

How Neuroscience Informs our Teaching of Elementary Students

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“Neither anguish nor the elation that love or art can bring about are devalued by understanding some of the myriad biological processes that make them what they are. Precisely the opposite should be true: Our sense of wonder should increase before the intricate mechanisms that make such magic possible.”

Antonio Damasio, *Descartes' Error*

Introduction

Neuroscience research is literally re-writing our collective understanding of learning, including reading comprehension (Wolfe, P. & Neville, P., 2004; Sousa, D. 2005). Yet it would be a mistake for educators to simply integrate this research into a model of teaching that still largely emphasizes transmission and memorization. Helping students “learn” from the perspective of the brain leads to an entirely new vision of what that means to have understood text, one that is most readily described as constructivism. Here are some examples:

- Research on neural plasticity (Begley, S., 2007; Doige, N., 2007; Conlan, R., 1999; Diamond, 1988) shows that the brain is extraordinarily malleable and that many areas of the cortex are literally shaped by experience.
- Research on the vast degree of interconnectedness between different regions of the brain, and on the nature of neural networks, indicates that academic learning and comprehension is never separate from emotions, meaning, motivation, past experience, recognition and memory (Fuster, 2003).

- Research on what are called “mirror neurons” (Rizzolatti, G., & Craighero, L., 2004; Iacoboni, M., & Woods, R., Brass, M., et al. 1999) demonstrates that children continuously and largely unconsciously learn from what is modeled by events and others around them.
- Research on emotions and the brain documents that some types of comprehending are inhibited by fear and helplessness (LeDoux, J. E., 1996; Wiedenfled, et. al.,1990), and how the more positive emotions can affect and enhance certain types of learning (Paanksep, J., 1998; Peterson, C. , Maier, S., & Seligman, M.,1996).

We realized how critical this emergent research could be for educators. Yet we also recognized that this information had little chance of getting to teachers and administrators given the focus of their past professional development activities and the intensity of their day to day classroom responsibilities. The goal of this chapter is to begin the process of assisting literacy educators to rewrite the traditional view of reading comprehension instruction in elementary schools. Specifically, this chapter will highlight:

- Basic Learning Principles that impact learning and comprehension.
- A process that helps teachers translate the Principles into practice.
- Documentation of how the process was used in one k-5 school to move teachers to a more constructivist approach to teaching and simultaneously raise test scores.

What’s Out There Today: Established Research and Practice

In 1990 my co-author and I sought to integrate research from neuroscience, perceptual psychology, behaviorism, cognitive psychology, biology and a large number of other fields.

We did this to determine a set of Brain/Mind Learning Principles, which we most recently updated in 2005 (Caine, R. et al., 2005). The Principles we delineated were based on a view of human beings as living systems. They had to meet four basic criteria:

1. *The phenomena described by a Principle should be universal.* A Brain/Mind Learning Principle must therefore be true for all human beings, despite individual genetic variations, unique experiences, and developmental differences.
2. *Research documenting any one specific Principle should be evidenced in and its influence must span more than one field or discipline.* Since a Learning Principle describes a systems property, one would expect it to withstand validation and confirmation by triangulation of research that crosses multiple fields and disciplines.
3. *A Principle should anticipate future research.* It should be expected and anticipated that research will continue to emerge that refines and confirms each brain based learning principle. For example, much of the brain research on the links between emotion and cognition was published after we first formulated our Principles in 1990. That research was added in 2005, thus a Principle is a continuous work in progress, in the sense that new perspectives and ongoing research are constantly shaping and advancing our understanding of each truth a Principle addresses.
4. *The Principle should provide implications for practice.*

By their nature, principles are so general so they cannot be expected to tell educators precisely what to do. However, effective learning principles ought, as a minimum, provide the basis for an effective general framework to guide decisions about teaching and help in the identification and selection of appropriate methods and strategies. Principles illuminate new sparks of *capacities for learning*, which can be translated into further enhancements of comprehension instructional practices.

New Research Since the National Reading Panel: Brain/Mind Learning Principles

Based on our research, meta-analyses and syntheses, we formulated a set of 12 Brain/Mind Learning Principles (Caine and Caine, 1990; 1994; 2005). They do not follow a sequential or hierarchical pattern. We present them here because they hold a primary value for learning in general, and in particular, for literacy educators. Each Principle explains a capacity that all students have for learning language and comprehending text

Principle #1: *All learning engages the physiology.*

One reason so much traditional comprehension teaching involves students sitting in their assigned seats is the belief that the brain is somehow separate from the body and that the body is not very involved in learning. The research on neural plasticity, as well as other research (Diamond, M.C. & Hobson, J., 1998; Capra, F., 1996; Damasio, A. R., 1994; Thelen, E. & Smith, L., 1994), tells us that the body and mind are totally interconnected. Cognitive scientists often refer to this in terms of embodied cognition (See e.g. Lakoff and Johnson, 1999). The brain is a parallel processor in which body, emotions, senses, memory, motivation and action, are deeply interconnected.

Capacity #1: *All students have the capacity to comprehend more effectively when involved in experiences that naturally call on the use of their senses and their bodies.*

Principle #2: *The brain/mind is social.*

Every individual on this planet comes complete with what Gopnik, Meltzoff, & Kuhl (1999) have called the “contact urge.” Social relationships, with an emphasis on belonging, being recognized, listened to, and noticed, all contribute to an optimal state of mind we call relaxed alertness (Azar, B. , 2002; Brothers, 1997; Sternberg, R. & Grigorenko, E.,2001). Recent research on mirror neurons confirms that the social nature of human beings is grounded in biology. The social nature of learning is sometimes described in terms of situated learning (see e.g. Lave et.al.,1991).

Capacity #2: *All students have the capacity to comprehend more effectively when their needs for social interactions and relationship are engaged and honored.*

Principle #3: *The search for meaning is innate.*

The need to make sense of things is characteristic of every human being from infancy to adulthood. It has been called the “explanatory drive” (Gopnik, Meltzoff, & Kuhl, 1999). One aspect of even young students’ search for meaning is illustrated by the way that all people respond to novelty. For example, “in reading a text on one of Christopher Columbus’s voyages, imagine yourself as a rat on the ship. What is your point of view of the voyage?”

Another dimension of the mind’s innate search for meaning has to do with the compelling power of purpose. For example, a girl of about 9 years old recently described what she

understood to be the causes and best treatment for breast cancer. She was extremely articulate. Her interest had been sparked by the fact that her mother had been diagnosed with the disease, prompting her to read as much as she could find on the subject.

Learning that is reducible to memorizing facts that are true-or-false is different from learning that engages actor-centered adaptive decision-making (Goldberg, E., 2001). This kind of decision making is the result of an authentic question generated by the learner, and is one that inevitably requires more complex thinking. It is the search for meaning that organizes actor-centered questions and encourages the use of higher order functions.

Capacity #3: *All students have the capacity to comprehend more effectively when their interests, purposes and ideas are engaged and honored.*

Principle #4: *The search for meaning occurs through patterning.*

Patterning refers to the meaningful organization and categorization of information. People make sense of experience by their mind's drive to find and create patterns and relationships. The brain is designed to perceive and generate patterns and resists having meaningless patterns imposed on it by others. Cognitive scientists have developed a large number of terms in order to describe patterning, terms such as categories, frames, and schemata. All decision making before, during, and after one reads is based on the patterns that a person perceives and the choices that are made about where to focus their attention in a text. Education in reading comprehension should be about increasing the patterns students can use, recognize, and communicate to gain new knowledge and ideas.

Capacity #4: *All students have substantial unused capacities to perceive and create patterns and to link those new patterns to what they already understand.*

Principle #5: *Emotions are critical to patterning.*

Emotions are central to human life. Neuroscience now shows (Pert 1997, Damasio 1999) that emotions are involved in every thought, decision, and response. Powerful learning is enhanced by rich emotional experiences, guided and moderated by higher order functions. In fact, emotion and physical reactions are so much a part of understanding (and comprehending text) that psychologist Eugene Gendlin (1981) describes the link in terms of the phrase “felt meaning.” **Capacity #5:** *All students can comprehend more effectively when appropriate emotions are elicited before, during, and after their experiences with a text.*

Principle #6: *The brain/mind processes parts and wholes simultaneously.*

The brain/mind is designed to make sense of the world. Making sense of experience requires both a big picture and paying attention to the individual parts. The experience of the whole provides a story, a model, or a fascinating example of what can be achieved. Gestalt psychology (Sternberg, 2006) explicitly shows how the mind connects parts to make these wholes. And, some of the most recent brain research is now exploring this relationship between parts and wholes in terms of neural networks – lattices of individual neurons that fire together as one reads (Fuster, 2003).

Capacity #6: *All students can comprehend more effectively when details (specific facts and information) are embedded in wholes that they understand such as a real life event, a meaningful story, or a project that they create or witness.*

Principle #7: *Learning involves both focused attention and peripheral perception.*

Every human being is continuously immersed in a field of stimuli, and constantly selects a part of that field to attend to. Attention is a natural phenomenon guided by interest, novelty, emotion, and meaning, and paying attention is critical. What is less understood is the fact that human beings also learn from the background – the context that is not consciously attended to. This is illustrated by research on implicit memory (Schacter, 1996) as well as mirror neurons (Rizzolatti, G., & Craighero, L., 2004) which shows how children “pick up” behaviors, beliefs, and preferences or dislikes while engaging in life experience. Implicit memories include unconscious memories that influence one’s thinking and behavior without conscious awareness. Mirror neurons enable this kind of unconscious learning, which is activated (affects organization of neurons in the prefrontal cortex) by the actions or modeling by another individual who is significant in the learner’s eyes.

Capacity #7: *All students can comprehend more effectively when their attention is deepened and multiple layers of the context are used to support learning.*

Principle #8: *Learning is both conscious and unconscious.*

Learning involves layers of consciousness. Some learning requires a person to consciously attend to a problem that needs to be solved or analyzed. Some learning at a deeper level requires unconscious incubation in the same way that the creative insights of artists and scientists sometimes occur after the mind has done some conscious processing. Beyond that, really successful comprehenders are also capable of monitoring themselves by means of the

executive functions of their brains (Denkla, 1999) – a central feature of higher order functions – so that they know their own strengths and weaknesses and can take charge of how they process text.

Capacity #8: *All students can comprehend more effectively when given time to reflect on and process those experiences about which they live and read.*

Principle #9: *There are at least two approaches to memory.* Researchers have identified many different memory systems. These tend to be organized into two primary categories – declarative and procedural memories. However, of more value to literacy educator’s view is the separation of memories in a slightly different way. One type of memory is designed to store or archive isolated facts, skills, and procedures read or taught as strategies to comprehend a text. The other type of memory is very dynamic in that it engages multiple mental systems in order to make sense of the reading experience itself as well as the experiences read about. The key distinction that educators need to make and understand is between rote memorization, which is the hallmark of traditional approaches to comprehension teaching, and the dynamic memory that is engaged in everyday experience. Sometimes facts and comprehension procedures or steps in strategies do need to be memorized, but rote learning is different from dynamic memory. Dynamic memory is likely to be engaged naturally as learners sift through the ideas that they recognize in order to make sense in new contexts.

Capacity #9: *All students can comprehend more effectively when immersed in experiences that engage multiple ways to remember.*

Principle #10: *Learning is developmental.*

All human beings develop in several somewhat predictable ways, though rarely in precisely the same way or at exactly the same rate. There are stages in brain development (Bransford et.a., 2000; Sylwester, 2007) for instance, and in the formation of identity, all of which impact reading comprehension. In addition, all learning builds on previous learning. We now know that this additive/cumulative process is accompanied by changes in the physiology (Huttenlocher, 2002) of the brain. This mental alteration is in turn altered by new experiences with text, and the cycle continues throughout life. Unfortunately, the traditional age/grade organization of students does not adequately deal with the realities of their mental development. Performance, not age or grade level, provides a much better foundation for teaching reading.

Capacity #10: *All students can comprehend more effectively if individual differences in maturation, development, and prior learning are taken into consideration.*

Principle #11: *Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and/or fatigue.*

A great deal of research from such disciplines as neuroscience (e.g. LeDoux 1996), creativity theory (Deci & Ryan 1987), stress theory (Sapolsky, 1998; Lazarus, 1999) perceptual psychology, (Combs, 1999) shows that effective mental functioning can be sabotaged by fears associated with helplessness. Thus, both inferential and applied reading comprehension can be sabotaged. One consequence of such frightened negative emotions is that higher order

executive functioning have been hijacked. That is why the optimal state of mind for reading comprehension is relaxed alertness, a combination of low threat and high challenge.

Capacity #11: *All students can comprehend more effectively in a supportive, empowering, and challenging environment.*

Principle #12: *Each brain is uniquely organized.*

The paradox that faces education is that human beings are both similar and different. For example, every human being is an expression of DNA. Yet every individual has a unique genetic blueprint. Everyone has a lifetime of experience, and yet some of the experiences of every person are unique. All of this complexity is compounded by a wide variety of social, ethnic, gender, and economic differences.

Capacity #12: *All students can comprehend more effectively when their unique, individual talents, abilities, and capacities are engaged.*

When used and understood, these Brain/Mind Learning Principles challenge traditional views of learning and teaching. Neuroscience has proven that while direct instruction is important, constructivism is fundamental. In effect, neuroscientists have shown that even young, elementary learners really do make sense of their own reading experience and construct meanings for themselves and in association with others (Wolfe, P. & Neville, P., 2004)

HOW NEUROSCIENTIFIC PRINCIPLES CAN BE INTRODUCED INTO ELEMENTARY SCHOOL COMPREHENSION INSTRUCTION.

When the “No Child Left Behind” law became a reality in 2001, we were faced with an opportunity to test the 12 Brain/Mind Learning Principles in an elementary school. The law emphasized test results on standardized tests as the primary indicator of reading ability. Many teachers and schools felt the pressure to demonstrate almost instant results.

Two administrators at a low performing K-5 school came to us because they were concerned that in an effort to implement district standards, teachers at their school were sacrificing the more complex, constructivist teaching advocated by the *California Standards for the Teaching Profession* (July, 1997). Teachers were opting for direct instruction, focusing extensively on memory of isolated, decontextualized facts and skills through rote practice and rehearsal, or “teaching to the test.” The administrators felt that our work with schools and the Principles, cited in this chapter could help teachers maintain a constructivist focus even as they attempted to raise reading comprehension test scores.

The school

Redwood School in Fontana, California was a low socioeconomic, low performing K-5 elementary school with over 1,000 students (89% Hispanic students). Redwood School operated on a multitrack, year round calendar. The school site was in an industrial environment with a fertilizer factory next door.

As with other schools in California, it was also ranked by the *Academic Performance Index*

(API). The API ranks schools in two ways: statewide and similar schools rankings. The California Department of Education (CDE) takes the SAT9 (Stanford Achievement Test) results for all public schools in California and ranks them from highest to lowest. Then schools are grouped into ten deciles, giving them a performance ranking with ten being the highest and one the lowest. In the past two ranking years, Redwood was in the bottom decile, with a ranking of one. The second measure takes the demographics of each school into consideration and finds similarities between sites in the domains of socioeconomic status, ethnicity, and parent level of education, to name a few. The CDE then re-ranks the schools by comparing the SAT9 results of schools with similar demographics. This ranking is also in deciles with ten being the highest, one the lowest. In 2000/2001 Redwood had a similar schools ranking of one.

Overview of our approach. My coauthor and I developed a small group approach to professional development, working with what we call process learning circles (Caine G., Caine, R. & Crowell, 1999 ; Caine, et al., 2005). I set out to use these circles as the basic method for building a learning community among teachers and some of the administrators.

Within the context of that community, I introduced one Principle and the capacity, a month, as the focal point for professional development. Participants were exposed to the theory, developed practical implications and strategies to try it out in their classrooms, and came back to their process learning circles with feedback (documentation) and to share their reflections.

It was not possible to cover the entire set of 12 Principles in the one year, though it remains our ideal. We dealt with the first 7 Principles, and their corresponding capacities.

The Group Process. At our first meeting, teachers were placed in process learning circles. Each group consisted of 6-7 participants across grade levels (At their request, groups were later changed to reflect grade levels). I also explained and modeled the group process, which has four distinct phases:

1. Ordered Sharing: The purpose is to help participants learn to listen deeply and speak their own truth, and to *optimize the social/emotional conditions for their own learning*. They do this by speaking on an issue, one at a time, without interruption around the circle until everyone is finished.
2. Reflective Study: The purpose of the “reflective study” is to help the participants make sense of new material (in this case a new Brain/Mind Learning Principle). Participants are provided with relevant research and have time to relate to, and dissect, the new material in order to clearly identify essential elements and connect to their own understanding and experience as learners.
3. Implications for Practice: In this phase, participants explore how to translate their new understanding of a principle and capacity into practice. They are given examples and models of things to do, but are encouraged to develop their own.
4. Regrouping: Participants come together as one large group to briefly review the meeting and recall what they thought, felt and remembered, and to clarify what they intend to do to implement the principle.

Additional procedures. After the first extensive introductory meeting, we set up a series of monthly meetings. Tuesdays had been designated minimum school days and students were dismissed around noontime, leaving the teachers the rest of the day to meet in teams and plan together. I met on the first Tuesday each month with all teachers and members of staff who had volunteered to participate. We followed the procedure described above.

Although there were incentives for teachers to attend the workshops and participate in the program, ultimately participation was voluntary. Because the school was year round, almost all teachers missed the introduction to at least one Principle. Several teachers, however, chose to attend these workshops while they were officially off campus.

During the second through fourth Tuesdays of each month, teachers met in process learning circles as well as to conduct other school business. In these groups, teachers also had the opportunity to further discuss the Principle under investigation for that month and to share what they were doing in their classes.

On Tuesday, other than the first one in each month, I again visited the school. I was available for classroom observations in the morning. Discussions and feedback were handled on a sign-up basis in the afternoon.

DOCUMENTING THE IMPACT OF THE PROCESS.

I had made four basic predictions that I wanted to test.

Prediction 1: *There would be a clear movement to learner centered teaching – a critical implication inherent in the Principles - and an aspect of constructivism.*

Constructivist teaching tends to be more complex than direct instruction in the sense that it is more directly student centered. While allowing for direct instruction and a standards-based curriculum, it deviates greatly from more prescriptive teaching.

We had developed an instrument called *The Teacher/Student Responsibility Questionnaire*. The *T/S R Questionnaire* was administered three times during the year. The questionnaire consists of a piece of paper with a line down the middle. On the left hand side, teachers listed what they had to do in order to assure a good teaching day. On the right hand side, teachers listed what students had to do in order to assure a good learning day. Over the period of a year, there was a clear indication of teacher changes in philosophies and actions when the data in these questionnaires were compared.

All answers on the first set indicated that teachers were clearly doing teaching that relied on their own decision making and student compliant behavior was indicative of teaching for transmission. On the pretest questionnaire, teachers initially described their responsibilities as follows:

- Planning
- Making copies
- Having a clean room
- Making lessons fun, entertaining and easy to learn
- Rewarding students appropriately
- Disciplining appropriately
- Communicating with parents

On this same pretest, student responsibilities were basically viewed as “doing whatever would let the teachers do their job.” We were particularly looking at how passively or actively students were being engaged. According to pretest questionnaire teacher responses, “what students had to do in order to assure a good teaching day” were to:

- Come to school ready to learn
- Have plenty of sleep the night before
- Come to school with a positive attitude
- Behave appropriately
- Dress comfortably for class
- Respect all rules and classmates
- Make an effort
- Smile at the teacher
- Try

Almost all pretest teacher responses lacked reference to actual strategies, active learning, or engagement in learning on the part of the students. Students were seen as passive learners. References to teaching concepts or teaching for depth were also not evident.

While little change was evident when the questionnaire was given in the middle of the year, at the end of 12 months, when the third time the questionnaire was given, we saw major shifts in teachers' beliefs and actions. Here are some examples of how teachers saw students' responsibilities in the learning process:

- Raise questions
- Get involved
- Work effectively in a group
- Listen actively, participate and question
- Call on prior knowledge
- Collect data from peers
- Be willing to take risks
- Be an independent worker

Many teachers' beliefs about their own responsibilities also changed after 12 months of professional development. The third time the instrument was given, responses ranged from those that had changed little, to responses that described what *should happen*, to actual examples that documented application of the Principles such as:

“I have students socially engaged as part of every subject.”

“I allow students to teach each other and answer questions without my feeling a constant need to press on.”

“I try to have lessons that fit the standards but also fit the kids.”

“I provide a climate for social collaboration on [specific] topics.”

“I try to spark interest by using motivational activities.”

Prediction 2: *There would be a steady change in teacher professional dialogue centered around the Principles.* This prediction held true. One overriding comment made by teachers, by 2 months into the study, referred to the shift in conversations that teachers had with each other. Frequently comments like the following were made: “I truly feel like a professional because we find ourselves talking about learning and what we are doing with students.” Such statements were accompanied by others that reflected a change in the nature of how teachers listened to and worked each other. Here are two typical examples: “With my colleagues, we have begun listening to each other more quietly and carefully in meetings (I’m still working on it).” Also, “My colleagues have begun to team teach.”

Prediction 3: *There would be documentable evidence that teaching would begin to incorporate the Principles and the Capacities.* Our prediction was that as the additional capacities for learning became obvious to teachers, they would more easily see opportunities for teaching in different ways. I developed two instruments that allowed teachers to record

changes in teaching. The first was *The Brain/Mind Constructivism Check List*.

This instrument was administered before embarking on the next Principle in order to identify changes in teachers' practices that directly incorporated the the previous one. This questionnaire consisted of items such as the following:

Given Principle #2, "The Brain/Mind is Social", please check the following:

- I have changed the way I interact or communicate with my students.
- I have observed that others interact differently with their students.
- Please give specific examples.

Here are some of those examples:

"The third grade "POD" (students are divided among staff into groups of from 6-10 in order to study something students care about) is now collaborating weekly about students rotating activities every Friday."

"I have seen more students working together as partners and in groups"

"I have students working on various issues together, looking for means of validating each other's experiences, and relying on each other for support."

"I use lots of counseling style prompts like 'Can you explain this to me?' 'Show me?' 'Where would you use this . . .?' "

The second instruction that allowed teachers to record changes in teaching was *The Teacher Research Questionnaire*. This questionnaire had three, open-ended inquiries and was

administered one-month after each principle had been introduced. It was administered 6 times. Participants were invited to write their answers and observations anonymously:

1. What evidence do you see that you and your fellow teachers are beginning to understand the *Brain/Mind Learning Principles*? Give specific examples if at all possible.
2. What evidence do you see that teacher(s) understand principle # _____ (different every month)?
3. How are teachers putting the principle(s) into action in their teaching?

The responses included the following:

“We searched the campus for evidence of animals living or having lived on campus. We found birds nests, wasps nests, and gopher holes”. [This statement came from a teacher on a campus with little vegetation, surrounded mostly by cement.]

“I use more ‘into’ activities and work harder to tap into (students’) prior knowledge”.

“[Understanding] that learning is innate seems to have given some teachers permission to elaborate – to allow their students to think outside of the box.”

Prediction 4: *At the end of the school year test scores on the Stanford Achievement Test (SAT9) would improve significantly.* We were delighted with the improvement of student scores on standardized tests. The original goals for the school included a growth target gain of 16 points on the SAT9 for the 2001 - 2002 school year as measured by the Academic

Performance Index (state standards). The school's actual growth amounted to 48 points, thus far exceeding their target. In addition, Hispanic students, who make up 89% of students (and whose target growth base had been set at 13 points) ended up with actual growth of 54 points. Moreover, students identified as coming from low socioeconomic environments and disadvantaged, also exceeded their target. Their target had been set at 13 points and their actual growth was 47 points.

Also, Redwood school moved out of the bottom decile in the similar schools ranking and has continued to maintain the original rise in achievement every year since, which has been 5 years. There were additional indirect indicators that teachers, schools, and students were functioning more effectively. These include reductions in faculty and student absenteeism, faculty and student attrition, and disciplinary referrals.

Perspective

Since our work together at Redwood school, we have continued to use the Process Learning Circles in helping teachers work with the Principles. Here are two quotes from our most recent Summer Workshop:

"My overall response is that I feel as though I have grown in wisdom as a human being. My thought process was challenged beyond what I had originally known to be my capacity. As participants we joined together bringing totally different backgrounds and experiences but were able to bond and work together to digest and process the same information"

" As an educator, I can see how learning and the work of schools have to be re-worked and re-configured to align with how the brain does its work. As I train teachers and supervise their development I will need to show them how vital their role is and how enriched their own practice can become. When they shift their paradigm and look at how [this approach] can inform their development as catalysts in their school and as people."

We are convinced that the Principles and the Process Learning Circles combine to shift the teacher's view of the learner from someone whose primary role is to follow instructions, to a learner as someone who needs to be deeply engaged in the learning and writing process as a creative individual, seeking to express their own meaningful ideas and connections. This can be done while students are held to high standards and do well on tests.

Suggestions for Future Research

- Identify more clearly which parts of the group process are critical to change and why.
- More closely document changes in teacher beliefs about learning and how these are related to shifts in practice.
- Document long term change over 4-5 years.
- Use performance standards in addition to standardized testing as student outcome measure.

Projections & Possibilities for the classroom of 2030.

We predict that the alignment between schools and what is understood about the brain's natural, biological approach to learning will force great challenges for education. I suggest that the educational community come to understand and address what neuroscience is corroborating - that children are whole individuals whose emotions, motivation, past learning and beliefs about themselves as learners all interact with the curriculum.

In practical terms we can expect to see the following:

1. First, educators will ensure that learners are constantly immersed in experience in which the content standards are embedded, and where students have opportunities to:
 - *Physically interact* with what is to be learned or understood;
 - *Make associations* with what they already know;
 - *Ask their own questions*;
 - *Adapt to real world situations* through what neuroscientist Goldberg (2001) calls actor centered adaptive decision-making.
 - *Conduct research* and find what experts know about their questions.
 - *Receive guidance, instruction and feedback* tied to real world standards.
 - *Demonstrate real world knowledge and competence* in both formal and spontaneous ways.

2. Educators will strive to create a social/emotional climate of relaxed alertness. This consists of low threat on the one hand, and high challenge and high expectations on the other. Healthy relationships based on respectful and coherent procedures will be seen to be essential.

3. There will be extensive and active processing of student experiences. This will range from the deliberative practice and rehearsal in which all experts engage, to responding to respectful but challenging questions. Active processing will be seen to provide feedback for both teachers and students at the same time that it expands and deepens student thinking. This provides both formative and summative assessment.

Over the last hundred years the educational system has segmented and divided learning into distinct disciplines that are studied in equally fragmented environments largely limited to “classrooms”. The change to a more integrated environment and curriculum will not be easy, but both technology and neuroscience are providing the evidence that requires education to do so.

SUMMARY

The purpose of this chapter was to describe how 12 Brain/Mind Learning Principles can inform the teaching of reading comprehension at the elementary school level. If standards are to be raised, and if success is to be sustained, then the professional development of teachers is paramount in this age of critical research. Educators need to access THEIR additional capacities – because the Brain/Mind Learning Principles in this chapter apply to ALL learners

including themselves. In the last few years, Rewood School has continued to thrive and raise their API, despite the fact that they have had a new school principal almost every year. Grade Level Teams are powerful, and the current principal assures me that the entire learning environment has been transformed by the school's continued implementation and "living by" the Principles described in this chapter.

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