is too difficult. What is important about Schaar's comment is that it can be supported with scientific data.

- When children realize that they can master these subjects (math and
- science), and that doing so can dramatically open up future
- possibilities, they become interested and engaged in the learning
- process.
- Richard Schaar

On the other hand, I am encouraged by research about the brain's plasticity, which is the ability of the brain to change through experience and its exceptional ability to learn complex information when necessary. This data confirms my belief that learning opportunities always exist. It is my responsibility to provide students with academic experiences for mathematical success. Furthermore, these results validate my desire to incorporate a math environment that is rich with stimulating and meaningful lessons. My sentiments are supported by Caine and Caine. Their text, Making Connections: Teaching and the Human Brain, emphasizes: brain research establishes and confirms multiple complex and concrete experiences are necessary for meaningful learning and teaching. [4]

Perhaps the most important information gathered during my research on how the brain learns mathematics is

the following theme. The key obstacles preventing students from achieving math success are lack of engagement, relevance, and real world connections. Consequently, I think a strategy to combat this pervasive negative attitude regarding learning is by implementing a holistic approach to education, specifically brain-based learning.

Brain-Based Learning

My unit emphasizes brain-based learning, which correlates with my philosophical views on how children learn. Brain-based learning is defined as a "comprehensive approach to instruction based on how current research in neuroscience suggests our brain learns naturally." [5] As a result, the approach points out the importance of teacher's instruction connecting to student's real life experiences. This type of learning underlines the following concepts: mastery learning; learning styles; multiple intelligences; cooperative learning; practical stimulations; experiential learning; problem-based learning; and movement education. Brain-based learning concepts are defined in appendix A.

Although brain-based learning suggests twelve core principles, five components stood out for me. First, meaning is more important than information. It is crucial to start with the learner's prior knowledge rather than make assumptions. For example, I need to talk with students and analyze the strategy utilized to solve the problem. Second, complex learning is enhanced by challenge and inhibited by stress. I intend to organize math tasks in a clear and concise manner. Such as, I will integrate multiple note taking strategies, give students numerous practice opportunities, and develop effective cooperative groups to enable children to review comprehension. Third, every brain is uniquely organized. Differentiation and learning styles are fundamental to this principle, which implies that for some activities students will require individualized modifications. Fourth, information is stored in multiple areas of the brain and is retrieved through multiple memory and neural pathways. I foresee this principle as the most difficult for students to grasp. I anticipate student access to appropriate Internet websites will clarify student understanding. Fifth, learning involves focused attention and peripheral perception; effective and creative lesson presentations will facilitate this principle. Lesson activities about the anatomy and function of the brain should provide students with a basic understanding. I will convey information in small chunks, allow adequate processing time, practice, and review. Advocates of brain-based learning believe that when a teacher understands the functions of the brain, it enables the teacher to establish efficient learning environments.

Summary

Learning about the anatomy and function of the brain has challenged me to re-examine my instructional practices. Through extensive research, I have obtained detailed background knowledge about how the brain works and the essential skills that are needed for mathematical achievement. I am now prepared to incorporate innovative strategies that will require students to synthesize and construct meaning. Writing this unit has provided me with an opportunity to create interdisciplinary lesson plans that address a variety of learning styles. Ultimately, students will continue to build a strong math foundation, which is an important life skill and a mandated subject for testing on state assessments.

Background

What is a Learning Disability?

Within the classroom, learning disabilities are characterized by a significant difference between a child's achievement and that individual's overall intelligence. Initially, the regular education teacher who has observed a difference in student ability compared to their grade level peers identifies students. Students are then referred to a special education teacher to complete formal cognitive reading and/or math assessments. If a deficit, for example, is identified meaning students score is below their actual grade level, students are referred (with parental consent) to the school psychologist to complete additional testing. Students found to have a learning disability are normally two grade levels below their age appropriate peers.

Scientific research defines a learning disability as a neurological disorder that affects the brain's ability to receive, process, store, and respond to information. These disabilities can make it difficult to acquire certain academic and social skills . [6] "Learning disorders affect about two million children between the ages of six and seventeen, or about one out of every twenty school children. These children have problems learning new information, remembering that information, and knowing how to transfer the information for practical purposes. The three main types of learning disorders are reading, mathematics, and writing." [7]

Anatomy and Function of the Brain

A recurring idea that is mentioned by neuroscientists is that the human brain is a complex and amazing structure. As a result, research in this area continues to expand, including as it relates to how the brain learns math. In the past, reading was given greater research effort, due to societal emphasis on reading comprehension. Nevertheless, over the past two decades, math brain research has made significant findings.

The brain is approximately three pounds and is divided into three main parts. They are known as the cerebrum, cerebellum, and the brain stem. Each part serves a different function. The cerebrum made of two distinct hemispheres makes decisions that require conscious thought, sensation, and voluntary movement. The cerebellum controls balance and coordination. The brain stem involves involuntary actions such as breathing and heartbeat. However, for this unit, the focal point is on the four major lobes and the limbic area.

The cerebral cortex or the exterior part of the brain is divided into four sections known as lobes: frontal, temporal, occipital, and parietal lobe. The frontal lobe is important for planning and thinking. Most of working memory is located in the frontal lobe. Broca's area in the left frontal lobe processes our language vocabulary, including number words.

David Sousa mentions that the frontal lobe matures slowly and usually it is not fully developed until the age of 24. This information helps to explain why adolescents engage in impulsive emotional responses. The temporal lobe is responsible for sound, music, face, object recognition, and some parts of long-term memory. The occipital lobe is almost exclusively for visual processing. The parietal lobe deals mainly with spatial orientation, calculation, and certain types of recognition.

Buried within the cerebrum is an interior part of the brain that is important for our math study: the limbic area. It consists of four sections that are essential for memory and learning. Section one the thalamus, which is responsible for all incoming sensor information, except for smell. Initially, sensory information travels to the

thalamus and then goes to other parts of the brain for processing. Section two is the hypothalamus, which maintains the equilibrium within the body. This part of the brain impacts our students because if the hypothalamus is out of balance, then it becomes difficult for them to concentrate on academic processing. Section three is the hippocampus, which according to Sousa plays a major role in consolidating learning and in converting information from working memory via electrical signals to the long-term storage regions. The process may take days to months and is essential for the creation of meaning. Section four is the amygdala, which impacts emotions, particularly fear.

Learning and Memory

According to Sousa, "learning is the process by which we acquire knowledge; memory is the process by which we retain it." [8] This comment represents one of the fundamental purposes of my unit. I believe that my learners have the cognitive ability to learn new concepts and retain them. So, I will provide them with the tools and strategies to bring these ideas to fruition. My first step is to acknowledge that learning and retention occurs differently in individuals. When students learn they use the brain and the environment. The interaction of the two, facilitate learners to acquire information and skills. Conversely, retention requires the learner to do several things. During instruction, the student needs to maintain focus. Because students with learning disabilities often have some form of attention deficit disorder, it is difficult for them to remain focused for extended periods. Simultaneously, they need to build conceptual frameworks that have sense and meaning. Eventually, the goal is for student learning to consolidate into long-term memory.

Have you ever taught a new skill and students appear fully engaged? Then, to discover a week later, they do not remember basic information. Many students lack the capability to retrieve information, which Sousa defines as "rehearsal a critical component in the transference of information from working memory to long-term storage." [9] He mentions that the brain's decision to retain learning seems to be based on two criteria: sense and meaning. Does the student understand what they have learned and does the student gain a personal connection? Sousa further states that sense and meaning requires repetitive occurrences and time for authentic learning to occur.

Sousa expounds on two types of rehearsal: rote and elaborative. Rote rehearsal is used when learners need to remember and store information exactly into working memory. [10] It is a basic and commonly used strategy practiced by students with learning challenges. Elaborative rehearsal is used when it is unnecessary to store information exactly as learned, and when it is important to associate new learning with prior learning to detect relationships. [11] This is a complex thinking process that requires students to review the information, make connections to prior knowledge, and to make meaning. Rarely do special education learners implement elaborative rehearsal. For example, students would use rote rehearsal to memorize multiplication facts, but elaborative rehearsal to multiple fractions. Consequently, students with learning disabilities need more time and guidance than others to rehearse the new learning in order to determine sense and recognize meaning.

To improve my instructional practices and enhance student learning, a deliberate concentration on meaning is necessary. An eye-opening revelation is Sousa's comment that experimental and anecdotal evidence reveals that mathematical content does not have meaning for students. [12] Meaning becomes an essential element because if the content being taught has meaning and makes sense then retention occurs. Therefore, I want to maintain my current classroom environment where students are encouraged to reflect upon their learning and ask questions when they do not understand a concept. A simple statement "I do not get this" is an indicator that students have not made sense of the learning and/or they do not feel that the learning is relevant. We cannot deny the importance of meaning when brain scans show dramatically increased cerebral activity when

new learning makes sense and is connected to prior experience, whereby improved retention follows. More often than not, without meaning students blindly memorize procedures without understanding how and why they work.

Previously neuroscientists believed that humans had two major memories: short-term and long-term memory. Current research has uncovered that we have two temporary memories and one long-term memory. Immediate memory stores information for seconds whereas working memory stores information from minutes to days. Long-term memory stores information for years. The two major types of long-term memory are declarative (conscious or explicit) and nondeclarative (implicit) memory. Declarative memory has two components: episodic involves autobiographical information; and semantic involves words, facts, objects, and faces. It is also important to mention that declarative memory improves when combined with elaborative rehearsal. Nondeclarative memory has three components, which are procedural (meaning rote motor and cognitive skills), conditioning, and nonassociative learning. Why is having accessibility to this information imperative for teachers? Because the more emphasis that teachers place on declarative processes involving understanding and meaning, the more likely children will succeed and actually enjoy math. A declarative-based approach encourages reflective inquiry and allows opportunities for students to become creative decision makers on how to solve problems.

Why Do Students Have Learning Disabilities?

Until recently, science could tell us little about the causes of learning disorders and even less about ways to address them successfully. Recent research and brain studies, including the development of imaging and other technologies, have enabled neuroscientists to look inside the live brain and gain new knowledge about its structure and functions. One type of research on learning disorders compares the functions of brains without deficits to the functions of brains with deficits. The latest research has shown that learning disabilities do not stem from a single cause but from difficulties in bringing together different regions of the brain. [13] Currently, the general consensus among researchers is that most genes associated with common learning disabilities, such as language impairment, reading problems, and mathematics, are not specific ones. As a result, no one strategy, technique, or intervention can address all student needs. Some additional factors that affect brain development are genetic links, tobacco, alcohol, and other drugs, problems during pregnancy or delivery, and toxins or stress in the child's environment.

Neil Sturomski mentions several reasons why students have learning disabilities. [14] First, students are overwhelmed, disorganized, and frustrated in new learning situations. Second, due to prior unsuccessful attempts, they have given up and developed low self-esteem and low expectations for achievement of the stated goals. Third, persistent apathy about learning happens because they have not made the connection to the importance of academic success. Unfortunately, I have observed these behaviors in my classroom.

Student inability to make the distinction between rote and elaborative rehearsal has severely impacted their achievement. Compound cognitive challenges with unrealistic school district's expectations that students' with math deficits are required to master new and multiple concepts based upon an aggressive pacing schedule. The result in the classroom, according to Sousa, is that students resort more frequently to rote rehearsal for nearly all processing. They are able to memorize facts but are unable to transfer the information to solve problems. "Consequently, they fail to make the association or discover the relationships that only elaborative rehearsal can provide." [15] Consistently they are unable to answer higher-order questions that require them to apply prior knowledge to new learning, especially when the problem has several solutions.

Nevertheless, Sousa's idea about future research makes me optimistic. "As we gain a greater understanding of the human brain, we may discover that some students designated as 'learning disabled' may be merely schooling disabled." [16] And as he suggests, "just changing our instructional approach may be enough to move students to the ranks of successful learners." [17] But, a more comprehensive approach to address disability challenges will require a collective effort among neuroscientists, psychologists, computer experts, parents, and teachers.

How Do We Learn Math?

Research in cognitive neuroscience has elaborated a timeline of how number structures develop in the brain of children from ages three through eleven. This research allows for some generalizations. Sharon Griffin and her colleagues learned that significant reorganization occurs around age five and that changes in cognitive structures occur every two years through the age of ten. [18] The findings indicate that sixty percent of children develop appropriately and twenty percent will develop below or above the norm.

A primary skill that is critical for students to attain is number sense. Russell Gersten and his colleagues define number sense as the ability to recognize that an object has been added or removed from a collection. [19] They go on to compare the early acquisition of number sense, understanding basic arithmetic, correlates to phonemic awareness, which is a prerequisite to learning phonics and becoming a successful reader. Usually, children whose number sense is not developed typically encounter future math challenges. "Number sense, then, can be considered the innate beginnings of mathematical intelligence." [20] Also, some evidence indicates that when a person is performing basic arithmetic, the greatest brain activity occurs in the left parietal lobe and in the region of the motor cortex that controls the fingers. [21] This may explain why younger children automatically use their fingers for counting. It is crucial to note the brain processes numerical symbols and number words in different locations. Sousa reveals, "the human brain comprehends numerals as quantities, not as words. This reflex action is deeply rooted in our brains and results in an immediate attribution of meaning to numbers." [22]

The natural progression after mastering number sense is learning to calculate. Due to our genes, the human brain has serious problems with calculations. Part of the problem might be attributed to how the brain translates and tries to find mental representations for large numbers.

As a rule, multiplication is the next skill because students need to manipulate large numbers. Imaging studies show that the brain recruits more neural networks during multiplication than during subtraction. The difficulties could be due to associative memory, pattern recognition, and language. Thus, it makes sense that students with learning disabilities encounter challenges.

Learning for preadolescent ages six through twelve is heavily dependent upon maturity. Previously, it was believed that this age group had a learning pause, but new research shows they can solve more difficult problems, since the gray matter in the brain continues to increase. The gray matter in the brain is responsible for sensory perception, such as seeing and hearing, muscle control, speech, numerosity, and emotions. At puberty the brain is nearly at its full adult size. For that reason, by sixth grade these students have the ability to incorporate sophisticated math strategies. An area that matures later, and impacts student proficiency to use multiple approaches to problems, is the frontal lobe.

Adolescents, between the ages of thirteen through seventeen, are unique in their ability to successfully engage in answering additional complex and abstract problems. Scientists have discovered this new

information about brain growth from imaging studies using Functional Magnetic Resonance Imaging (fMRIs), which is a major source of the study. Researchers found that adolescents used more of their prefrontal cortex than adults. As mentioned above, the prefrontal cortex, which is part of the frontal region of the brain, is not fully developed until approximately around the age of 24. Student concentration in this area has the potential to present trouble given that their response to problem solving can be emotional rather than rational. As the temporal lobes mature, adolescents improve in their visual and language processing skills. Another difficulty for adolescents is that their working memory matures slowly. Adolescents can have difficulty working with problems that have more variables and/or components than working memory's limited capacity can handle. Essentially, teachers need to remember that the adolescent brain is developing at various stages with a maximum of information that it can process at once. Therefore, teachers need to uncover diverse and meaningful applications of mathematical operations or concepts to maintain interest and attention.

Additionally, the way math is taught in schools is not directly correlated to how the brain processes numerical information. As students transition from elementary to the middle grades, the content is abstract and comprehension problems persist. Sousa mentions that children encounter a shift from primary grades when they move from an intuitive understanding of math to rote learning, as a result meaning is lost. [23] In summary, Sousa assertions that mathematical competence involves a blend of skills, knowledge, procedures, understanding, reasoning, and application makes sense and correlates to my actual classroom experience.

Student Environment Today Versus Yesterday

My conversations with colleagues suggest that children today learn differently from children from the 1960's, 1970's and even the 1980's. I found reading about today's student enlightening; it is one of the factors that has motivated me to include student-focused strategies in my unit. Hopefully, this brief comparative list will shed some light on the reason for these differences in how students learn.

Due to the advent of technology in almost every aspect of our daily life, teachers in the classroom encounter students who are technological and media literate. As a result, young people's brains are different from people that were born prior to the 1990's. Sousa asserts that part of our success as a species can be attributed to the brain's persistent interest in novelty; that is, changes occurring in the environment. [24] Sousa presents key points to document a comparative analysis of the environment of the past versus the environment of today. Accordingly, schools and teachers need to expedite changes that reflect what and how we teach to accommodate our changing students. This change is necessary because many students think schools are boring. These learners are consumed with spending excessive amounts of time with friends and/or engaging with some form of technology. In view of that, too many students are entering college and/or the workforce unprepared. Listed below are a few highlights: [25]

Environment of the Past:

- The home was quieter.
- Parents and children did a lot of talking and reading.
- School was an interesting place because it had television, films, field trips, and guest speakers. There were few other distractions, so school was an important influence in a child's life and the primary source of information.

Environment of Today:

- Family units are not as stable as they once were.

- Individuals are surrounded by media: cell phones, televisions, movies, computers, video games, e-mail, and the Internet. Teens spend nearly 17 hours a week on the Internet and nearly 14 hours a week watching television.
- Many 10 to 18 year olds can now watch television and play with other technology in their own bedrooms, leading to sleep deprivation.
- The multimedia environment divides their attention.
- Young brains have responded to the technology by changing their functioning and organization to accommodate the large amount of stimulation occurring in the environment.
- Their diet contains increasing amounts of substances that can affect brain and body functions.

Objectives

The overall objective is to offer students information on how the brain works, and its impact on the types of learning activities that are most effective to strengthen problem-solving skills and building mastery. I want students to become critical about their learning and confident in their attempts to solve complex word problems. Above all, by using the technique of writing in math, they will acquire meta-cognition skills to help them understand how to clearly communicate their mathematical thinking. Student writing will include a math journal and a detailed problem solving explanation incorporating numbers and words. They will become aware of their dominant learning style. They will learn how to select the appropriate strategy to solve problems. As a result, this curriculum unit will serve as an integrated unit that includes activities connected to the content areas of literacy, math, and science. I will collaborate with the science teacher for implementation of applicable activities. Students will have numerous practice opportunities to expand analytical skills, improve math comprehension, enhance written expression, and connect math to real life experiences.

Cook-Wissahickon Elementary School is an urban public school that features a small learning environment. I teach a part-time learning support class for grades fifth through eighth, which incorporates all content subjects. These classes are organized into five 50 minutes periods per day. This math block will enable me to incorporate the unit over the course of six to eight weeks, which is equivalent to one grading period. Therefore, the unit will be taught primarily during my math block. It will extend across the content areas to achieve the goals and objectives.

I want to teach lessons that have students utilize meta-cognitive skills. I will incorporate hands-on interactive lessons to reach the various categories of learners that Howard Gardner describes in his book Frames of Mind: The Theory of Multiple Intelligences such as visual, auditory, and kinesthetic/tactile. [26] The unit incorporates a range of learning styles and abilities, which is an educational approach that was developed by Howard Gardner. Students arrive in the classroom with numerous strengths and deficits; educators are encouraged to incorporate differentiated instruction as part of the routine learning environment.

- Teachers can facilitate a lifetime of successful learning by
- equipping students with a repertoire of strategies and tools for
- learning.
- David A. Sousa

Math Journal

Writing in mathematics will be an integral strategy that I will implement in the classroom. Popular researchers' such as the National Council of Teachers of Mathematics (NCTM) and others have stated the benefits of utilizing writing to improve student comprehension. According to NCTM "writing in mathematics can also help students consolidate their thinking because it requires them to reflect on their work and clarify their thoughts about the ideas developed in the lesson." [27] Student will implement writing in mathematics applying two formats.

First, to get student acclimated to the idea of writing, I will utilize "mathography prompts," which is an autobiography of their history with mathematics. Examples of the prompts include the following: When you were in first, second, or third grade what did you like about math? What didn't you like? Draw a picture of all you know about mathematics. What year in school was math the best for you? What made it a good year in terms of math? [28] Student responses will provide me with background knowledge to assist me in planning future lessons and responses are an indicator of student learning styles.

Second, I decided to use "Read, Imagine, Decide, Do" (RIDD), a four-step process to analyze word problems. RIDD was created by Fay Balch Jackson in 1997 for students who have difficulties in both reading and mathematics. Since the majority of my student population has disorders in both subjects, I believe this strategy is ideal. In addition, the steps are simple and with perfect practice they should be easy to remember and understand. Step 1: Read the problem from beginning to end to ensure that students focus on the entire task. Step 2: Imagining the problem requires students to create a mental picture of what they have read. "Using imagery when learning new material activates more brain regions and transforms the learning into meaningful, visual, auditory, kinesthetic images of information." [29] Step 3: Decide what to do. Students need to decide upon the operation that is required. Step 4: Do the work. Students solve the word problem. Students provide a written response for steps 2 through 4 to document the process they utilized to solve the problem.

Cognitive Closure

Because my unit places a significant emphasis on meaning, a cognitive closure activity to help students focus on what was learned and whether it made sense and had meaning is valuable. Students will keep a journal and document their responses when new learning is presented at the end of the school day. They will be required to answer the following questions: [30] What did you learn today? How does what we learned today connect or add to something we already have learned? How can what we learned today help us in the future? I predict this writing assignment should take approximately five to ten minutes. As this journal is maintained throughout the school year, students will have a record of their progress and a tool to use for reflective inquiry.

Cooperative Groups

Establishing cooperative groups as part of this unit will offer positive outcomes for my students. Cooperative Groups will provide a learning environment where students can help, assist, encourage, and support each other's efforts to learn. Student will engage in cooperative groups during a jigsaw activity and a walking tour. In the case of the jigsaw activity each group will be assigned a math problem based on their ability. This is one of the many opportunities when I will incorporate differentiated instruction. After completion of the problem, each group will assign a classmate to present results using RIDD. Next, the walking tour allows students to work in small groups. I will use this strategy as a review. Questions related to the skills discussed are written

on chart paper around the classroom. Each group is given a few minutes to write their responses. When the signal is given, the groups move to the next chart. At the end of the activity, the group assigns a classmate to present their responses.

Graphic Organizers

A picture is worth a thousand words. Graphic organizers illustrate the concepts and it helps students to read and understand difficult text. Consistently I use graphic organizers to enhance my lessons. Graphic organizers provide multiple benefits. First, it helps them focus on specific math skills as opposed to becoming overwhelmed with a multitude of expectations. Second, it allows them to work in shorter chunks. Third, it allows time to digest new or difficult ideas. Fourth, it is a visual tool for improving understanding, meaning, and retention. The graphic organizers applicable to this unit are word problem maps, charts, diagrams, and graphs.

Technology

Using technology in the classroom will appeal to my visual, auditory, kinesthetic, and tactile learners. "Research studies show that, particularly in middle-grade mathematics, technology can have positive effects on students' attitudes toward learning, on their confidence in their mathematics, and on their motivation and time on task." [31] Students will use math software, graphing calculators, and the Internet. For instance, students will access websites such as "Neuroscience for Kids" to view diagrams of the brain and read factual data. This will give students the opportunity to view an animated explanation of this complex structure, which will bring alive the intricacies of the human brain. In addition, they will integrate Microsoft Word and PowerPoint to complete class assignments and projects. A project may include students researching a mathematician to analyze how this person contribution impacts our lives today. The mode of presentation will require students to develop a PowerPoint slide show.

Choice Boards

Providing special education students with options is essential. Choice boards are one way to differentiate. Presently, we use this strategy in our school and it has been successful. Students are required to complete one assignment out of approximately four choices. Nunly's method improves on my previous implementation of the strategy. Nunly refers to this strategy "as 'three steps to layering the curriculum', which is a simple way to differentiate instruction, encourage higher-order thinking, prepare students for adult-world decision making, and hold them accountable for learning." [32] What I like is that all students are expected to complete each layer of an assignment. They may not demonstrate advance competency at the highest level, however all learners are required to attempt each level. There are three levels beginning with level C that is the lowest on the continuum progressing to level A, the highest. Nunly's technique is comprehensive and forces students to scaffold their learning.

Assessments

To provide students with numerous opportunities for success, student overall assessment will be based on a portfolio collection of the above assignments and completion of lesson plans activities that follow. In addition, students will be assessed on what Sousa states as "level of learning mastery." Cognitive research findings promote that students should transition through six levels of mastery to truly learn and retain mathematical concepts. [33] Typically, my students have extreme difficulty following directions based on countless reasons. Therefore, to help them remain focused they will consistently need to refer to a checklist to ensure adherence.

Levels of learning mastery are included in the appendix C.

Classroom Activities/Lesson Plans

Presented here are 3 sample lesson plans to be used in this unit. Teachers can use the ideas for a single lesson or plan the entire integrated unit based upon the objectives and strategies aforementioned.

Lesson 1: What's In A Brain?

Objectives: Students will learn a few basic facts about the anatomy of the human brain. Students will become familiar with vocabulary to describe the brain.

Materials: Internet access, modeling clay or jello brain mold, CD player, photographs, and brain diagram.

Procedures:

Critical Thinking Question: Why is your brain important for learning?

Teacher introduces the lesson by having five-work stations set-up around the classroom.

Students in groups of three will be required to spend three-five minutes at each station to complete a task.

Station One: Students put together a simple puzzle (kinesthetic/tactile).

Station Two: Individually, students complete one-step addition, subtraction, and multiplication problems. The worksheet will have numerous problems and students complete as many as they can within three-five minutes (mathematical/logical).

Station Three: Students examine approximately ten photographs of various themes, such as food, nature, and famous musicians. Students select their favorite photograph (visual).

Station Four: Students listen to a musical selection (auditory). They complete a teacher created checklist to rate their opinion about the song. For example, do you like, dislike, or somewhat like the song?

Station Five: Students smell four scents that have been stored in film containers. The containers are numbered one through four. Teacher provides a checklist that has correct and incorrect scents listed. Students try to guess the correct scent.

Teacher will brainstorm with students after all the groups have participated in every station by asking a series of reflection questions. Finally, students are asked why and how they were able to complete the tasks. Students will provide various responses. Teacher will direct them to the fact that different parts of the brain were involved and responsible for their actions.

Teacher will begin to focus on the brain by revealing the title: What's In a Brain? Teacher will assess student prior knowledge by completing a modified word splash. In a word splash all the key words related to the topic are written on the chalkboard or chart paper. Students will predict how each term relates to the brain. Also,

the teacher will have a blank diagram of the brain posted to stimulate students' prior knowledge about the terms. The terms for our study are cerebrum, cerebellum, brain stem, frontal, temporal, occipital, and parietal lobe.

Teacher will provide students with a diagram of the brain and give a brief definition of the three parts of the brain. Teacher will emphasize that the brain is a complex and intricate structure and everyday neurologist are learning new things about how it works.

Teacher will have students create brain models using either molding clay or jello brain mold. Students will label the parts of the brain and write the definition. In subsequent lessons, the teacher will refer to the brain models and specifically reference the parts of the brain that are responsible for learning math.

Students answer the critical thinking question in their journal.

Extension Activities: Students can complete a jigsaw activity. The purpose is to become an expert in your assigned section. Every student will be assigned one part of the brain to complete further research. Students will complete a PowerPoint that defines the brain section and an example describing how they use the section in their daily life.

Lesson 2: The Write Stuff

Objectives: Students will discuss, describe, read, and write about whole numbers, decimals, fractions, and percents that are related to sports. Students will review different ways of how numbers are used in their daily life. Students will improve math written communication skills.

Materials: Sports numbers activity sheet [34] and Internet access.

Procedures:

Critical Thinking Question: How do sport statistics clarify an athlete's status?

Teacher starts the lesson by asking students how numbers are used in sports. Student ideas are recorded on chart paper or chalkboard.

Teacher distributes a copy of the Sports Number activity sheet to each student. This sheet has four sport scenes (basketball, indoor track, swimming, and board games) with whole number, decimals, fractions, and percents noted. For example, the basketball sports scene has a scoreboard with the home and visitor score. Also, the attendance number is recorded in the corner. See: http://illuminations.nctm.org.

Individually, students examine the scenes and find examples of how the numbers are used. Students write about the different ways that the numbers are used for each scene. For instance, the indoor track picture has the length of races, runners' times, weights of object thrown, and lengths of objects thrown.

Students pair up with a partner and compare their responses to the four pictures.

Teacher brings the whole class together and asks students to share the numbers identified in the pictures.

Students select one number from one of the four pictures and write a detailed description in complete sentences of how that number is used. Also, students critique how the number is meaningful for the applicable

sport.

Students answer the critical thinking question in their journal. Also, at the end of this lesson, students will complete the cognitive closure strategy.

Extension Activities: Student can research the Internet to obtain local and world records for selected sports events, for example local and world records for the 100-meter race. Students write a short report about their research data.

Note: Lesson #2 was obtained from: http://illuminations.nctm.org 7/29/2009. Lesson: Numbers and Language - Sports Numbers (I modified portions of the lesson).

Lesson 3: Is It Hot or Not?

Objectives: Students will solve a real-word problem and make an analysis by conducting a survey to determine the radio station that plays the best music. Students will improve their reasoning and critical thinking skills.

Materials: Student created survey list.

Procedures:

Critical Thinking Question: What major factors determined how many teenagers listened to a particular radio station?

Teacher starts the lesson by asking students what are the most popular/favorite radio stations. Student ideas are recorded on chart paper or chalkboard.

Teacher informs students that they will conduct a survey of 6 th - 8 th grade students to obtain data on the radio stations that students in their school listen to most frequently.

Teacher separates students into cooperative groups to develop a list of questions that can be used in the survey. Students will be advised to create general questions that can be easily answered by the majority of the students. Also, as groups begin to construct their questions, teacher will point out that questions should be worded so that quantitative data can be obtained, analyzed and used to make recommendations.

Teacher will specify the number of surveys students are to conduct. It is essential that the sample is large enough to provide the amount of data needed to make a conclusion.

Students collect the data and then work in cooperative groups (comprised of a data organizer, graphic constructor, checker, and reporter) to complete the tasks of recording, organizing and displaying the data.

Students analyze the results and state the top three reasons why a radio station is popular. Students will present graphs and charts to document the results.

Extension Activities: Students write a letter to the radio stations and share the results of why students choose to listen to a specific station. The letter includes the survey questions and the data results.

Annotated Bibliography- Teacher Resources

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was extremely clear and concise. I recommend this book to all teachers. It is a resource guide that I will consistently use to improve my pedagogy. The bibliography was extensive and references numerous experts in the field of education. I am definitely a better teacher because of the new knowledge that I have studied.

Sousa, David A. How the Special Needs Brain Learns. California: Sage Publications, 2007. It was an excellent resource. The information was extremely clear and concise. I recommend this book to all teachers. It is a resource guide that I will consistently use to improve my pedagogy. The bibliography was extensive and references numerous experts in the field of education. I am definitely a better teacher because of the new knowledge that I have studied.

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Appendix A: Brain-based Learning Definitions

— Mastery Learning- The goal of mastery learning approaches is to have all students learn instructional material at roughly equivalent, high levels.

— Learning Styles- Are different approaches or ways of learning. There are four major learning styles: visual (learn through seeing); auditory (learn through listening); and tactile/kinesthetic (learn through moving, doing, touching).

— Multiple Intelligences- Developed by Howard Gardner, there are seven different ways to demonstrate intellectual ability: visual/spatial, verbal linguistic, logical/mathematical, bodily/kinesthetic, musical/rhythmic, interpersonal, and intrapersonal.

— Cooperative Learning- Is the instructional use of small groups so that students work together to maximize their own and each other's learning.

— Practical Stimulations- The use of various methods to stimulation student learning, for example talking to expand student vocabulary.

— Experiential Learning- Experiential education is a philosophy and methodology in which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills, and clarify values. From the AEE (Association for Experiential Education) Website: http://www.aee.org/ndef.html.

— Problem-based learning- Problem-based learning is student centered approach that challenges them to learn through engagement in a real problem.

— Movement Education- Students learn through moving around, which activates regions of the brain.

Appendix B: Pennsylvania 5 th -8 th grade literacy, math, and science standards met by this unit.

Standard 1.2 Reading Critically in all Content Areas

1.1A Read and understand essential content of informational texts and documents in all academic areas.

Standard 1.5: Types of Writing

1.4B Write multi-paragraph informational pieces (e.g. reports, instructions, interviews)

Standard 1.5: Quality of Writing

1.5A Write with a sharp, distinct focus.

Standard 2.4: Mathematical Reasoning and Connections

2.4D Construct, use and explain algorithmic procedures for computing and estimation with whole number, fractions, decimals, and integers.

Standard 2.5: Math Problem Solving and Communications

2.5A Invent, select, use and justify the appropriate methods, materials and strategies to solve problems.

2.5B Verify and interpret results using precise mathematical language, notation and representations, including numerical tables and equations, simple algebraic equations and formulas, charts, graphs, and diagrams.

Standard 3.2.7: Inquiry and Design

3.2.7A Explain and apply scientific and technological knowledge.

3.2.7C Identify and use the elements of scientific inquiry to solve problems.

Appendix C: Levels of Learning Mastery

Level One: Connects new knowledge to existing knowledge and experiences

Level Two: Searches for concrete material to construct a model or show a manifestation of the concept.

Level Three: Illustrates the concept by drawing a diagram to connect the concrete example to a symbolic picture or representation.

Level Four: Translates the concept into mathematical notation using number symbols, operational signs, formulas, and equations.

Level Five: Applies the concept correctly to real-world situations, projects, and story problems.

Level Six: Can teach the concept successfully to others, or can communicate it on a test.

Notes

- [1] Basic of Mathematics, http://www.pbs.org/wgbh/misunderstoodminds/mathbasics.html, 7/6/2009.
- [2] Difficulties with Mathematics, http://www.pbs.org/wgbh/misunderstoodminds/mathbasics.html, 7/6/2009.
- [3] Sousa, 143 How the Brain Learns Mathematics (HBLM)
- [4] Reneate Nummela Caine & Geoffrey Caine
- [5] Andrea Spears and Leslie Wilson
- [6] National Center For Learning Disabilities http://www.ncld.org/ld-basics, 7/6/2009.
- [7] Learning Disorders, http://www.faqs.org/health/Sick-V3/Learning-Disorders.html, 7/7/2009.
- [8] Sousa, 13 How the Special Needs Brain Learns (HSNBL)
- [9] Sousa, 13 HSNBL
- [10] Sousa, 14 HSNBL
- [11] Sousa, 14 HSNBL
- [12] Sousa, 54 HBLM
- [13] Sousa, 20 HSNBL
- [14] Sousa, 32 HSBNL
- [15] Sousa, 53 HBLM
- [16] Sousa, 4 HSBNL
- [17] Sousa, 4 HSBNL
- [18] Sousa, 37 HBLM
- [19] Sousa, 26 HBLM
- [20] Sousa, 33 HBLM
- [21] Sousa, 15 HBLM
- [22] Sousa, 24 HBLM
- [23] Sousa, 41 HBLM
- [24] Sousa, 16 HSNBL
- [25] Sousa, 16 HSNBL
- [26] Howard Gardner
- [27] Sousa, 65 HBLM
- [28] Using Writing in Mathematics http://www2.ups.edu/community/tofu/lev2/journaling/writemath.htm, 7/6/2009.
- [29] Sousa, 193 HBLM
- [30] Sousa, 105 HBLM
- [31] Sousa, 131 HBLM
- [32] Sousa, 144 HBLM
- [33] Sousa, 152 HBLM

- [34] National Council of Teachers Mathematics