

## **The Brain-Based Benefits of Writing for Math and Science Learning (Part 2 of 7)**

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*Former neurologist and teacher Judy Willis MD continues with her 5-part series on how young brains develop neurologically. This post covers the benefits of writing, particularly for logical functions like math and science learning.*

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As science and math are slated for more emphasis in our classrooms, writing should not be sacrificed. Indeed, in the past two decades, neuroscience and cognitive science research have provided increasing evidence that correlates creativity with academic, social, and emotional intelligence. Writing can help the brain to develop the logical functions required for successful math and science learning.

### **Writing to Develop Executive Function**

During the school years, especially from ages 8-18, the most rapid phase of maturation is taking place in the prefrontal cortex. This is a critical time during which the brain is developing the individual's executive functions. These include judgment, critical analysis, induction, deduction, delay of immediate gratification for long-term goals, recognition of relationships (symbolism, conceptualization), prioritizing, risk assessment, organization, creative problem solving. There are also emotional aspects to executive function, including the ability to identify one's emotional state, exert emotional self-control, and reflect about emotional response choices.

When it comes to math and science, writing brings more than literacy and communication advantages. The practice of writing can enhance the brain's intake, processing, retaining, and retrieving of information. Through writing, students can increase their comfort with and success in understanding complex material, unfamiliar concepts, and subject-specific vocabulary. When writing is embedded throughout the curriculum, it promotes the brain's attentive focus to classwork and homework, boosts long-term memory, illuminates patterns, gives the brain time for reflection, and when well-guided, is a source of conceptual development and stimulus of the brain's highest cognition.

## **How the Brain Stores Information**

There is an involuntary information intake filter that determines what sensory input is accepted into the brain. Input must also pass through an emotional filter, the amygdala, where the destination of that information is determined. When stress is high, the intake filter selectively admits information related to perceived threat, virtually ignoring other sensory input. The high stress state also directs the amygdala switching station to conduct information to the lower, reactive brain, where long-term retrievable memories cannot be formed. In addition, the behavioral outputs of the lower brain are limited to fight (act out), flight (self-entertainment sometimes misinterpreted as ADHD), or freeze (zone out).

## **Use Code Names to Reduce Anxiety**

Fear of making mistakes in front of classmates is one of the greatest sources of anxiety for students. This fear impacts learning. With the help of blogs and wikis, a teacher can set up an environment that enables students to post anonymously via a code name that's known only by the teacher. These code names afford individual privacy so students can express themselves without the fear that limits in-class responses and questions.

With these tools, we can introduce a variety of writing activities that reduce the stress that blocks passage through the amygdala to the reflective prefrontal cortex. For instance, students can write descriptive responses to math or science questions, as well as predictions, hypotheses, and questions. Other useful writing exercises include journaling, newspaper editorials to defend a position, and formal research-style formatted reports of student experimentation with data analysis.

These activities provide all students with the opportunity to actively participate in learning, as they receive timely feedback, reflect, revise, and risk making mistakes. In this way, writing can build confidence and reveal gaps in foundational knowledge. Students can share creative insights, and build their capacities to communicate their ideas and defend their opinions.

Through these shared written reflections about content and concepts students have opportunities to express creative hypotheses, alternative perspectives, and concerns about their understanding. Especially with peer anonymity, there is accountability and peer interaction, without the concern about mistakes that is so paralyzing to many students during class time. As students consider and define their opinions, conclusions, and predictions in

writing, their brains construct valuable concept networks. (More on these below.)

When learning is examined through shared writing, students are exposed to multiple approaches to solving problems. This is so important in building the flexibility and open-minded approach to other cultures as the science, math, and technology world is indeed global. Furthermore, students have the chance to communicate using their own words. They build communication skills they will surely use in their collaborations now and in the future science and math communities they will enter.

### **Make Writing Relevant to Help Curb Dropout Rate**

Writing can also reduce the neural processing blockades that result from the stress of boredom -- the most frequent reason high school dropouts give for leaving school. We know that students are engaged when material is personally relevant, and connects to real world issues and problems. And when this happens, there is increased information flow through the attention and emotional filters to the higher processing prefrontal cortex.

Writing can increase both personal relevance and confidence. Personal relevance comes when students can write for creativity and personal expression. Even when the facts of the math or science are not debatable, individual responses to the information are appropriate writing topics. When writing is incorporated in learning and assessment, there is increased opportunity to produce the ideal situation for active, attentive learning with collaboration, revision, and metacognition through personalization, and creativity.

Reminding students of previous successes promotes confidence, as does providing them the opportunity to recognize their own progress over time. One way to help them recognize their progress is through their written assessments: For instance, along with the content you're assessing, you can also have students write their responses to both the learning itself and to recognition of their progress. These can be maintained in computer files or portfolios and reviewed as evidence of successful, incremental progress with student opportunities for metacognition about strategies used for success.

### **What's Going on in There? Writing "Sprouts" Conceptual Brain Networks**

The construction of conceptual memory networks builds the most valuable neural architecture a brain owner can have. These networks serve as "nets"

to catch and hold new input with similar patterns, and "work" when activated for creative transfer -- use of the information learned in one context for application in a new context.

Concept networks are the valuable tools the brain uses in the highest orders of thinking. When the brain seeks to predict the best response, answer, solution to a problem or make a choice, the executive function control networks in the prefrontal cortex send out messages to the memory association areas, such as the hippocampus and memory storing cortex of each hemisphere. These messages activate stored prior knowledge memories that relate to the new situation. The more extensive the brain's collection of memory networks, the more successful it will be in activating the best prior knowledge to predict the best responses, answers, and choices for any new situation. The greater the links and cross-connections among networks of stored information, the greater a person's access to multiple storage centers of background knowledge to use in response to the new problem or opportunity.

### **Writing as Memory Cement and Concept Clue**

Memory bundles, such as Piaget's schema, contain category-related information linked in circuits based on commonalities (such as similar sounds, visual images). These bundles of neurons are linked together because they have been used together repeatedly.

The many varieties of writing can serve to guide the brain to recognize, construct, and extend its patterns. Writing can illuminate sequential procedures that students need to learn in mathematics and science, from factoring an equation to the photosynthetic chemical process. Prior knowledge can be activated to link with new input through writing and drawing mind maps or graphic organizers, and new learning can be added into visible and mental patterns when students write analogies and other comparisons.

The neural activity or mental manipulation that transforms formulas, procedures, graphs, and statistical analyses into words represents the brain's recognition of patterns. When this is also done in writing, the facts, procedures, and observations are processed symbolically in the writing process -- giving the memory another storage modality and truly illuminating the patterns for the brain to follow as it adds new learning to existing concept networks.