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Neuroscience, Play and Early Childhood Education: Connections, Implications and Assessment

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Abstract Paralleling the works of Cambourne's Conditions of Literacy Learning (*The Reading Teacher, 54*(4), 414–429, 2001), Copple and Bredekamp's (Developmentally appropriate practice in early childhood programs serving children from birth though age. National Association for the Education of Young Children, Washington, 2009) Developmentally Appropriate Practices and the findings from the field of Neuroscience this article explores the important components of creating an active, stimulating learning environment; one purposely designed to actively engage the minds of young children in order to help strengthen their neurological networks. The article concludes its exploration with the role of "mirror neurons" in the learning environment and how they affect the young child's mood, emotions, and empathy.

Keywords Neuroscience · Mirror neurons · DAP · Cambourne's conditions · Learning environment

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Mr. Rushton, can you turn on the computers?" "Mr. Rushton, Mr. Rushton, can you take the top off the sand box?" Michael and Jenna call out simultaneously. Meanwhile, Sarah has resorted to feeding rabbit food to the newly acquired turtle. The sound of the hammer from the carpentry center echoes across the room as two more girls place their photographs in the appropriate card holder to explore the "hospital", which recently replaced the housekeeping center. From where I'm standing I can see Michael all bandaged up lying on the operating table. I tell myself, "It's going to be one of those mind-expanding days!

Introduction

The room is buzzing with activities as fifteen 4- to 5-year-olds begin taking responsibilities for their exploration and discovery of learning for the day. From the outside looking in, these kindergarten children are exploring their senses in full bloom. What may look like chaos to the untrained eye is in fact a well orchestrated hub of learning. The children, well versed in the routines of the classroom, are interacting freely with the different learning centers around the room. Each center is designed to intrigue and stimulate even the most reserved child. Some are enjoying the textures, sounds, and aromas in the various parts of the room such as different types of sand from the wet and dry sand boxes; or, the smoothness of the hard wood from both the small and big block centers. Still others are enjoying the coolness of finger paint against their hands or the spicy aromas from the cooking center. The specialty today is making applesauce using sequenced, "production line cooking cards."

If we could sneak a peek inside these learners, an even more intriguing and fascinatingly complex process is taking place. As Mary begins to make the connection between the relationships in the room, how the shape of the letter 'A', for instance, connects to the making of Applesauce and the sound/a/, her brain forms new dendrites, which in turn, branch out to hundreds, even thousands of other neurons across the different regions of her brain (Whalen and Phelps 2009). These millions of connections are unnoticed by her teacher, her parents or even Mary herself. Moment by moment, and with each new discovery of learning, an electrical-chemical reaction is rapidly firing across Mary's outer-cortex, the ¼ inch bark shape outer layer of her brain. To complicate matters, in-between each of the hundreds of millions of electrical 'neuron firings', called synapses, various chemicals which affect her mood, focus, and attention are moving from one neuron to another. The quantity, type, and ratio of the different neurotransmitters being released from one axon terminal (the end of a neuron) to the beginning of another neuron are constantly being altered as the child moves from one learning experience to another. This combination of 'releasing' and 'up-taking' of particular neurotransmitters, such as serotonin, dopamine and norepinephrine (the latter being both a hormone and a neurotransmitter) will have a strong impact on the emotional experience and well-being of the child (Amici and Boxer 2009).

Literally millions of neurons are constantly firing in both the child's and the teacher's brains as each engage with the classroom. At the same time the classroom teacher is setting up and organizing for his teaching day, his neurological networks are rapidly making connections. Similarly, his fifteen 4–5 year olds entering this 'enriched' environment will connect emotionally, cognitively, and physically to the room's design.

On the outside, the teacher perceives the wonderment taking place on the child's face with each new discovery. On the inside, our brains are continually changing as each experience helps either to grow new neurons or prune away old ones (Miller and Cummings 2007). Each day our children leave our classrooms with new synaptic connections and a changed cerebral cortex. The brain's neurological wiring changes as each new experience forms new dendrites (Diamond and Hopson 1998). Part of our brain is 'hard wired' (the limbic system) and changes little over time (such as our automatic heart beat, lung movements, keeping balanced while walking etc.), while other parts are 'soft wired" and are constantly changing with experience. For instance, the child's ability to hear and learn new languages and adapt to new environments are forms of 'soft wiring' (Wolf 2007). Neuroscientists refer to this later process as 'plasticity', that is, the brain's ability to continually alter itself (literally forming new synaptic connections and memories) as it processes information. Gallagher (2005) suggest that this adaptation of the brain may lead us to living more efficient lives in the future.

This article will explore the important components of creating an active, stimulating learning environment. This learning environment is one that is purposely designed to actively engage the minds of young children in order to help foster growth. This growth will be strengthening the neurological networks already existing and creating more interconnecting dendrites—the essence of learning—in a young child's brain. Then, our exploration will turn to the concept of "mirror neurons" and how they play a vital role in the mood, emotions and empathy of the young child in connection to the teacher. Additionally, we will connect theory with practice by paralleling Camboune's Conditions for Literacy Learning (2001), and Developmentally Appropriate Practices (Bredekamp and Copple 1987, 1997; Copple and Bredekamp 2009), and neuroscience relationships. Finally, we will explore some authentic assessment tools that support the engaging, brain friendly model of teaching as suggested in this paper.

Advances in the Literature

The past two decades have seen an unprecedented number of articles, research studies, and conferences outlining the importance of understanding the mechanisms of the brain (Miller and Cummings 2007; Whalen and Phelps 2009). Recently, more connections between these findings and their relationship to early childhood education are being made (Bergen and Coscia 2001; Rushton and Juola-Rushton 2007a, b, 2008). Initially, Bredekamp and Copple (1987) paved the way for educators and researchers to better understand what 'best practices' are for young children. Recently revised, Copple and Bredekamp (2009) explore the principles of learning to meet the needs of the modern day child. Bredekamp and Copple's (1987) initial work opened the door for educators (Caine and Caine 1997; Jensen 1998; Rushton 2001) to begin making connections with the neurosciences and learning processes (Diamond and Hopson 1998; Whalen and Phelps 2009). Additionally, Rushton and Larkin (2001) aligned nine of the 12 DAP position statements to various brain principles and learning strategies in an article titled, *Shaping the Learning Environment: Connecting Developmentally Appropriate Practices to Brain Research.* More recently, Gallagher (2005) postulated three critical elements for early childhood educators to better understand their students' learning in relationship to the mechanisms of the brain. She states, "Neural development, stress hormones, and brain specialization are three areas of brain research that inform and support developmentally appropriate practices (DAP) in early childhood education" (p. 12). Clearly, great gains are being made in bringing together the sciences of the brain and theories of practices in early childhood education.

As early childhood educators we are well aware of the importance that the first 5 years have on the social-emotional and physical development of the child (Copple and Bredekamp 2009). What is perhaps not as well understood is that these same 5 years are also some of the most critical years with respect to the developing brain (Elliot 1999). With exciting and continuously changing research in the field of neuroscience the truth of this has never been more real. The numbers of dendrite connections that are formed in the first 5 years of growth has been estimated to be over 100 billion (Miller and Cummings 2007). Indded, it is an over production of neurons, some speculate (Gallagher 2005), that enables the child to adapt to any number of circumstances during the early years. Forming language, identifying cultural and social norms, and learning to distinguish right from wrong, requires this intense neurological growth to take place, thus strengthening the connections between neurons. This rapid growth in the minds of young children inspires them to explore, to discover, to play and to make the natural connections between self, others and their surrounding world. It is these dendrite connections that open the window of opportunity to assimilate one, or several, of 3,000 different languages effortlessly (Nevills and Wolfe 2009).

Two great responsibilities of the early childhood educator, then, are development of the learning environment and modeling an engagement with learning. To create a purposeful learning environment, the early childhood educator will need to intrigue and capture that child's interest. As well, and perhaps more importantly, educators must also conduct themselves in a professional and manner that will lead to the release of certain neurotransmitters in the brain that supportlearning.

A Learning Environment that Supports Optimal Brain Stimulation

The following dialogue is a snapshot of what we believe exemplifies age appropriate sensory stimulation, empowerment of children, and overall what is often referred to as a "brain-enriched" classroom. The room represents aspects of the author's present and past classroom environments.

As you enter the room your sensory system becomes alert to all of the sounds, sights and aromas that are emanating. Immediately, your sense of smell is aroused with the scent of cinnamon. You notice a parent sitting with several students near a crock pot cooking apples in the far corner of the room. Next, your eyes notice the various colored hanging paper globes from the ceiling with different color lights illuminating soft hues of yellows, blues and reds. A couple of soft lights also illuminate the corners of the room including a floor lamp in the library area. It takes a second for the eyes to adjust from the harsh iridescent lights from the hallway. As your eyes begin to adjust you notice that children are moving quietly from one location of the room to another. Two children are sitting knee- to- knee in what appears to be a peer writing conference. Two other children are experimenting with sand as they pour the dry sand through the plastic wheel watching gravity at work. Yet another group of students is sitting in a colorful reading corner that contains a couch, a rocking chair and some beanbags. Sitting on the book shelves are a couple of aquarium tanks. One appears to have actual fish in it while two others have various animals such as a lizards and gerbils. Several students are standing in front of the cages with clipboards and pencils in hand, recording their observations.

Below the shelves are buckets of books categorized by themes, genres and reading abilities from picture books to longer chapter books. The walls are covered with children's art work and group stories, some using inventive spelling, class editing notes, and lines drawn all over some pieces (obviously a piece in progress). One such story illustrates the most recent field trip to the local newspaper. Underneath that story are folders with the various sections of the newspaper written by the children (Headlines, Playground News, Fieldtrip, Units of Study) pinned against a bright background. One child has just written something about the pets and is now placing it in the folder called 'Pets."

Finally, your eyes drift to the large tree shape structure that begins in the far corner of the room with paper vines spreading from the ceiling across toward the library. Students' profiles and art work are hanging from the vines. The children are interacting, conversing, and sharing what they are experiencing. This is their exploratory time when they integrate the various mini-lessons they have had over the course of the week. The teacher is observing the children's interactions and is carefully listening to the language development of several students. She has a clipboard by her side too (not unlike the children making observations at the aquariums), noticing certain types of behavior and language being expressed. She listens intently to children's dialogue as they write on sticky notes questions they want to have discussed at the next reading conference.

On average, school age children spend more time in the classroom environment than they do at home. Why not provide learning environments that stimulate the children's curiosity and allow them to experiment with their surroundings in a manner that is empowering for them? The description above illustrates a room filled with active, engaged learners who have varying interests. Numerous learning opportunities are located around the room: computer stations, writer's workshop lab, science area, dramatic play materials—all beckoning the imaginations and sensory stimulation of the young learner. The students here have control of their learning and the teacher has become more of a facilitator. She is eavesdropping on both the types of syntax being employed by her second language learners and the level of semantics they are developing.

From a neurological perspective, a sense of excitement and novelty in the room helps to generate dopamine, a neurotransmitter that creates a feeling of well-being. Emotions (in a sense, neurotransmitters and hormones) drive attention (the ability of the child to stay aroused and connected to the material being presented), and attention drives learning. With this being so, the classroom teacher must transition to a more emotion-based teaching efficacy. This means capturing and maintaining the attention of the students by including them in the instructional process. If the students are emotionally invested, they tend to stay interested and connected to the learning process. The explosion of new technologies makes it even more imperative for the classroom teacher to take a whole new look at the meaning of "learning engagement."

Sometimes, classrooms are directed by teachers who fear losing control and may prefer a more traditional 'teacher-directed' class in which children are not always free to express their wants and needs. Inadvertently, these well-intended educators dominate their classrooms and may stimulate the release of other neurotransmitters and hormones such as serotonin and cortisol within their students, which actually decreases attention and learning. Once released into our bodies, these two particular chemicals, often as a result of fears, inhibit learning from taking place until rational thought (prefrontal lobe) has been able to make sense of their experience. The old adage, "the lights are on but nobody's home" depicts what is happening for a student in this scenario. For the teacher, it is the frustration of knowing she's "covered" the content, but her students are not demonstrating an understanding.

When students are provided with numerous opportunities to express and engage in what they are learning, the connections between what has been taught and the application of this learning is then evident not only in the classroom but is also extended to the students' outer world. The learning centers help to stimulate the growth of neurons from one part of the brain to another. Remember, emotions plus attention equals learning. The more connections are naturally made, the better the problem solving ability of the student becomes. By exploring the same learning focus within different contexts, the myelin sheath that surrounds the neuron axon thickens. It has been suggested (Diamond and Hopson 1998) that the thicker the myelin sheaf the faster the electrical impulses move down the neuron before igniting the chemicals in the axon and then into the synapse to be picked up by the next neuron. Much like the rubber or plastic on the cord of an electrical appliance, the thicker the gauge of wire used, the thicker the insulation required to allow the atoms to move down the copper wire. For the classroom teacher, this means that our choice of facilitation styles physiologically supports or hinders our students' learning every day they enter our classroom door.

An active learning environment requires numerous components that work independently of each other and also set a whole tone. For example:

- the physical arrangement of the tables, chairs, centers, library, lighting and other components attract the child's interest;
- space designed for both individualized work, small group and large group meetings;
- availability of manipulative materials and exploratory spaces that intrigue the natural curiosity of the child; large blocks of time for the child to explore, role play, and experiment; and
- perhaps most importantly, a compassionate and caring educator who demonstrates a love for learning and models positive interactions.

Equally important is the underpinning theory adopted by the early childhood educator that governs the movements, the flow of actions and interactions among the teacher and the children.

Mirror Neurons

Copple and Bredekamp (2009) reiterate in the latest edition of *Developmentally Appropriate Practice in Early Childhood Programs: Serving Children from Birth thorough Age 8*, that, "A teacher's moment-by-moment actions and interactions with children are the most powerful determinant of learning outcomes and development. Curriculum is very important, but what the teacher does is paramount" (p. xii). It is intriguing that after 30 years of research the single most important factor in a child's learning is the classroom teacher's actions, reactions, and, interactions with students. Recently, a new discovery in the field of neuroscience has provided the classroom teacher and educational researchers with new data to support Copple and Bredenkamp's claims. During the late 1980s and early 1990s several Italian neuropsychologists noticed the behavior of Macaque monkeys while hooked up to a variety of brain monitoring machines. They observed how the monkeys imitated their instructor. "Monkey see, monkey do." For instance when the neuropsychologists ripped a piece of paper, or, poked their tongues toward the money, the young money did the exact same thing. The results of brain imaging experiments using functional magnetic resonance imaging (fMRI) demonstrated that the same portions of the human brain, the inferior frontal cortex and superior parietal lobe, were similarly active when the person performed an action as when the person saw another individual performing the action. From this, some scientists (Iacoboni et al. 1999) are concluding that these brain regions contain mirror neurons, and they have been defined as the human mirror neuron system. When the instructor reached for some food the monkey mirrored the actions of the instructor. Parents have observed this behavior with very young babies. If you stick your tongue out at a baby, the baby often sticks his or her tongue back out at you. Since these early days of initial observation, entire networks of neurons have been observed via various PET scans and fMRI machines.

Mirror neuron networks throughout the brain confirm the importance of the teacher's moment by moment actions as the child's neurological synapses 'mirror' not only the teacher's actions and reactions. Some researchers (Hurley and Chater 2005; Winerman 2005) are speculating that perhaps far more importantly, these same mirror neurons affect the mood of the individual observing the instructor. At a subliminal level, children observe the teacher's expression and dispositions and internalize how the teacher is feeling. Neuroscientists' believe that our ability to empathize with another human being is due, in part to the activation of the mirror neuron networks being activated by what we observe.

It is vital that we empower our teachers to model various dispositions such as caring, cooperation and authenticity so that our students may become positive contributors to society (Carr et al. 2008). From a neurological perspective, it may appear that we educators help shape our children's dispositions and attitudes neurologically simply by their observing our body language, our expressions and even our moods. How we present ourselves may trigger a network of neurons in a child's brain that mirrors the image being observed. The social cues of looking stern, upset, happy, or excited may elicit a set of similar emotions in the child due to the mirroring effect of the network of neurons that are designed to learn from these social cues in our environment (Oberman and Ramachandran 2007). The subtle changes in our disposition, attitudes and body language can impact what a child feels, thinks and believes. This in turn, sets in motion any number of chemical reactions that can either support or hinder learning from taking place. The important connection to make here is that learning first requires that the children are attentive to what is being taught. Mixed signals can confuse a child. If a teacher's body language indicates that she is not interested in the topic, or, that she is nervous because she does not know the content area fully, then the message being interpreted by the children at a neurological (and unconscious) level is apt be one of confusion, anxiety, and distraction.

Connecting Theory to Practice

Brian Cambourne (2001), an Australian educator, developed eight conditions of literacy learning while observing young children's writing skills for 3 years. Rushton et al. (2003) aligned Cambourne's "Conditions of Literacy Learning" with the brain research principles highlighted from the literature at that time in a similar manner that Rushton and Larkin (2001) did with the DAP principles. We believe that the new insights from the neurosciences extend these conditions of literacy learning as universal conditions of learning that, when applied, will greatly enhance all learning, from early childhood through graduate school. Both "Developmentally Appropriate Practices" and "Cambourne's Conditions of Literacy Learning", when connected to the principles gleaned from neuroscience, create a compelling theory to ground educators' teaching practices (see Table 1).

We suggest that the following principles of learning take into account the neuroscientific educational principles, DAP, and Cambourne's Conditions of Literacy Learning:

- It is evident that if a young child is "immersed" in a rich learning environment (Rushton 2001) one that is filled with age-appropriate literature, materials to manipulate, and questions that excite the child's interest, then greater learning opportunities can take place. Immersing a child in an environment that stimulates all the senses and has an emotional element to it alerts the brain's neurological networks that something here is worth paying attention to, and learning is likely to occur.
- "Models" or "demonstrations" (Cambourne 2001) of age-appropriate lessons presented in an interactive manner, allow the child's creative and spontaneous abilities to be expressed. This is critical in the overall development of learning. Having stimulating 'mini-lessons' or 'teaching points' modeled in a manner that is non-threatening will focus the student's attention.
- Children require the opportunity to make relevant choices regarding their daily activities as well as the content studied. Freedom of choice is inherent in creating a non-threatening environment.
- In the middle of the brain is a walnut shaped organ (the Amygdala) that has now been recognized to have a powerful impact on both children's and adults' responses to stress. If the Amygdala is activated by a perceived or real threat it will immediately send

Table 1 Connecting developmentally appropriate practices, Cambourne's conditions of learning and brain research

NAEYC's positions on developmentally appropriate practices (DAP) Position statements	Cambourne's 8 literacy conditions of learning Conditions of learning	What brain-based research (BBR) suggests about how the brain best learns Brain principles	Classroom practices Possible classroom activities
Domains of children's development—physical, social, emotional, and cognitive—are closely related Development in one domain influences and is influenced by development in other domains	*Immersion* Classroom teacher provides opportunities and makes available many different forms of text that are appropriate to the child's world	Each region of the brain consists of a highly sophisticated neurological network of cells, dendrites and nerves which interconnect one portion of the brain to another	Educators create active learning environments that help builds community and context. Integrated curriculum is critical in allowing for individual differences and for the unique brains that enter our classes daily Students are fully immersed in the learning process including field trips, guest speakers, plants, animals, and art work of the students displayed around the room Curriculum is interrelated so that each of the five senses are used and as many of Gardner's nine multiple intelligences as possible
Development occurs in a relatively orderly sequence, with later abilities, skills and knowledge building on those already acquired	*Demonstration* Children need to be able to explore with all their senses and have modeled for them language and reading. This condition infers that learners have modeled the action, skill or knowledge that is to be learned	The brain changes physiologically as a result of experience. New dendrites are formed every day, "hooking" new information to old experiences As the child experiences an event for the first time, new dendrites have to be formed. As other information is gained, the brain looks to associate the information to existing dendrites	Educators act as facilitators, investigators, caregivers, and listeners while providing related mini-lessons Thematic curriculum aids the student in making connections from one content area to another Hands-on activities also stimulate the various regions of the brain which help form stronger associations in the brain and make learning more enjoyable
Development proceeds at varying rates from child to child as well as unevenly within different areas of child's functioning	*Engagement* Children need to be active participants in their learning. Talking, discussing, sharing are critical ingredients for children in their language development. Opportunities need to be provided that allow for both independent and shared discussions and writing	Each brain is unique and different. Learning new skills and knowledge literally changes the brain structure Brain research suggests that a spread in differences up to 2 and even 3 years in completely normal developing brain	Children are provided with choices that meet their level of development. Multi-age classes or looping Use of planning boards and individualized contracts along with large blocks of time are provided for students to discover, play, and learn Language and motor development require children to engage. Discussion, movement and active learning are extremely important Provide individualized educational plans for all students.

Table 1 continued

NAEYC's positions on developmentally appropriate practices (DAP) Position statements	Cambourne's 8 literacy conditions of learning Conditions of learning	What brain-based research (BBR) suggests about how the brain best learns Brain principles	Classroom practices Possible classroom activities
Early experiences have both cumulative and delayed effects on individual children's development Optimal periods exist for certain types of development and learning	*Expectation* Teacher's belief and expectations in learners' abilities is critical to develop the child's interest and aspirations to succeed	Brain-based learning also indicates that certain "windows of opportunities" for learning do exist as the brain's "plasticity" allows for greater amounts of information to be processed and absorbed Lock-step, assembly-line learning violates a critical discovery about the human brain: each brain is not only unique, but is also growing on a very different timetable	Teacher provides time for both class and group discussions, sharing and thinking aloud. Kagan structures support language development Students' repeated experience at interactive centers helps to develop problem-solving skills and long-term memory. Large blocks of time allow students to assimilate and synthesize both new and familiar information Young children require opportunities to interact with each other regularly
Development proceeds in predictable directions toward greater complexity, organization, and internalization	*Responsibility* Teachers need to model and immerse children in their learning by providing choices for individual differences. Responsibilities include decision-making on the part of the learner for choices and engagement	The brain processes on many paths, modalities, levels of consciousness, and meaning levels. It's designed to process many inputs at once and prefers multi-processing so much that slower linear pace reduces understanding (Caine and Caine 1997)	Information is presented in the context of real life situations; new information builds on prior knowledge The learner is able to connect new information to well established schema Activities and learning environment are organized for both low and high order thinking skills Students' meaning should be personal first, then adapted to fit more symbolic understanding
Children are active learners, drawing on direct physical and social experience as well as culturally transmitted knowledge to construct their own understanding of the world around them	*Employment* As children explore language, they need to be provided time and opportunity to do so both in a social and individual setting	Learning does not take place as separate and isolated events in the brain When a child is engaged in a learning experience a number of areas of the brain are simultaneously activated	Young children need learning environments in which they can interact with as diverse population as possible (various cultures, adults - including grandparents) Meaning is understood within the context that it is provided, exposure to as many facets of real life situations are important for the child to interpret and make meaning as well as to broaden their understandings of the world. Field trips, guest speakers, exposure to technology and multi-cultural units of study will all help the child to better understand society and themselves

Table 1 continued

NAEYC's positions on developmentally appropriate practices (DAP) Position statements	Cambourne's 8 literacy conditions of learning Conditions of learning	What brain-based research (BBR) suggests about how the brain best learns Brain principles	Classroom practices Possible classroom activities
Development and learning result from interaction of biological maturation and the environment, which includes both the physical and social worlds in which children live	*Approximations* A child is not expected to wait until he has mastered the native language before talking, nor is it possible for a child to learn to write without going through various stages. Educators should permit learners to take risks and make approximations in learning new skills, concepts and knowledge	The human brain is constantly seeking information from a variety of stimuli. These "data" are interpreted thorough all the senses Each of the senses can be independently or collectively, impacted by environmental factors that in turn will affect the brain's ability to learn	The learning environment reflects a child's interests, one that allows for a high degree of interaction and manipulation on the student's part. Materials are age appropriate and content is presented using a variety of strategies Environments are monitored for appropriate lighting, aromas, ionization, and noise Water and appropriate foods are available to the child, remembering that each person's internal clock differs
Development advances when children have opportunities to practice newly acquired skills as well as when they experience a challenge just beyond the level of their present mastery	*Response* Exchanges between the child, teacher, and more capable peer help the student to adapt, modify, and extend learning	The brain is primarily designed to survive. "No intelligence or ability will unfold until or unless given the appropriate model environment"	Healthy, engaged learning environments require a moderate degree of anticipation, low stress, and yet, challenging lessons and activities

messages to the pituitary gland and the adrenal glands in order to release a host of hormones and neurotransmitters into the body that inhibit rational thought. Initially designed for humans to survive, this spontaneous reaction needs to be dampened in the classroom. Children of all ages need to feel "safe," allowing and learning from mistakes along the way and celebrating accomplishments.

- Children learn most favorably in positive, stimulating learning environments, where they are able to make the decisions about their own thinking and learning; being allowed to choose a topic of inquiry has immediate 'buy in' from the child. As educators, it becomes our responsibility to connect the topic of interest to existing broad standards.
- Young children use play as a model of learning that is open-ended and congruent with individual differences as well as unique talents.
- When children are exposed to caring, imaginative educators who accept the 'whole child,' and are encouraging of the natural progression of learning, children will feel confident about their abilities, trust their teacher, and in turn, will be more inclined to 'want to learn.'

Assessment

Many creative teachers are forming good practices based upon standards set by state and county guidelines and have made the connections to authentic assessments (Jones et al. 2007). Using Developmentally Appropriate Practices (Copple and Bredekamp 2009) these teachers understand the natural progression of learning and development that children pass through. Unfortunately, many other children continue to be taught in 'traditionally based' classrooms which are often driven by poor funding, very young adults with little advanced education (Ritchie et al. 2007), or by teachers who are mandated to use state testing and are fearful of stepping beyond their administrators' demands and expectations, leaving little room for child-initiated exploration (Takanishi and Kauerz 2008). Figure 1 outlines the influences that have impacted the course of education in the United States and how, with the passing of *No Child Left Behind*, along with a long history of other important commission groups (National Commission 1997) educators have been left with two choices. Either: (1) design curriculum with assessment in mind first, thus creating programs based on the latest text book company's best effort to align tests with curriculum standards (Wien 2004); or, (2) be led by what they know about child development and research on the brain, and allow for authentic assessment to

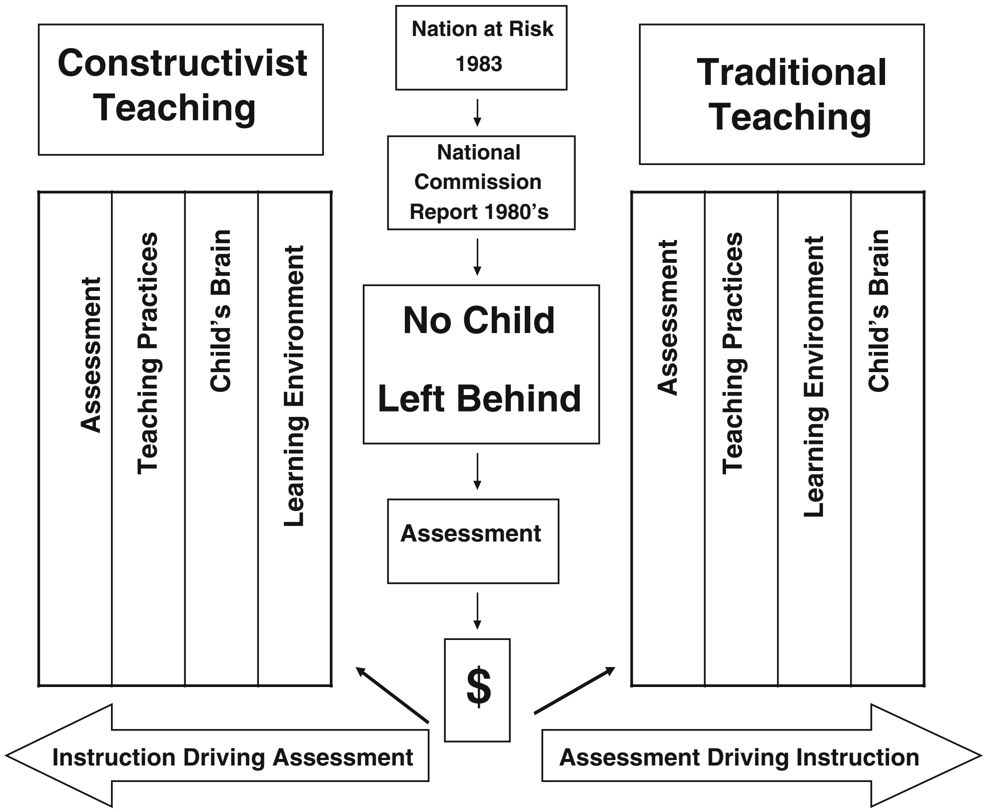

Fig. 1 Curriculum driven by assessment or instructi

follow the inquiry and exploration of the students (Rushton and Juola-Rushton 2007a, b). What makes the difference? Why do some classrooms engage, excite and stimulate the child's natural curiosity and create deeper learning and meaning while other classroom environments dampen, dull and shut down the executive parts of the brain? As complicated a question as this may appear on the surface, a child senses the atmosphere or tenor of the classroom at a subconscious level and the 'flight or fight' response is engaged, deciding in a split second if this will be an environment to build defenses or to embrace what is offered.

Observation has long been the primary tool for documenting how children engage in the learning process (Cohen and Stern 1969). Teachers note what children do, say, try and show in order to guide their development. Standardized testing captures only part of what children know and understand. There are many ways that children can demonstrate learning, creativity, social skills and emotional intelligence, but these strategies are more time consuming to assess, and open to biased interpretation. Despite these thorny challenges, authentic expressions of knowing that grow naturally out of children's engagement with the curriculum can produce satisfaction for learners, parents, and teachers alike. The key is to document what children are thinking and doing in multiple ways on a continuous basis. Collecting and displaying evidence can be in the form of photographs, video or audio recordings, performances, constructions, multimedia bulletin boards, drawings and other visual arts, or writing. These concrete expressions of understanding can be shared, discussed, sequenced, and compared until their value is clear. Then, teachers will have the insights they need to shape each learning environment in optimal ways for the learners therein.

By purposely organizing the learning environment we can create opportunities for active engagement. In other words by immersing a child in a highly motivating and challenging room, we may be able to engage the brain, especially the pre-frontal cortex, which helps to solidify learning. It is here, in the developing pre-frontal cortex, that higher-order thinking skills take place such as comparing and contrasting or making connections between size and shape. For instance, if Michael chooses to play at the wet sand box and starts building a castle, he has stimulated his motor cortex, his occipital lobe (seeing) as well as his prefrontal lobe when he attempts to calculate how much sand is required before his castle falls down. Neuroscientists suggest that the pre-frontal cortex is the last part of the brain to develop fully. Patience and careful observation are required on the part of early childhood educator as the natural development of the brain unfolds. In short, the following points help to create an environment that is conducive for learning:

- The physical learning environment is non-threatening, yet stimulating.
- Large blocks of time are made available for exploration.
- Children have choice over what they engage with and are viewed as the 'expert'.
- Hands-on, experiential learning is the norm, not the isolated lesson, and children have real events to explore, read and write about.
- Lessons are modeled for the children and ample opportunities are provided to explore, play, and celebrate.
- Literature response activities connect to the child's real world.
- Open dialogue takes place between the students and the teacher and among students.
- Curriculum across all content areas is integrated, and opportunities for meaningful problem solving are provided.
- Assessment strategies are an authentic outgrowth of children's activities, and lead to a sense of accomplishment rather than stress.

Conclusion

Many years ago, while I was teaching pre-kindergarten, a parent once made a collage which hung on the classroom door. The collage, designed in the shape of a flower, had the opening quote underneath the flower: *"You can't make children grow faster by pushing them, just as you can't make flowers grow faster by pulling them."* Developmentally appropriate practices urge us to meet the child where he/she is and to slow the educational process down in order to suit his or her needs, yet this does not always match the desires of the teacher, administrator, district, or state. We live in a time in history in which it has become fashionable to use assessment tools that do not always support what we know to be best practices (Carr et al. 2008). Today, the study of the brain assists educators in understanding how children learn best and what connects the learning environment with neurobiological changes in the child's brain. The truth is, *we can't insist that important connections in the brain be made, but we can support or hinder children's dendritic growth with the practices we implement.* Thus, we can optimize learning from the moment we greet each child at the classroom door if we create a brain-friendly environment.

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