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Mind, Brain and Education as a Framework for Curricular Reform

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Mind, Brain and Education as a Framework for Curricular Reform

A dissertation submitted in partial satisfaction of the
requirement for the degree Doctor of Education

in

Educational Leadership

by

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2013

The dissertation of Abigail L. Larrison is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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2013

Dedication

This dissertation is dedicated to all the students who struggle to be understood. May our education system grow to meet your expansive spirits.

Epigraph

The world is going to need all of the different kinds of minds to work together. We've got to work on developing all of these kinds of minds. You've got to show kids interesting stuff, and they've taken out the auto-shop class, and the drafting class, and the art class. I mean, art was my best subject in school. We've got to think about all these different kinds of minds, and we've got to absolutely work with these kinds of minds, because we are *absolutely* going to need these kinds of people in the future.

Temple Grandin on TED Talks, February 2010

Table of Contents

List of Tables

List of Figures

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ABSTRACT OF THE DISSERTATION

Mind, Brain and Education as a Framework for Curricular Reform

by

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Doctor of Education in Educational Leadership

University of California, San Diego, 2013

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Professor Carol VanVooren, Chair

A growing collaboration between psychologists, neuroscientists, and educators has culminated in the emergence of a new academic discipline known as Mind, Brain and Education (MBE). MBE differs from previous efforts, such as educational neuroscience, in that it is focused on the problem of how we might bring findings from the learning sciences into the classroom. As such MBE is placed squarely in the classroom, and works through engaging teachers as primary participants. Hence, MBE must work through an awareness of the systems of education and within the current context of educational policy and practice if it is to find a firm grounding in educational reform. In many ways the goals of MBE are in alignment with the voices of educational leaders across the globe. Pedagogical approaches referred to as neuropedagogy or neuroeducation, emphasize the development of high level cognitive capacities, such as critical thinking and creativity and address the connection between motivation, emotions, sleep, stress, circadian rhythms and development in learning processes. The primary purpose of this study was to define the emerging field of MBE with respect to its goals, vision and potential to serve as a significant framework for education reform. Because the basic constructs of the field are still being developed, interviews with expert members of the MBE community, including academic researchers, consultants and other educational leaders were conducted using a grounded theory approach. The definition of MBE was highly complex, but contained central elements relevant to reform. Special attention to developing a curricular model of MBE resulted in a vision of a holistic approach centered on developmental and individual needs of the students. To further investigate the possible impact of neuroeducation on student outcomes, two existing curricular models—Waldorf and International Baccalaureate, were examined as examples of programs of neuropedagogy/neuroeducation. Findings indicated that examining curricular models currently in use holds promise for understanding the impact of the principles of neuroeducation on student outcomes and development and can serve as a first step towards developing a proof of concept for the field.

CHAPTER 1: Introduction

A new model of education is emerging from the growing awareness of the biology of learning. This novel approach to teaching and learning is taking shape on many fronts, and has coalesced as a formal effort for reforming education under the developing field of Mind, Brain and Education (MBE). MBE provides both the curricular theory and the guiding structures to bring that theory into place and hence hosts a suitable forum for this effort as a movement in educational reform (Tokuhama-Espinosa, 2011; Battro, Fischer & Lena, 2008). MBE provides a shared vision and philosophy which allows multiple stake holders to participate in the co-creation of successful learning environments and school structures that meet the needs of all students (Sousa, 2010; Suarez-Orozco & Sattin-Bajaj, 2010). On the organizational end, MBE is focused on creating connections between policy makers and scientists, teachers and researchers, all in a manner that will help to inform policy and practice through shifting the current focus of education away from the failed model of No Child Left Behind (NCLB) towards a system based on a deep understanding of the biological development of the individual human brain and mind.

Educational reform in recent years has been a highly politicized affair that has taken little care to address the curricular implications of the inordinately directive policies (Ravitch, 2010). Nearly ten years after the signing into law of the federal Title I educational reform act known as No Child Left Behind (NCLB, 2002), schools and districts are scrambling to meet the coming 2014 deadline requiring that 100% of all students will score proficient or advanced in math and language arts according to state mandated standardized tests. The growing number of schools failing to meet the proficiency standards (i.e. 51% as of 2011 for the state of California,www.cde.ca.gov), reflects the failure of a policy that is misaligned with what we understand from the science of learning. As a program of forced school reform (i.e. mandated school reconstitution) NCLB has been questioned both for its lack of legality (Spitser, 2011) and for its lack of logic (McGhee & Nelson, 2005). From the wreckage of this failed initiative there is a cry of reason coming from teachers and educational leaders calling for something else (Meier, 2000; Popham, 2004; Ravitch, 2010). Research on the success of reform efforts in the past suggests that a historical and contextual understanding of the current trends and practices is necessary if any change effort is to find even moderate success (Kliebard, 2002; Tyack & Tobin, 1994). As such, it is critical to evaluate how MBE fits into the larger structures and policies guiding our schools today.

NCLB: A Default Philosophy of Education

One reason for the conflict and disagreement surrounding the current standards based reform has been attributed to the basic ‘default’ philosophy of NCLB. A default philosophy is one that results from a lack of reflective and engaged dialogue among all stake holders regarding their goals and practices (Gunzenhauser, 2003). The goals of NCLB have become almost entirely singular in focus and that focus is test scores in reading and math. Hence, if we understand an educational philosophy as addressing *why we teach*, under the mandates of NCLB, the default philosophy becomes *to pass the test*. Eisner (2005) states that,

> The lack of attention to fundamental questions of why we educate results in the aimless pursuit of school reform…We are not clear about what we are after. Aside from literacy and numeracy, what do we want to achieve?

> What are our aims? What is important? What kind of educational culture do we want our children to experience? In short what kind of schools do we need? (p 577)

MBE supports shifting our educational focus back to the processes of learning and the intrinsic biological needs of the student. This is done through the use of the burgeoning knowledge from the brain science. Bringing the discussion of the practices of public education back to a humanistic level required that we re-evaluate policies for their alignment with the development of the brain. This approach would bring us a far way towards addressing the crises in our schools and in our student body. This however, represents a major change in the way we do business, and requires a serious paradigm shift. The goal of this dissertation research is to understand how we might begin apply the growing knowledge from the brain sciences towards effectively implementing a new model of curriculum within our public schools. As such, understanding how policy and politics influence curriculum selection and implementation will be critical (Goodson, 2005; Kliebard, 2002).

The influence of federal policies on curriculum is relatively new. Earlier educational policies focused on creating equity and excellence for education through the distribution of funding (see Manna 2008 for a full review) and little curricular influence was involved in that distribution. Title I of the Elementary and Secondary Education Act (ESEA) enacted in 1965 was created to support disadvantaged students and tended to emphasize the building of basic skills. This was further supported through the creation of the Individuals with Disabilities in Education Act (IDEA). These programs did not directly influence the core practice of teaching and learning. Districts and schools that had less money were given Title I and IDEA funding to even the playing field and increase opportunities for disadvantaged students. The beginning of the curricular influence is attributed to the 1983 report published under the Reagan administration, *A Nation at Risk* (Berliner & Biddle, 1995; Manna, 2008). This is considered by some to be the start of the standards movement and the full-fledged involvement of the federal government in directing curricular content (Cuban, 1997; also Demarest, 2010).

Content standards, at first developed voluntarily, became a central requirement under the Clinton administration through the Improving America's Schools Act. This mandate required states to develop content and performance standards, and to align assessments with these content standards as a requirement to receive Title I funding. This encroachment of federal policies on curriculum evolved into No Child Left Behind. NCLB shifted the policy focus from standards-based reform to school accountability effectively increasing pressures on schools to perform according to a single yearly measure of student achievement. This system of accountability did not address how schools were to make the yearly gains in student performance, in part because NCLB was not placed within a pedagogical framework for improving student learning.

The current policy framework is based on a business or factory model and not on a respect and evaluation of the developmental and learning sciences. According to Michael Apple (2004) the political and philosophical motivations behind the current educational policies are based on neoliberal politics of free-markets combined with conservative back-to-basics content that are united to create a system of external directives that powerfully drive educational practice. Taylorism, based on Frederick Taylor's concept of scientific management of factory workers, is by all accounts the dominant force for directing schools via NCLB policies today (Au 2011). In theory, by testing the product, in this case students, a school will be able to see where the problems lie and fix them accordingly. Through the use of incentives and mostly punishments, NCLB deigns to direct the behavior of learning institutions so that their focus is on improving their product, the student. The core premise of this approach is completely misaligned with the learning sciences. A system designed on a factory management approach is bound to fail when dealing with the rich and complex cultural diversity of individual students from dissimilar communities. It fails to address the needs of the individual and defines a strict limit as to what is deemed important to learn and to know. Although there is little argument that literacy and numeracy are important goals of education, the need to achieve these skills in earlier and earlier grades, and moreover, that each child must reach the same level of achievement at the same time, discounts even the most basic tenets of child development.

What is concerning to many educators is the impact of NCLB on our schools' curriculum. Educational theories, founded in social theories for over a century and more recently in the learning sciences, have developed rich and complex frameworks for curriculum. A pedagogical theory created from the learning sciences attends to the needs of the developing child and is able to address issues such as higher cognition, social and emotional development, and even aspects of individual purpose and global citizenry. One of the unintended consequences of policies focused on performance on tests is the failure to address the primary goals of education on this broader scale (Pearlstein, 2010). Although NCLB policies emerged from the theories of standards based reform efforts, the inordinate focus on testing and accountability are what have driven the school practices towards focusing on test preparation in limited subject areas, and resulted in the elimination of many of the educational activities that created enriched and engaging experiences for students. Even the original goals of the standards based reform model have been distorted and revised through the strict and limiting regulations of NCLB and High Stakes Testing (HST) (Cawelti, 2006; Emery, 2007).

Two of the original participants in the designing of the current standards based reform model, Smith & O'Day (1993), advocated teaching and assessing complex thinking and problem solving skills. The current standards-based multiple choice tests do not measure higher cognitive capacities, but rather drive educational leaders and administrators to teach-to-the-test, frequently resulting in the use of workbooks and scripted curriculum with pacing guides designed to follow the testing schedule (Perlstein, 2010, 2007; Valli, Croninger, Chambliss, Graeber, & Buese, 2008). MBE does not automatically eschew all testing, rather it would support a model closer to what Smith and O'Day had originally envisioned. As such, MBE supports an alternative measure of standards that assess not just facts, but deeper learning, critical thinking and measures of 21st century skills. This approach is one that may help to realign our focus in education while working within the grammar of schooling (Tyack & Tobin, 1994).

Although it has been previously stated that NCLB utilizes a default philosophy of education, on another level, NCLB is the epitome of the psychological learning model of Behaviorism. In her book, *A Learning-Centered Framework for Educational Reform*, Elizabeth Demarest (2009) points to the overwhelming dependence of NCLB on extrinsic motivators. Emphasis on extrinsic motivators and competition is a central aspect of Behaviorism. This approach aims to shape and condition behavior *not* through inner-reflection and personal motivation, but through external rewards and punishments.

Extrinsic motivators, as they are called, are associated with rather negative outcomes, such as reduced self-determination (Deci, Koestner & Ryan, 1999; Joussemet, & Koestner, 1999) and decreased creative expression (Amabile, 1982; Hennessey & Amabile, 1998; Hennessey, Amabile & Martinage, 1989). MBE points towards a different focus of education, one that addresses the needs of the 21st century student (Sousa, 2010; Tokuhama-Espinosa, 2010, 2011).

Schools in Crisis = Students in Crisis

We are now seeing the fallout of ten years of policy mandates that fail to provide for anything more than the most superficial learning goals. Our schools continue to demonstrate below grade level learning for many students,. but the true miscarriage of educational goals has been the ignorance of the emotional and physical needs of students. Research in the neuro and biological sciences recognizes the intimate connection between the emotional, physical and cognitive aspects of development in relation to maximizing students' potential. Motivation, as it relates to personal interests and desires, is central to cognitive development and provides the impetus for an individual to seek out learning as a pleasurable experience in a goal directed manner. The current system dehumanizes the educational experience, and has resulted in a crisis for our student body. The Center for Disease Control website reports increasing levels of ADHD in our student body, at a rate of 3% per year from 1997 to 2003, and an even higher rate of 5.5% increase per year from 2003-2007 ("ADHD Data & Statistics," 2013). This is associated with an increasing rate of prescribing psychotropic medications with some states reporting nearly 10% of their student body receiving drugs for ADHD ("ADHD Data & Statistics," 2013). Rising just as quickly are the number of students receiving drugs for mood disorders, with the CDC reporting nearly 4% of students age 11-17 being prescribed one or more antidepressant medication (Pratt, Brody & Gu, 2011). This trend does not speak well to the mental health of our students.

Perhaps even more disturbing is the degree of school violence perpetrated by students against students, a problem that has brought up the need to attend to the mental health of our students (Haigh & Collins, 2013). Zero tolerance policies have done little to reduce violence, but have simply increased the tension on school campuses as a growing feeling of a totalitarian regime expands into what used to be acceptable play activities (Fletcher-Bates, 2009). The increase in lethal violence in our schools has been attributed to the accessibility of guns, and yet, few discuss the source of the emotional despair that had driven these students to such extreme lengths.

The emotional wellbeing of students has been completely lost in our current focus on passing tests. Research from the neuro and cognitive science shines a powerful light on the importance of attending to not just the cognitive aspects of neural development, but to the physical and emotional aspects of the developing brain. As such, the field of MBE addresses not just the academic crisis occurring in our schools, but the more deeply disturbing trend towards heavily medicated students, violence, and the social ills that shadow a troubled populace. It is clear that we need a new way, and MBE offers a path of hope for addressing many of the core issues facing our schools and our students and for bringing us out of crisis towards a new ideal.

Developing a New Science of Education

One of the primary goals of MBE, according to Kurt Fischer, is “to join biology, cognitive science, development, and education in order to create a sound grounding of education in research" (p 3, 2009). The growing body of knowledge coming from the neurosciences, along with the desire and receptivity of teachers and educators to utilize this knowledge in their teaching (Pickering & Howard-Jones, 2007) makes MBE an alternative to the current assessment-based reform. MBE provides a model that addresses student needs on a biological level. It is proposed that brain research can indicate where changes in policy could be altered in order to better meet the biological needs of students, and hence, MBE may hold a key to transforming the current destructive policies into effective and healthy ones (Eisenhart & Towne, 2003).

Members of the MBE community agree that the current practice of HST is misaligned with a biologically informed model of education on a number of levels (Carlson & Levin, 2007; Fischer, 2009; Lang, 2010). In particular, HST focuses on lower order skills and does not support developing higher order cognitive capacities. HST are summative, and cannot measure the processes underlying learning, which are so intimately connected to biological processes of learning. As such, HST do not accurately inform teachers or districts as to the nature of learning happening in their students. This is supported by research from teachers, stating standardized tests are not accurate measures students' real abilities; and, more importantly, that their ability to engage students in higher level thinking and creative work is limited by the need to prepare for the test (Achinstein & Ogawa, 2006; Cawelti, 2006; Faulkner & Cook, 2006; Valli, et al. 2008). MBE provides an avenue to begin to examine how educational approaches support or constrain critical cognitive capacities and can provide the framework for understanding how to encourage a change in the system so that we are supporting teachers and schools to develop students' cognitive abilities.

Another concern often addressed by members of the MBE community is the emphasis of the testing on reading and math. When looking at the focus of research relevant to MBE, reading and math make up only a small portion of published articles. Music, movement, attention and emotion are just some of the areas that are critical to brain researchers studying the learning sciences (Blakemore & Frith, 2005; Hardiman, Magsamen, McKhann & Eilber, 2009; Posner & Rothbart, 2005, 2007a, 2007b). In general, MBE emphasizes the development of the brain with respect to cognitive development and the support of cognitive capacities, such as emotional intelligence, communication, critical thinking and creativity. MBE researchers argue that although it may be possible to evaluate cognitive capacities, these are not generally measureable by standardized tests (Lang, 2010). The recommendations of a school program as well as a system of assessment based on the principles of the developing human being are quite different from what is currently defined and implemented by NCLB. Unless policy is shifted to allow teachers to meet the diverse needs of their student body, it is unlikely that a curriculum based on the brain sciences will make progress in the public school system despite the concerted efforts of teachers, administrators and scientists.

MBE and Curricular Reform

In a recent article, Carew and Magsamen (2010) state, "Something must be done to prepare our children for a 21st century future, and here we propose that Neuro-education may provide one critical element toward a solution" (p 685). This new approach to educating, referred to as *neuroeducation*, is the part of the MBE initiative that holds a greatest potential to provide a framework for evidence-based practice that goes beyond HST. Through a deep understanding of the processes underlying human consciousness, learning, and development, neuroeducation brings the knowledge from the learning sciences about the developing nervous system into teaching practice (Tokuhama-Espinosa, 2010; Sousa, 2010; Suarez-Orozco & Sattin-Bajaj, 2010).

Although there is enthusiasm for this shift in focus, the reality is that there is as yet an unclear conception of a curricular model that could be applied in schools. Ansari and Coch (2006) state, “little attention has been paid to either an overarching conceptual framework or the mechanisms by which bridges between education and cognitive neuroscience might be built” (p 146). The pedagogical approach of neuroeducation (Hardiman, et al. 2009) is not directly aligned with any single curriculum, and more especially is not presently attached to specific content. Teachers trained in principles of neuroeducation indicated that understanding the brain is important for instruction design and delivery, but less important in curriculum content (Pickering & Howard-Jones,2007; Serpati & Loughan, 2012). Along these same lines, Ansari and Coch (2006) emphasize the point that neuroeducation is *not* about making radical changes in content knowledge, but is about developing cognitive capacities that can be utilized across content areas.

In this vein, it is necessary to define curriculum beyond the selection and delivery of content as has been the traditional view and represents the approach taken by text-books aligned with content-standards. The definition of curriculum as content selection and delivery reflects the view of curriculum as *transmission*, curriculum based on objectives, or curriculum as a product. It is these product oriented definitions that have taken hold in our schools today. Modern education must move beyond these limiting definitions of curriculum if we are to embrace dynamic forms of schooling and encourage self-directed learning. Curriculum theorists from Dewey to Freire call for moving beyond the selection of content and creation of learning objectives towards creating curriculum that empowers the student and teacher and addresses the dynamic nature of learning. The process model of curriculum views learning as a dynamic goal rather than something that can be dictated through the creation of an external objective (McKernan, 2008; Stenhouse, 1975). The process model can be combined with the praxis model of curriculum which views curriculum as the means of transforming the world through reflection and action (Freire, 1972). Neuroeducation supports these definitions of curriculum over the product or transmission models more common in today's public schools.

Academic content, as discussed by educational neuroscientists, is often examined in terms of higher level explanations of cognitive development and systems level neuroscience (SLN) (Ansari, 2010; Hruby, 2011). To this extent, guidelines as to when certain aspects of content should be introduced in the classroom are a central aspect of neuroeducation. Based on developmental milestones and knowledge of critical and sensitive periods, a curriculum of neuroeducation provides guidance to teachers and policy makers concerned with maximizing students' inherent abilities. A core component of this thesis will be to demonstrate both the pedagogical implication of a program of neuroeducation, as well as to describe how neuroeducation may help to guide content decisions even in this age of testing, state content standards and accountability.

Statement of the Problem

As the new multidisciplinary effort of MBE develops, there will be a need to define the field on several levels. As of yet, there is no clear construct definition of either a curriculum associated with the effort, or a clearly articulated vision of where and how this reform effort will take place. MBE requires combining multiple levels of analysis in order to connect research with practice. As such, there is a need to develop the definition of the field from the perspective of the various stakeholders whose domains of knowledge reside in disparate fields. Creating a novel construct definition to confront the challenges while revealing the benefits of developing a program of MBE, will require a concerted effort on the part of researchers and educational leaders.

If this new field is to succeed, we must evaluate its potential to create lasting and significant change within the current content of education. To do so requires examining what supports and constraints are in place towards allowing the recommendations from MBE to enter the educational mainstream. Critically affecting the implementation of MBE is the current policy and use of HST. The pressure to assure that students will obtain passing test scores has directed school focus and curriculum (Valli, et al, 2008) and has driven school educational leaders towards a rigid response of maintaining status quo (Daly, 2009). Given the radically different framework necessitated by MBE, teachers and educational leaders facing punitive sanctions with program improvement often do not see this type of education as a viable option. Part of the fear of leaders to make this change relates to another major challenged faced by MBE, that is the lack of empirical evidence supporting the ability of MBE curricular models to produce their purported effects.

There is presently a dire need to address what is happening in education with respect to the student. Each generation that we continue to educate using policy and practice misaligned with the development of the brain represents a loss of creative and human potential necessary for finding solutions to the problems facing a rapidly changing world. Carew and Magsamen (2010) ask the question, “If not now, what price will we pay in 10 years?” The authors point to the changes that will be necessary with dwindling budgets and escalating student needs. The dearth of empirical research on student outcomes beyond standardized reading and math scores currently limits the ability to provide the necessary evidence based practice guidelines for teachers and administrators making school or district-wide curriculum decisions. This empirical work will become critical when making decisions as to what programs will be on the chopping block.

Purpose Statement

The pieces are in place to begin to address the issues relevant to bringing effective education based on the brain and learning sciences to the forefront of discussion surrounding education reform. The purpose of this research is to demonstrate what the new field of MBE can provide for a future of education that will meet the needs of students facing an unknown globalized world. In defining a purpose it is essential to have a vision. The vision is defined as much by what it believes in as with those things that are antagonistic to it. Defining the boundaries of the emerging field, and creating a clear operationalized construct definition of MBE, the emerging effort must be recognized in terms of its organizational and leadership components as well as for its recommendations for curricular frameworks. In addition to defining the field, the extended purpose of this research was to contribute to the empirical research base and to provide an example of how to work within the current system as a first step toward the necessary “proof of concept” of neuroeducation. The means of achieving the purpose of this study was to look across multiple levels with the intention of bridging the divide between research and practice. This was done while keeping in focus an awareness of the current context of educational policy and practice and the history of parallel reform efforts.

Through assuring that pivotal findings coming out of the field of MBE and educational neuroscience are made available to those in positions of influence, including teachers, administrators, and educational leaders, it is possible that we will begin to evolve our educational practice towards healthful experiences aligned with brain development. The goal of MBE is to promote the full development of the range of cognitive skills that will be necessary for the future of the country in the era of globalization.

Research Questions

The researcher set out to address three primary questions.

First, *How is MBE defined and what are its central goals?* How is MBE defined by various contributing stakeholders? How do the separate factions of the academic community, administrators and consultants view MBE with respect to informing policy and practice? What are the implications for how this effort can take shape within our school system?

Second, *What is the consensus regarding a curricular model of neuroeducation?* What are the agreed upon components of a curricular model of neuroeducation? What are the content suggestions for this curriculum? What are the implications for teaching?

Third, *Can we create a "proof of concept" by using existing models of education?* Can we evaluate existing models of education for their alignment with the principles of neuroeducation? How do students in alternative educational programs aligned with the principles of neuroeducation perform academically, on standardized tests, and on measures of higher level cognition? How can this approach be used to advance the empirical base for building effective programs of neuroeducation?

Study Overview

The following study used a multi-level mixed-methods design (Creswell, 2008) to achieve two goals: (1) to inform the research questions moving sequentially towards levels of inquiry closer to the classroom, (2) to evaluate active models of education aligned with the principles of neuroeducation for their potential value as a method for developing an empirical research base for MBE.

The research was conducted in three phases, one qualitative, one using mixed methods, and a final comparative case study. These phases were conducted in a semi-overlapping sequence, but in general, the first two phases were completed as to direct and inform the final phase. Overall findings from each phase acted to inform the questions and approaches taken in the other two phases. Specifically, findings from phase one contributed to the selection of relevant survey instruments for phase three, and the findings from evaluation of school pedagogies in phase two contributed to an additional focus of the interviews on curriculum in phase one. The intention of this design was to be able to use the emerging data to inform the process of data collection and maintain the connection between the separate phases to aid in making global inferences from the completed study.

One of the goals of this dissertation is to determine how we might begin to work toward developing an effective curricular model of neuroeducation. This goal was embedded within each of the research phases, as well as being a focus of the initial literature review. Three primary approaches to developing an initial construct definition were taken here: (1) the construction of a model based on the literature, (2) the expansion of this construct-model based on conversations with educational leaders in MBE, and (3) the evaluation of existing school pedagogies for alignment with the model.

The initial approach towards the creation of a conceptual framework was to examine the literature from the brain and learning sciences to create a model which could prove useful for providing a framework for points of connection between theories and research from neuro and cognitive science towards classroom practices. For the creation of this initial model, the literature on education in neuroscience was reviewed, drawing on repeating themes in books, edited books and review articles. From this process ten research themes emerged from which it was possible to begin to define the relevant research areas or categories (see Chapter 2 for a review of these themes and a description of the model). The model addressed the research content relevant to MBE and divided it into four themes: primary (central themes), secondary (mediating factors) and tertiary (emergent capacities), and one meta-theme (development). The construct definition was then used throughout the thesis as a framework for evaluating the literature, evaluating existing pedagogical approaches, and as a comparison with findings from the research presented here. The importance of this initial construct definition is to help understand and organize the broad research base from which the field of MBE draws its knowledge in order to help create that first step in creating an effective model of education based on the neuro- and cognitive sciences.

The second phase of developing a curricular model was based on findings from interviews with academics. This was done through the coding and evaluation of emergent themes, and initially without reference to the construct definition developed from the literature. The findings from the interviews were then categorized into their own framework, and the two models were compared. Differences between the two were discussed, and changes to original model were made as a synthesis in order to create a synthesized model of neuroeducation.

Finally, a similar approach as to what has been promoted by Suarez-Orozco and Sattin-Bajaj (2010) in their evaluation of the Ross school model is taken as part of this dissertation research. In their edited book on the Ross school model, Suarez-Orozco and Sattin-Bajaj (2010) describe the goals and success of one school's approach to education as it related to the field of MBE and the research in educational neuroscience. In this dissertation, the final evaluation of the construct definition of neuroeducation is used to evaluate two alternative models of education, Waldorf and International Baccalaureate. These two schools, applying a number of principles of neuroeducation, were then assessed for their impact on student outcomes. It is hoped that through the use of forward and backward mapping of the goals and concepts of neuroeducation, MBE efforts will more quickly and easily transition effectively from theory into practice.

Significance of the Study

The significance of this study can be viewed on a short and a long time frame. In the short term, the pressing issue affecting our students and schools can be informed by this study through demonstrating the unbalanced focus of our classroom practices and in particular our system of accountability. Under the federally mandated testing regimes effective schools that are meeting the emotional, cognitive and developmental needs of students are currently not being assessed in those important goals most directly relevant to life-outcomes. The rate of discovery from the learning sciences and the intense desire on the part of practitioners to use this information makes this study a timely issue that can help to contribute to understanding how to bring that science to teachers. Using the emerging structures of MBE it is possible to imagine a change in the way we educate to be better aligned with brain development. In the long term, working towards a collaborative system of education based in the brain science can only help to improve practice and understanding on the part of the educator. It is important that there be clearly understood guides and constructs if we are to be sure not to misapply the findings from the sciences. There is great enthusiasm and market value in creating a curricular model of neuroeducation. This research is intended to produce a grounded look at where we may be able to successfully connect the findings in the sciences with practices in the classroom. By understanding what is possible, and practical to apply to education right now, it is hoped that the mystique of the multi-colored brain sciences will be transformed into meaningful constructs for a curriculum of neuroeducation.

Definitions of Terms

Brain Based Education: The popularized term referring to educational programs designed to be aligned with the brain. The commercialization of this term has lead researchers to prefer the use of neuroeducation, educational neuroscience, and/or mind, brain and education science. However, the term is still in popular use, especially in the educational community.

Cognitive Science: Christopher Longuet-Higgins coined this term in 1973. Cognitive science is an interdisciplinary field melding computer science, psychology, neuroscience, artificial intelligence, anthropology, linguistics, psychology and philosophy.

*Cortex (*plural: *Cortices)*: Also referred to as neocortex, the cortex is the columnar cell layer of the brain thought to be the source of consciousness and high-level cognitive functions. It is organized based on sensory modalities and undergoes changes based on experience in a process referred to as neuroplasticity.

Critical Periods: Points in the development of the human being during which specific biological and environmental stimuli are required for the unfolding of genetic programs. Failure to provide particular environmental stimuli during these periods will result in permanent anomalies in the organization of the brain.

Curriculum: The term used to describe everything from the objectives, content and sequence of presentation of that content, to the processes of learning. The definition most useful in neuroeducation is that of curriculum as the process of learning (Stenhouse 1975).

Dendrite: The terminal end of a brain cell fiber, distinct from the cell body. Dendrites receive input from incoming cellular inputs and neighboring cell axons and dendrites.

Dendritic Arborization: The process by which the dendrites of a cell expand their branching providing a greater spatial network on which to connect to and process incoming and neighboring information. Greater dendritic arborization is associated with more complexity of cell connections and is increased in enriched environments.

Executive Functions: A term made popular by cognitive science, and applied to the functions of the frontal cortex by Patricia Goldman-Rakic. Executive functions describe the neural processes responsible for intentional planning of actions. Executive functions are shown to critically involve the dorsolateral prefrontal cortex, and have been shown to be important in both executing intended actions as well as inhibiting prepotent responses.

Holistic Education: Holistic education refers to a humanistic educational approach in which the student is regarded first as a human being within a community. The role of the individual self is respected in holistic education, and practical programs often include activities designed to help students express their life experiences as well as to develop a love and appreciation of learning. Holistic education integrates physical, social-emotional, cognitive and spiritual aspects of learning into the curriculum.

Limbic System: The limbic system is comprised of the hippocampus, amygdala, cingulate cortex, regions of the ventral striatum and several inter-related areas of the thalamus and hypothalamus. The practical categorization of the limbic system as a functional system is refuted in part because of its limited definition in its first inception. However, the term limbic system is a generally accepted term in relation to the brain regions mentioned here as they functionally relate to emotional cognition.

Long Term Potentiation: The process by which synapses strengthen their connections. LTP has been implicated in memory and is associated with activating a series of biochemical pathways now known to further influence synaptogenesis and dendritic spine growth.

Mind, Brain and Education Science, AKA *Mind, Brain and Education*: The term agreed upon in the 2005 Delphi panel to indicate the emerging field comprised of multidisciplinary research from neuroscience, psychology, cognitive science and education. This term has taken formal standing with the 2006 establishment of the International Society for Mind Brain and Education Science with Howard Gardner and

Kurt Fischer as co-founders. The major goal of MBE is to bridge the gap between the separate disciplines through direct dialogue between researchers and educators. This term is preferred in relation to academic programs, while neuroeducation may be better suited for classroom activities and in relation to the teacher as a neuroeducator.

Neuroeducation: Defined by Zenhausern (1982, p 122), "Neuroeducation is a term that can be applied to that aspect of education that focuses on the interaction of the brain and behavior in learning systems." (from Sonnier & Goldsmith, 2005) Neuroeducation has also been used to describe the emerging interdisciplinary field of Mind, Brain and Education. It has recently gained credibility with its adoption by the Dana Alliance and John Hopkins, http://www.dana.org/news/publications/publication.aspx?id=23964

Neuroeducator: A term defined by Howard Gardner (2008) as "a professional who is grounded in both the theories and research of neuroscience and in the practice of education" (p 165). This term is most frequently used with regard to the classroom teacher.

Neurogenesis: The process of cell birth previously thought to end *in utero*. It is now known that neurogenesis occurs in multiple brain regions, including the hippocampus and the cortex, and continues throughout development even into adulthood.

Neuron: The brain cell most frequently associated with functions of communicating messages throughout the brain.

Neuroplasticity: A process by which cells change their functional connectivity and responsivity during development as well as into adulthood.

Neuroscience: The science of the nervous system. Originally a branch of biology, neuroscience has expanded to include all aspects of brain structure and function. The Society for Neuroscience was formed in 1969. Educational neuroscience represents one of a number of offshoots of sub-disciplines of neuroscience and relates to the issues in neuroscience as they directly relate to issues in education.

Neurotransmitters: The chemicals produced by neurons used to communicate between cells.

Sensitive Periods: Periods in development during which a human (or organism) is primed to develop certain skills. Utilization of sensitive periods for the full development of neural systems is an important aspect of creating a developmentally appropriate educational pedagogy.

Somatosensorimotor System: The system of sensory integration from the sense receptors in the skin, joints, and muscles with the motor networks producing both overt and covert responses of movement and attention. The somatosensorimotor system integrally involves the basal ganglia comprised of the dorsal striatal loop of subthalamic nucleus, globus pallidus, caudate and putamen, with cortical inputs from both primary and secondary sensory and motor cortex, as well as from prefrontal cortex.

Synapse: The point of communication between brain cells. The synapse is the junction over which neurotransmitters are released in a process first known as chemical synaptic transmission established by Henry Dale & Otto Loewi around 1936. The response of adjoining cells during synaptic transmission is electrical and this aspect of the process of neurotransmission was advanced by John Eccles around the same time.

Synaptic Pruning: The reduction of an overabundance of synapses. Synaptic pruning is seen as the tuning of the nervous system during development and also may reflect processes of refining neuronal networks or cell assemblies in adulthood.

Synaptogenesis: Creation of new synapses. Synaptogenesis is seen most heavily in early brain development, but continues throughout adulthood and has been implicated in processes of learning and memory

CHAPTER 2: Literature Review

The following literature review provides the impetus for the studies proposed here. It is intended to give the reader a basic understanding of the history and present status of the field of Mind, Brain and Education (MBE) and its related fields of educational neuroscience and neuroeducation. The process of bringing together research findings from the neurosciences and educational practice requires addressing relevant topics across each field in order to find points of connection. Hence the literature review covers a broad range of material with the goal of addressing theoretical, conceptual and practical issues.

The first section of the review gives a historical narrative of some of the most prominent neuroscience research as it has influenced the thinking of educators and educational leaders, including creating false beliefs and inappropriate practices. The second section of the review outlines the central findings from neuroscience, psychology and cognitive science as they provide useful knowledge to the creation of effective pedagogy. This differs from the historical review in that it attempts to create a model of what are the critical factors that can be gleaned from the research in a general sense. Such a model would be useful in creating and evaluating curricular models, and/or guiding practice. The third section discusses classroom pedagogies and practices that are supported by neuroeducators and are aligned with the learning sciences. This section also reviews two complete curricular models, Waldorf and IB. The final section examines the role of MBE in education reform. This section in intended to place MBE in the context of our present educational policies, in particular those of NCLB, HST, and the coming Common Core State Standards (CCSS).

Section 1: A History of Brain Research in Education

Neuroeducation as a curricular model has yet to be fully enunciated. Nonetheless, there have been significant influences from child development, psychology and brain research that have shaped our understanding and have impacted practice in our present system of education. To be sure, the history of the implementation of scientific findings from brain research into education is imbued with misunderstandings and pseudoscience (Howard-Jones, 2008). Despite this, however small, certain more enduring aspects of pedagogy from the neurosciences have found their way into traditional practice. Until recently, these advances in the knowledge base resulting from significant scientific findings were incorporated into teaching practice without the input of scientists themselves. It has only been in the last decade, with the formation of MBE focused on interdisciplinary collaboration, that the influence of science on teaching practice has seen the direct participation by the scientific researcher. Critical points in this history are selectively reviewed here, demonstrating a pattern of discovery in science, to adoption into classroom practice, and frequently misinterpretation and inappropriate adoption of models. It is believed that the most recent discoveries discussed here are only at the initial phase of adoption, with the potential to be misapplied if scientists do not quell the rising tide of marketing. It is hopeful that this pattern of discovery, adoption, and misapplication can be limited now that scientists are more closely connected to the classroom through MBE.

Stress, Hemispheric Specialization & Brain-Based Education

The use of scientific research in informing educational practices has its roots long before the existence of neuroscience as a field. Probably the most influential scientific research used as a framework for education has come from behaviorism (Skinner, 1953, 1958). A full history of the psychology of behavioral conditioning—the core of behaviorism, and its major contributors, i.e. Watson, Pavlov and Skinner, deserves a critical examination both with respect to its validity to teaching and learning, but also with regards to its political and social implications. However, it is beyond the scope of this dissertation to go into the complexities and lengthy history of this field of research including the historical explanation as to why it was selected and why it is a poor fit for any system of education in a free society. Sufficed to say, our current model is based heavily on the principles of behaviorism, and likely this is due to political and economic forces more than the influence of modern scientific principles of learning.

The earliest research derived directly from the brain sciences to find practical application in classroom practice can be said to have come from two areas. Early research on stress, including the work from the originator of the term, Hans Selye (1950), found its way into educational literature in the early 80s, and represented some of the earliest crossover scholarship (Sylwester, 1981). The second area came out of the hemispheric isolation studies by Roger Sperry (1968) which showed distinctive function of right and left hemispheres in patients who had had the connecting fibers between their two hemispheres (corpus callosum) severed in order to reduce the severity of epileptic seizures.

Although there was great interest in this work by educators from the beginning, the manner in which the science found its way into practice resulted in much of the actual science being lost or misinterpreted. In the 1980’s, in response to the hemispheric and stress research, several pedagogical approaches claiming to be supported by brain research were adopted, only later to be refuted (see Tokuhama-Espinosa, 2008; Sousa 2010 Chapter 1). This was the beginning of a growing divide between marketization of products versus educational neuroscience as a domain of research.

During the presidency of George Herbert Walker Bush, the 1990s were declared the decade of the Brain, and interest in applications for the increasing knowledge from the brain science grew exponentially. In 1991, ushering in the decade of the brain, Renate and Geoffrey Caine published their book *Making Connections: Teaching and the Human Brain*, a wildly popular book that paved the way for applications of neuroscience into classroom practice and demonstrated the receptivity of teachers and educational leaders to this work. Unfortunately, the desire to translate science into practice in many instances out-paced the slow rate of validation required by the scientific process. Moreover, the small handful of dedicated translators who were willing to walk the line between science and education, reading and talking with both parties, were unable to fulfill the immense demand for classroom applications. It was at this time that another group appeared to fill the growing void—the entrepreneurs with primarily commercial interests. This period in the history of neuroscience in education has been referred to as the *brain-based education* phase.

A lot has been made of the term brain-based education, and for many who lived through this period the word has become synonymous with superficial programs that were hardly aligned with the brain science. If we are not conscientious we may face a rehashing of this abuse of the science with a new cycle of entrepreneurs. It is unlikely that the terms educational neuroscience, or Mind, Brain and Education will suffer the fate of commercialization that the term brain-based has; but the term *neuroeducation* is beginning to be popularized, and although it has been used by some of the core participants in this movement, such as Howard Gardner (2008) and the researchers at John Hopkins (Hardiman, Magsamen, McKhann & Eilber, 2009), one can already go online and find websites claiming to have videogames to train your brain under the heading of neuroeducation.

However, the term neuroeducation holds exceptional explanatory value, and a distinction is made by this author regarding the term neuroeducation, which represents the curricular component of the movement to join neuroscience and education, and MBE which includes neuroeducation but further addresses the policy and organizational system level issues. Neuroeducation is a useful term as it can be more easily applied to the pedagogy and curriculum models and is accessible to a wider audience of teachers and parents who could be intimidated by overly academic language. The term neuroeducation, however, must be guarded against being co-opted for profit, or we will face confusion on the part of educators hoping to increase their knowledge base.

During the brain-based education phase, many of the programs and products designed for teachers contributed to the confusion surrounding the mystery of the brain and education. In addition to the false marketing, however, there were a number of misunderstandings generated simply by the general psyche. The term *neuromyths* has been used to describe this misinterpretation of scientific research and continues to persist in the general belief systems about the brain (Christodoulou & Gaab, 2009; Goswami, 2006). For example, although the science does not support this idea, most people believe there are right-brained or left-brained people. The myth that we use only 10% of our brain is so far from the reality of brain function that it is difficult to fathom how it entered the general consciousness (Beyertsein, 1999). These misconceptions have been contested by members of the academic and MBE community as being misleading over-simplifications of how the brain actually engages in learning (Corballis, 1999; Hardiman, Rinne, Gregory & Yarmolinskaya, 2011; Tokuhama-Espinosa, 2010). Worse yet, programs that have been developed from these beliefs, such as Brain Gym (Dennison & Dennison, 1994) and Learning Styles (Dunn & Dunn, 1978; Honey & Mumford, 1982) are still in use today, and have been said to work against the validation of a true program of neuroeducation (Tokuhama-Espinosa, 2008).

Although there has been a strong negative response from the scientific community towards many of the generalizations about the brain that have entered the collective beliefs, to a certain degree some value has come from the generation of theoretical models. Such models have provided certain starting points for changing educational practice. For example, much of the stress research drew not only on the neurohormonal impacts of stress, but on the systems level theory of Paul MacLean, as described in his model in *The Triune Brain* (1990). This neuroanatomical model of brain function has been continually supported as a valuable heuristic, even though it is recognized as a gross oversimplification of the actual functional neuroanatomy of the brain (Smith, 2010). Although many of the models and programs developed under the guise of brain-based education have been refuted by scientists, in some ways these programs brought attention to issues that were previously ignored and paved the way for the entry of neuroscience into educational circles. The theoretical value of the various models, including those mentioned here, is part of the process of the translation of neuroscience into pedagogy and curriculum and must become a central focus of MBE if we are to transform the process of discovery, adoption, misapplication, into discovery, adoption, validation.

Enriched Environments & Critical Periods

Emerging slightly later on the educational scene was the research from two separate laboratories revealing the impact of enriched environments on brain structures (Diamond, Krech, & Rosenzweig, 1964; Black, Sirevaag, Wallace, Savin, & Greenough, 1989). What this research, conducted in rat and animal models, concluded was that exposure to enriched experiences changed the dendritic arborization and functional connectivity of brain cell networks (Diamond, et al. 1964). Furthermore, enrichment resulted in dramatic physical changes impacting the entire animal including a change in the rate of cellular growth and organ size (Black, et al. 1989). Greenough, Black, & Wallace, (1987) went on to look at this model in relation to what they referred to as experience-dependent, versus experience-expectant brain effects. This model indicated that certain neural connections were born through pruning of excessive synapses present following birth, while other connections were made through repeated exposure to environmental stimuli that may or may not have been evolutionarily pre-selected. Rather than viewing the brain as fixed, there was now a model to show that the structure of the brain was altered through experience.

Unfortunately these finding were taken out of context, and soon the enrichment fad began. The interpretation by educators of this science was that through adding more stimulation to the environment the brain would grow and make more connection. Rather than enrichment, teachers created what has been called by some over-enriched environments. “An over-enriched space is probably cluttered with too many alternatives.

We do not stop and process on them. We just scan." (quote in Radin, 2005, p 53). Nothing in the research supported this interpretation of the research, which in reality simply provided a more naturalistic environment for rats versus the impoverished environment of the standard laboratory housing. The failure to adequately translate the research into educational practice led teachers towards behaviors that did nothing more than create chaotic learning environments with disconnected materials.

Research on critical periods and sensitive periods has suffered a similar fate as that on enriched environments. Critical periods are those developmental windows when it is absolutely imperative that the organism gain particular experiences, while sensitive periods reflect developmental windows where it is easier to learn particular skills (Colombo, 1982; Knudsen, 2004). Developmental research in this area reflects a serious scientific study of the capacity for learning at various stages of development—such as when an organism is primed to learn a particular skill, as in the unfolding of a cognitive ability such as language (Kuhl, Conboy, Padden, Nelson & Pruitt, 2005). The reason for the misinterpretation of the data came from a leap in logic and methodology. A problem recognized as one of the significant barriers to the success of educational neuroscience (Hruby, 2012).

The research which was so misinterpreted originated from the work of Peter Huttenlocher (1979) on the developmental timecourse of synapse formation, i.e. synaptogenesis. Dr. Huttenlocher showed that the actual number of synapses—points of connections between brain cells whereby cells communicate—continued to rise until the age of three and then diminished with three periods of plateaus up until adolescence. The rapidity of synapse loss after age three, known as synaptic pruning, came to signify a loss in cognitive ability and that the period of high rates of synaptogenesis were a critical period for learning. The subsequent emphasis on the first three years as a critical period for education infiltrated educational policy and practice in programs such as "Starting Points", and the "I Am Your Child" campaign (see Bruer, 1999 for historical review).

Of course those early periods of development are important, but when examining higher level cognition, and those areas that are most frequently addressed in formal education, the brain continues to mature into the early 20s (Willis, 2011). In truth, periods of development in relationship to synaptic pruning or synaptogenesis do not address the phenomenological aspects of learning and behavior which should be looked at in terms of systems level development (Gotay, et al 2004). Indeed current research in this area, especially in the work on adult neurogenesis, long term potentiation (LTP) and synaptic plasticity, has begun to show behavioral changes in learning as they are associated with cellular mechanisms well into adulthood, and well beyond the synaptogenesis of the first three years of life. These advances in our understanding of cellular mechanisms have great potential to guide behavioral aspects of learning in education.

Neuroplasticity: The Fantastic Plastic Machine

Perhaps one of the most exciting finding from the past decade is the revolution in our understanding of neuroplasticity and how that relates to the dynamic nature of the structure and function of neuronal networks and cell assemblies. Although aspects of activity dependent neuroplasticity in development had been demonstrated for some years (Hubel & Weisel, 1963; Sperry, 1958; Weisel & Hubel, 1963), we now know this activity dependence begins even in utero (Shatz, 1994, 1996), and that it is the natural phenomenon or rule by which the brain is interconnected. Renewed interest in neuroplasticity came from research done by Micheal Merzenich and colleagues (see Buonomano & Merzenich, 1998) showing the expansion of functional brain regions once thought to be immutable. According to this research, primary sensory and motor cortices were no longer hard-wired maps, they were plastic regions in which cells could change their functionality as well as their connectivity. Imaging techniques made it possible to begin to look at similar phenomenon in humans. Studies showing that learning new skills, such as juggling, increased cortical gray matter, i.e. cell bodies, further supported the incredible plasticity of the brain (Draganski, Gaser. Busch, Schuierer & Bogdahn,. 2004; Driemeyer, Boyke, Gaser, Buchel & May, 2008). Most recently there has been added an additional layer of complexity to the story of neuronal flexibility. Neurons previously thought to be differentiated to produce specific neurochemicals, i.e. neurotransmitters, have been shown to not only change their functionality and connectivity, but also to change the type of neurotransmitter they produce (Spitzer, 2012; Velazquez-Ulloa, Spitzer & Dulcis, 2011), this adds a layer of complexity and flexibility within the networks of cell assemblies once thought to be fixed in their neurochemical and structural make-up.

Currently, efforts to take advantage of this knowledge have emerged through the work of neuroscientists who have developed interventions, in particular the program FastForWord® developed by Merzenich and Tallal, but also by neuropsychologists and educational consultants have begun to emphasize the importance of understanding neuroplasticity as critical for student and teacher awareness of these processes in the way they teach and learn (Dweck, 2006). However, in addition to effective programs, there are currently programs, in particular the use of video games designed to train your brain, that have attempted to monopolize the market on plasticity (see Bavelier, Green, Han, Renshaw, Merzenich & Gentile, 2011 for commentary). If we are to create a model of education based on the true science, it will be important for researchers to participate in the process of finding the place for the sciences within the current framework of education (Christodoulou & Gaab, 2009).

Adult Neurogenesis: Look Ma, New Brain Cells!

Perhaps one of the biggest shifts in thinking about the brain occurred with the eradication of the dogmatic belief that at birth humans are endowed with our full count of neurons, and that no new neurons produced in adulthood. Historically, research on the production of new brain cells into adulthood, i.e. adult neurogenesis, had been recognized for years in both rat hippocampal dentate gyurs (Altman & Das, 1965; Altman & Das,1967) and specialized regions of the bird brain (Nottebohm, 1981). Unfortunately, the belief that the bird brain or rodent brain needed to produce new neurons due to its size helped maintain the idea that adult humans and higher mammals did not produce new neurons in adulthood (Rakic, 1985). It wasn’t until 1999 when Elizabeth Gould published an article in the well-respected journal, *Science*, that this dogma was shattered forever (Gould, Reeves, Graziano & Gross, 1999). Gould demonstrated not only that adult neurogenesis occurred in the monkey brain, but that it occurred in the cortex, the region of the brain attributed to higher conscious processes, as well as the hippocampus. To further advance this idea that new neurons continue to be produced into adulthood, researchers at UC San Diego published findings of adult neurogenesis in the *human* hippocampus (Eriksson, Perfilieva, Bjork-Eriksson, Laborn, Nordborg, Peterson & Gage, 1998). This paradigm shift changed the way we looked at neural circuitry and has found relevant connections to our understanding in relation to education. However, the deeper details of the processes of adult neurogenesis have been somewhat diluted, and again there exists the very real possibility of misinterpretation of the science.

One of the most common misinterpretations is that increases in adult neurogenesis necessarily indicate increases in memory formation. It is interesting to note that much of the research on adult neurogenesis has been related to formation of memories, and not surprisingly the hippocampus has long been associated with memory formation (O'Keefe & Nadel, 1978). The research in songbirds, however, was the earliest to examine the mechanisms by which adult neurogenesis contributed to the processes of learning (for review see Nottebohm, 2005). This model can be used to show how making direct comparisons between the rate of neurogenesis and memory formation is a gross oversimplification of the science. Specialized birdsong circuitry undergo seasonal changes in the rate of neurogenesis. Notably, high rates of neurogenesis are associated with learning of new syllables from peer-songs (Wilbrecht, Williams, Gangadhar & Nottebohm, 2006). However, the actually consolidation of the learning is said to take place when the neurogenesis decreases. This final phase of learning requires that neurogenesis halt, and that the cells undergo a process known as crystallization (see Leonardo & Konishi, 1999). These data show that the story of neurogenesis is more complex that simply the creation of new neurons. It is the manner in which the cells are incorporated into functional networks that is truly the critical factor (Wilbrecht, Crionas, Nottebohm, 2002). Both increased rates of neurogenesis, and decreasing rates of neurogenesis are part of the learning process. The misinterpretation of these processes could be harmful especially for those who look for pharmacological enhancements of memory, since many of the drugs which increase neurogenesis also impair memory (Cameron, McEwen, & Gould, 1995).

In education today there has already been a rushed conclusion that providing exercise to students will increase both neurogenesis and by conclusion their rates of learning. This conclusion was based on the highly influential study showing an increase in neurogenesis in mice that spent time on a running wheel (van Praag, Christie, Sejnowski, & Gage, 1999). It is not to say that exercise isn't important for brain health, and that it isn't a potential means for enhancing learning and memory, but the overzealous generalization of this study has led to beliefs in which the subtleties of brain research are lost, a phenomenon which in the past has led to misapplication of the research. Nonetheless, the research in adult neurogenesis has changed the way we view the potential of the brain.

The implications of the findings relating to the changing structural architecture of the brain in relation to experience have not been lost on those in education. However, translating this research into practice is still a matter of clarifying those theoretical underpinnings between the science and the classroom practice. What does it mean when we recognize that our interactions are shaping the structure and neurochemistry of our students' brains? What does it mean when learning is understood for its functional and structural impact on the brain? The responsibility of teachers as shaping the architecture and neurochemistry of the brain brings about the discussion of ethics in education. By not providing teachers with an awareness of how they might be interfering with natural processes of learning, or how they may be mis-wiring the brain is one that deserves attention in relation to questions regarding whether we should move forward in the agenda of neuroeducation. Understanding the processes by which such changes take place would be invaluable to teachers struggling to fully engage students in their own learning and would move us towards truly equitable education for all.

Expanding Research and New Technologies

The role of technologies allowing scientists to examine the brain in relation to higher cognitive processes is in many ways responsible for making connections between the social sciences and neurosciences (Thompson, 2002). The now historic research on mapping cognitive functions in the brain using MRI and fMRI (Posner, Petersen, Fox & Raichle, 1988; Posner & Raichle, 1998) has expanded into tensor mapping of cortical white matter, transcranial magnetic stimulation (TMS), near infrared spectroscopy (NIRS), and even advanced uses of older technology such as Positron Emission Tomography (PET), or electroencephalography (EEG). Because of these new technologies, brain sciences have begun to quantify aspects of human thought and behavior that were once solely the domain of philosophy, such as insight (Raichle, 2010), spontaneous thought (Christoff, Ream & Gabrieli, 2004) and creativity (Heilman, Nadeau & Beversdorf, 2003). Advances in computer technologies have allowed the ability to map activity across the entire development of the brain, and to map dynamic changes in structure in relation to functioning of everything from emotions to critical thinking, to changes in neurochemistry (Stoessl, Brooks, & Eidelberg, 2011). The wealth of data generated from these brain mapping studies makes it possible to create data banks, such has been created in the genome project. This has made ways for examining implications for the social sciences, education and even policy decisions (Zwillich, 2001).

From Localization of Function to Dynamic Systems

Early research by Broadmann mapped the unique cytoarchitecture in differing brain regions, giving rise to theories of structural and functional organization of the brain regions (for historical review see Zilles & Amunts, 2010). The idea of localization of function was further supported by the revelation of consistent somatotopic maps representing the human body, i.e. a homunculus (Penfield & Rasmussen, 1950). The more dramatic flexibility of the organization of the brain as it is supported by adult neurogenesis and neuroplasticity has taken a quantum leap away from linear systems models and localization of function into dynamic systems models of the interaction of brain structure and function. The neural assemblies, once thought to be functionally static, have moved towards a quantum model of dynamic systems (Smith & Thelen, 2003). Taking advantage of the dynamic systems model requires a shift in the way we envision classroom practices. Passive, linear presentation of knowledge is not suited for learning in such a dynamic system. There must be the allowance for the emergence of higher order thinking through a non-linear approach. Davis, Smith, & Leflore (2008) developed a model of classroom engagement based on the use of dialetics and to evoke principles from quantum mechanics. This approach is intended to engage students in conversation and discussion to build ideas utilizing concepts from quantum physics, including attractors and catastrophe shelf. The use of non-linear dynamics as a means of understanding how to teach is an approach that has is supported by members of the MBE community (Steenbeek & van Geert, 2008).

As of yet there has not been the misapplication of findings from the dynamic-systems model. It will be up to members of the MBE community to remain vigilant when such approaches begin to be adopted on a large scale, and to intervene quickly when new products claiming to be based on the science are developed without scientific validation.

The road to developing an effective program of development and validation has been long. Now we are in the position to begin that process. The next step will be active participation in the creation of a large scale model of standards and benchmarks that are aligned with the brain development. The creation of a curricular framework for teachers and schools to meet the needs of the developing nervous system requires that we build a construct definition of how the science can provide a framework for educators across all critical domains. This next section works towards building a skeleton of such a framework based on the literature from scientists and educators working at the intersection of research and praxis.

Section 2: Understanding the Science of Learning

The foundation of a curriculum of neuroeducation must come from the research and findings from the fields of the brain sciences. The purpose of this section of the literature review is to begin to develop a model of neuroeducation based on recurring themes in the primary research base. The creation of a working model would be useful in several ways. First, by starting from what basic science has to offer without constraints one can create a global framework. Without a global model, there is a tendency to work in a rather piecemeal manner resulting in a fragmented view of learning. To maintain fidelity to the scientific findings that span across disciplines a global framework is designed to show how critical components to education are related. Second, even a working model would be useful in the present stage to aid educators in the evaluation of existing pedagogical practices, something that is recognized as needed by the various members of this emerging field (Ansari & Coch, 2006). Finally, a model of neuroeducation would aid in the creation of a shared vision of the field and to help guide educational leaders in spearheading initiatives. This first step in defining the emerging field is needed to create a common vision so critical to any effective reform effort.

There is a wealth of relevant science currently contributing to the field of educational neuroscience and MBE. There have been a number of books and edited books that have worked to synthesize material (Frauenfleder & Santoianni, 2003; Friedman, Klivington & Peterson, 1986; Meltzer, 2007; Olson & Torrance, 1996; Santoianni & Sabatano, 2007) as well as a number of teaching models developed from the literature (Caine & Caine, 1991, 2011; Given, 2002; Jensen, 2008; Laster, 2009; McNeil, 2009; Morgan, 2003; Slavkin, 2004; Sousa, 2011). From these synthesized materials and the other references cited here, repeating themes were extracted and divided based on conceptual groupings: primary, secondary, and tertiary themes as well as one meta- theme. Primary themes of attention, memory and learning were considered to be *central* to education, representing the primary purpose of education. Secondary themes were factors that significantly influenced the primary themes of learning and memory. These are considered *mediating* factors and included stress, motivation, emotion, and circadian rhythms. Tertiary themes consisted of *emergent capacities* and corresponded to higher cognitive functions such as concept formation, personal meaning, and creativity. Tertiary themes, in particular, resembled many of the ideals of education as recounted by the proponents of 21st century learning (Bellanca & Brandt, 2010). In addition to these three themes, an overarching meta-theme of development was considered separately because it spanned across and affected each of the other themes. Below, each theme is described briefly with respect to the current understanding in the sciences. Just as the ideas in brain-based education have evolved, so have the theories and findings from the sciences had their own evolution. It is important to understand how this evolution has left us in many cases with conflicting ideas and multiple explanations for even our most basic starting point of what is learning, memory or attention. This review is meant as a starting point for understanding to what extent we are able, based on the science as it stands to create a consistent pedagogical and curricular model.

Primary Themes: Learning, Memory & Attention

The earliest goals of neuroscience and education were connected through processes of learning and memory. The age old search for the engram, the physical memory trace in the brain, started debates regarding localization versus distributed memory. Historically, of the two competing camps, localization versus distributed function, separated around findings from the science that could not be understood at the time. Lashley (1929) supported a distributed model and this distributed functionality was referred to as cortical mass action (Lashley, 1950). This was contrasted with those who promoted the ideas of localization of function, initially supported by Broadmann's work on cortical architecture (see Zilles & Amunts, 2010). Interestingly, localization of function has received a large degree of attention, as it has evolved as a field of study in imaging cortical functions (Toga, Thompson, Mori, Amunts, & Zilles, 2006). Through our knowledge of neural plasticity, it is recognized that specific brain regions are not rigidly fixed, and through systems level neuroscience we understand that localized regions do not work independently from one another. Hence, the debate between localization and distributed function has found a certain middle ground in today's dynamic systems.

On a cellular level, the greatest contributor to a synthesis of localization and distributed memory systems came from the work of Donald Hebb in his seminal publication examining cellular basis of memory (Hebb, 1949). This work showed how memory could be both localized and distributed through the creation of cell assemblies. Memory was not presumed to be coalesced in a single cell, but rather was the product of the activation of networks of cells, or cell assemblies, that were functionally connected. Stimulation of a cell in any part of the network would activate connected regions that were often connected in loops. Similar to psychologist of his time, Hebb distinguished between short term and long term memory, and proposed that short-term memory was an active process that worked with the brains existing structures, whereas long term memory was created through structural changes in the brain, creating a physical trace, the engram. Consequently, the student of Hebb, Lynn Nadel, went on to create a comprehensive theory of memory related to a highly localized region, the hippocampus (O'Keefe & Nadel, 1978) a theory which is still used today and was the impetus for some of the early research in neuroeducation (Caine & Caine, 1991). Although the synapse was not morphologically validated until 1954 with the invention of the electron microscope, the theoretical basis of Hebb's work continues to remain a basic component of our understanding of the processes of learning and memory (Zigmond, Bloom, Landis, Roberts & Squire, 1999).

Perhaps the most exciting research on the mechanisms of learning has come from the work of Nobel Prize laureate Eric Kandel on the molecular mechanisms of memory (Kandel, 2001). Although highly reductionistic, what makes this work so exciting is the universal nature of these processes. By understanding universal processes of memory formation, a teacher can be given a tool that will work with every student. Although insights into how this knowledge can be applied are not fully realized, the possibilities to inform aspects of teacher-student interactions, temporal aspects of delivery, and physiological factors such as nutrition, sleep and even classroom environments, all may be informed from the unveiling of the secrets of the molecular mechanisms of memory. Early research in findings connections focused on learning, memory and attention as the core phenomenon, as is apparent by the early edited compilation by Chall & Mirsky (1978).

Learning as a phenomenon is tightly linked to attention. A large body of research exists describing the structure and function of attention networks within cortical and subcortical brain regions (Guigon, Dorizzi, Burnod, Schultz, 1995; Posner & Rothbart, 2007b; Sereno & Kosslyn, 1991). Research in attention points to one of the serious problems facing the field of MBE, and that is, on a very basic level there is still considerable disagreement regarding what “attention” really is.

Probably the most well developed model of attention in the neuroscience comes from the work of Micheal Posner. His model divides the processes into three cortical networks: orienting, altering, and sustained attention (Posner, 1988; Posner & Rothbart, 2007b). But even his prestigious work is contested, and there are those who focus on subcortical systems affecting broad cortical regions, rather than viewing attention as multiple cortical systems (Dantzker, 2006). Dr. Posner has recently contributed to the field of educational neuroscience (Posner & Rothbart, 2005; 2007a), however, the development of a classroom approach based on the research in attention and memory has yet to be advanced.

Creating a model of education based on the scientific findings from research in learning, memory and attention, is an important endeavor that must begin to be undertaken in a collaborative manner in order to help inform teachers as to best practices. Actual activities that engage networks of attention and memory are often not what an educator would immediately predict. One such example is the engagement attention networks through movement (Koch, & Ullman, 1985). Appropriate learning experiences that would engage attention networks, would be critical for development attention and working memory potentially decreasing problems with attention such as ADHD (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). Learning, attention and memory must remain a central focus of any model of neuroeducation. Information from the cellular basis of memory, and the systems/network studies of attention, can help to inform not only temporal aspects of learning, but also can guide teachers in providing the types of experiences that would best engage these systems. By making learning, attention and memory a central focus of designing a curriculum, teachers are given a starting point that can work with the brain's natural learning systems.

Secondary Themes: Emotion, Stress, Motivation & Circadian Rhythms

Historically, curriculum development has paid little attention to the students' emotional state or internal motivation. In the 1950s and 60s the emergence of a deeper understanding of the biological basis of emotion based on the stress response began to influence ideas of human behavior and learning (Selye, 1950). The physiological and behavioral effects of stress on learning and memory are well understood in the fields of neuroscience and experimental psychology (Sapolsky, 1992). For neuroeducators there is the need to recognize the fine line between challenge and stress in order to maximize the most effective psychological states and internal conditions conducive to learning. Mild stress and stress related hormones have shown benefits on learning for more than two decades (Cahill & McGaugh, 1996). However, the negative effects of chronic stress not only diminish performance but cause long term damage to regions of the brain critical to learning and memory (Sapolsky 1992; Uno, Tarara, Else, Suleman, & Sapolsky, 1989). Today no child (or teacher) is without stress in his or her environment. The normal pace of living reflects a high baseline stress level. Knowing this, neuroeducators can adjust their classroom demands to meet the needs of their student body. Reducing stress does not mean eliminating challenging academic material but it means being aware of the community within which one is working. For high stress communities it may mean bringing the material in a more relaxed way, without threat. It might also mean including other activities designed to reduce stress, such as meditation, exercise or art. The possibilities are endless and reflect the flexibility of attending to secondary themes including attending to the role of cultural differences as is indicated through the novel field of cultural neuroscience (Paulesu, et al, 2000).

Motivation is an issue that all educators struggle with, and is important to any model of neuroeducation. Our understanding of the mechanisms underlying motivation has advanced considerably from the initial behaviorist models of J. B. Watson and B. F. Skinner. Nonetheless, the behaviorist models are what drive not only many of the classroom practices, (i.e. grades, discipline, rewarding good behavior and punishing bad behavior) but also are promoted at the systems level by the current policies of NCLB through funding and sanctions. It has been since the 1970's that research on student behavior indicated the importance of intrinsic motivation in encouraging students' positive involvement in school (Csikszentmihalyi, & Larson, 1978). In systems level neuroscience, critical aspects of motivation, both intrinsic and extrinsic, have been ascribed to the ventral striatal system, also known as "the brain reward circuit" (Wise & Bozarth, 1984). This system is intimately related to learning (Shultz, Tremblay & Hollerman, 1998). More recent research has looked at intrinsic motivation in relation to goal related activity and not surprisingly the brain circuits involved overlap with attention networks (Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010). A deeper knowledge of how this system functions allows educators to meet the motivational needs of students.

The relationship between emotions and learning goes back to some of the earliest research in the learning sciences. From an anatomical level, the significant role of the amygdala, and the closely related hippocampus, link emotional experiences with learning and memory (Chavez, McGaugh & Weinberger, 2009; LeDoux, 2000). Significant work on the neuropharmacology of emotions, in particular positive emotions have expanded our understanding of the impact of emotions not only on memory, but also on higher cognitive functions such as insight and problem solving (Pert, Ruff, Weber & Herkenham, 1985; Subramaniam, Kounios, Parrish & Jung-Beeman, 2008). Being aware of emotion as a primary mediating factor in students learning will be necessary in any program of neuroeducation.

Circadian rhythms were categorized as a secondary theme, as they are known to mediate learning, and are more biological as opposed to being an emergent ability. Circadian rhythms relate to temporal changes in biological factors such as hormones, as well as cognitive changes in attention and memory. Chronobiology has much to offer the designing of classroom experiences to align with biological rhythms that will best maximize a students learning. The simplest rhythm to attend to is sleep, in particular with regards to its role in memory consolidation. Evidence from neuroscience supports the role of sleep in the formation of higher cortical circuits created via projected from trace memories imprinted in the hippocampus (Born & Wagner, 2009). The role of not only sleep, but also rest, has been shown to be a significant factor in memory recall (Mednick, Makovski, Cai & Jiang, 2009). The use of daily and even hourly rhythm s within a student's schedule to create alignment with inner biological rhythms can advance practice immensely as it will work with the natural biology of the human being. The role of resting and downtime is one means of working with these rhythms.

Raichle (2010) has changed the focus of brain research by examining *not* the task dependent regional activation of the brain, but the intrinsic, non-sensory brain activity associated with resting. Findings from Raichle's studies indicate that the brain's resting state, known colloquially as day dreaming or mind wandering, is actually a period of high levels of brain activity. What is the brain doing during these times? Some evidence supports the idea that these rest periods allow higher cognitive functions to happen such as: concept formation, problem solving, and making creative associations (Kounios, Fleck, Green, Payne, Stevenson, Bowden & Jung-Beeman, 2008). These higher level activities represent some of the highest goals of education, and were categorized as the tertiary themes, or emergent capacities, in the model developed here.

Tertiary Themes: Concept Formation, Creativity & Meaning

The tertiary themes represent the highest level of cognition discussed in the literature relating to neuroeducation and the highest ideals in education. Tertiary themes relate to 21st Century Skills and epitomize deep and effective conceptual learning. Issues of personal meaning, spirituality and self-actualization are also tertiary level goals. Traditionally part of other fields like philosophy, we now see brain research studies shedding light on systems of the brain critical to higher order thinking. What is being brought to our understanding through the science of higher cognition represents a paradigm shift in thinking about learning.

Although there are high levels of parallel processing, thinking and doing often command the same brain resources; therefore when one is engaged in 'doing' complex activities that require thought, there is a limit to their ability to engage in higher level thinking. The exception to this is when one is engaged in repetitive automatic activities, such as walking, as long as it is not walking a tightrope, or knitting if one is an expert doing a simple pattern (MacEachren, 2011). Neuroeducation calls for conscious efforts on the part of educators to include time for thinking and intrinsic brain activity in daily activities. Too often in education we gauge students participation relating to how much time they are "on task" and fail to recognize the importance of reflective thought or down time.

In some ways the tertiary themes are the least developed in the field of neuroscience, but perhaps the most sought after in the realm of education. Higher cognitive functions translate more easily into educational practice, and although neuroscience has yet to tackle higher level issues, the work in cognitive sciences, psychology and philosophy have begun to make strides in these areas. These are the themes that hold the promise for a true evolution of education that addresses the higher needs of the individual and emergent brain capacities.

The three themes discussed in this model all inter-related, so that the development of emergent capacities outlined in the tertiary factors is dependent on the right biological impact provided by the secondary factors or themes. This is true for each of the themes in the model, and is especially true for the final component of the model, the role of development.

Development as a Meta-theme

An overarching theme throughout the literature was the importance of development in its relationship to processes impacting learning. Ansari and Coch (2006) state that it is necessary for any model of MBE to be “characterized by a developmental perspective” (p 148). The brain grows and develops according to the unfolding of genetic programs as they are impacted by environmental factors. Epigenetics, the study of changes in DNA expression based on environmental and biochemical influences, has added a new dimension to our understanding of the nature versus nurture debate. A program of neuroeducation should provide the environmental experiences aligned with the unfolding of genetically driven capacities in order to best assist the full development of the neural systems that support higher cognitive capacities (Koizumi, 2004). The primary way neuroeducation looks at development is through examining the maturation of neural networks making up functional systems. This is the domain of systems level neuroscience (SLN) and developmental cognitive neuroscience (de Haan & Johnson, 2003).

The development of neural systems has been implicated as critical for creating a conceptual model of how educational theories can use neuroscientific data (William & Lloyd 2007). In SLN, rather than examining brain regions discretely scientists look at the interaction of functional circuits as loops, or as streams of sensory activity. Development of neural circuits is not an automatic process. The formation of functional systems of the brain is activity dependent. This dependence on activity for brain development is also true in adolescence and adulthood, where the brain shows expansion and reduction of different regions based on sensory exposure (Guic, Carrasco, Rodriguez, Robles, Merzenich, 2008; Maguire, Gadian, Johnsrude, Good, Ashburner, Frackowiak, & Frith, 2000). Understanding the processes of neuroplasticity and critical periods with respect to development are essential to designing an effective neuroeducation program. This can be exemplified by looking at early ages when the brain is beginning to self-organize around motor development (Thelen, 1995), while in adolescence, the brain requires different experiences to fully unfold higher cognitive abilities that engage the pre-frontal cortex (Benes, 1998; Gogtay, et al 2004).

The implications for educational practice when taking into account developmental issues provides a framework within which neuroeducator can create an effective curriculum. For example, creativity and concept formation would be approached differently depending on the age and developmental stage of the student. The functioning of executive processes at age eleven differs from mature adult attentional processing (Posner & Rothbart, 2007). With regard to secondary themes, it is also possible to see the relationship between development and hormonal changes in the brain. The developing emotional system of the brain has particular patterns of growth that are critical for neuroeducators describing how hormones affect memory at different developmental stages (LeDoux, 2000). Furthermore, the importance of critical periods and sensitive periods may dictate when particular academic challenges should be introduced, so that conceptual learning and meaning making are aligned with those neural systems as they develop, for example the introduction of foreign languages in the early grades when language systems are in critical stages of plasticity (Kuhl, Conboy, Padden, Nelson & Pruitt, 2005).

The use of general themes to create a working model of neuroeducation does not directly address classroom practices, but informs teachers as to what they must attend to in creating an effective activity. Such a model is flexible enough to allow for both new research to inform the themes, and for the use of novel and creative approaches to teaching. The following section discusses some of those practices that have the potential to better engage each of the themes developed in the model, such as learning and memory systems and emotions, as well as to encourage the development of emergent capacities such as critical thinking, creativity and problem solving.

Section 3: Classroom Pedagogies Aligned with MBE

Understanding the science of learning as it is outlined in the neurosciences can only take us so far in enacting curricular changes. The work of neuroeducation must be bi-directional. We must work from the science to create a construct definition, but it is just as important to look at approaches that have been used in the classroom, and to work towards that scientific model to find points of connection. This section examines several pedagogical approaches that are aligned with what is called for by the learning sciences. One approach that has gained some success in moving directly from the science to the classroom has been the development of specific interventions to address issues related to learning difficulties, for example the CAST project, or the program FastForWord®. Specific interventions will not be addressed here, although they hold an important place in neuroeducation. What is presented here reflects the more general picture of what might be considered effective classroom practices for a program neuroeducation. This is done through looking at general principles and approaches to teaching, as well as full-fledged school-wide models.

Not all present day models are prepackaged programs aligned with state-standards. There are a number of innovative programs and independent efforts to go beyond the tests, for example, the *Partnership for 21st Century Skills* (2008). In addition, project based learning has become a gold standard, and teacher and administrators alike are pushing to include creative student-centered approaches in their schools and districts. This is a risky leap of faith for some educational leaders who need to consider the consequences of not meeting the yearly testing requirements of NCLB. Nonetheless, the growth of alternative models utilizing project and inquiry based learning demonstrates the willingness of educators to take that risk in order to enhance the cognitive abilities and educational experience of their students. The following are a brief overview of approaches that are compatible with the model of neuroeducation.

Thematic Learning & Integrated Curriculum

Theme based instruction is perhaps the most frequently referenced approach by those who have translated the work of brain science into curriculum models (Caine &

Caine, 1991; Jensen 2006,2007,2008; Laster, 2008, 2009; Sousa, 2011; Wolfe, 2001). The concept of thematic learning addresses a number of components of how we understand the processes of learning, in particular the phenomenon of long term potentiation (LTP) and the well-known psychological construct of priming. When information is presented through experience either natural or engineered, the brain begins the process of learning through sensitization of relevant and related neural networks. Processing of information in the environment is mapped onto conceptual networks and the process of meaning making occurs in part through the evaluations of patterns of incoming information. At the cellular level this is related to LTP and neuroplasticity. With regard to classroom curriculum, understanding that the connections between cells in the brain at the level of the synapse are sensitized to respond to related information in an ongoing manner, thematic learning provides a means of tapping into this cellular mechanism to enhance learning across all subjects. Priming and LTP are powerful mechanisms for not only memory formation but conceptual learning. Thematic learning allows for the connection between subjects and a deeper relationship to the material being learned. When we have disjointed, or fragmented learning experiences as they are presented in traditional classrooms which move from subject matter to subject matter with no relation to one another, we actually work against the processes of priming and potentiation of these neural networks. Each new unrelated subject physically competes with the cellular processes of memory formation, basically wiping clean what has just been learned in the previous 50 minute class.

Theme based instruction can be further enhanced through the use of a fully integrated curricular approach. These two approaches are on a continuum, and both take advantage of the mechanisms of priming and LTP. On the one side of the continuum is a fully integrated subject model that seamlessly presents information in context. This is best suited to team teaching and blocked scheduling. On the other end of the continuum, schools using a traditional structure may rely on an overarching theme to connect separate more subject specific classes.

Thematic learning is a means of working at a conceptual level in education. Through the selection of themes with deep universal meaning learning can create connections between intrinsic concepts integral to the fundamental basis of how we make sense in the world from a neurobiological perspective. Time, for example, holds not only abstract meaning, but is part of the makeup of our brain systems through the science of chronobiology. From a psychological perspective, we experience time in a personal way. Having students think about not only the historical aspects of how we created calendars or a 60 second minute or 60 minute hour, but allowing them to reflect on their own experiences with time through self-referential experiments, expands their learning making it relevant and meaningful in their own lives. It is possible to imagine how the use of universal themes can be applied to nearly any course of study.

Embodied Cognition & Simulations

Embodied cognition is truly the intersection of mind and body. Advocated by philosophers from Kant to Heidegger, embodied cognition recognizes where cognitive, perceptual and emotive processes are connected with motor systems. This holistic perspective of cognition has found renewed interest in our modern understanding of learning from the neurosciences (Gallese & Lakoff, 2005; Thelen, 1995). With regards to classroom practice, embodied cognition can be utilized to better and more fully engage neural systems in learning. Lessons that engage learning of higher order concepts are particularly suited for the use of lessons involving embodied cognition. Movement and kinesthetic experiences with the subject matter is able to maximize neural circuits that are not fully engaged by verbal and auditory learning experiences.

Embodied cognition also engages students in activities that relate to synesthetic experiences, linking the auditory, visual and kinesthetic experiences, and hence fully engaging multimodal systems of the brain. To this extent, embodied cognition can be utilized in nearly any content but particularly those that has deep universal underpinnings in our neurobiology. Motor systems have been shown to be linked to perception (Gallese & Lakoff, 2005), abstract concepts (Barsalou 1999; Barsalou, Simmons, Barbey & Wilson, 2003), attention/memory (Kosslyn, 1995) and language (Olmstead; Viswanathan, Aicher & Fowler, 2009) and somatosensation is linked to vision (Blakemore, Bristow, Bird, Firth & Ward, 2005). The connection between motor systems and systems other than the visuo-spatial system are less well understood, but research demonstrates that concepts in language such as metaphor, engage systems other than simply temporal lobe/verbal systems, indicates that embodied cognition can be applied to enhance learning and engage higher order processes across various content areas.

Incorporating embodied cognition into lesson has been shown to increase students learning and problem solving ability. Mathematics, physics, and the sciences, frequently demand abstract conceptual knowledge that is non-verbal (Lakoff, & Rafael, 2001). By engagement in physical representations of these concepts through our physical bodies in space, we better stimulate more of the dorsal stream in the visual system, engaging parietal pathways more closely associated with non-verbal tasks (Ungerleider & Mishkin, 1982). Students shown finger symbols indicating chemical structures, for example, were shown to be better at understanding concepts of how such chemical structures interacted (Bivall, Ainsworth & Tibell, 2011). Using gesturing in math improves conceptual understanding and the ability to apply these concepts correctly (Goldin-Meadow, Nusbaum, Kelly & Wagner, 2001). Embodied cognition is beneficial in virtual reality environments, and studies in the physical sciences have shown that students were better able to understand molecular biological concepts when engaged in haptic exercises, involving the virtual senses of touch and movement, than with verbal or visual presentations alone (Schonborn, Bivall, Tibell, 2011). Although much of the research in embodied cognition has been done in physics, chemistry and math, disciplines with high abstract conceptual loads, there has also been research showing that simulations of events in history through physical drama, or enactment of stories using props or manipulatives, increases students' memory and ability to draw inferences from stories or historical events (Cooper, 2010; Glenberg, Gutierrez, Levin, Japuntich &Kaschak, 2004), and gesturing has been shown to enhance foreign language learning (Macedonia & Knosche, 2011).

Beyond actual movement activities, embodied cognition has been applied to the use of visualizations. Based on the ground-breaking research by Rizzolati and colleagues on mirror neurons, a whole new field of research on the connection between perceptual and motor systems has shown that to see an activity stimulates the same neural networks as to do that activity (see Rizzolatti, & Sinigaglia, 2008). Since watching an activity or visualization purportedly activates the same motor areas as engaging in that activity, educationalist have proposed that viewing others actions, or visualized animations should be more effective than static diagrams (de Koning and Tabbers, 2011; Decety & Grezes, 2006). This appears to hold a small kernel of truth, but it depends on how the visualizations are used. In their review of the literature on embodied cognition and visualizations, de Koning and Tabbers (2011) give several suggestions for increasing the effectiveness of this approach. (1) Let the learner follow the movements using gestures, (2) Make the learner manipulate the movements through interaction with the animation, (3) Embody the movements in the animation using a body metaphor, (4) Stimulate learners to reconstruct the perceptual processing of the movements at the test. The overarching findings and suggestions all point to the need to intentionally engage the motor systems to obtain the benefits. Movement as a critical source of learning is something that has been ignored in most cognitive learning activities until now. Hopefully the growing body of empirical research in motor systems and perception and cognition will help to change the structure of our student's learning experiences to incorporate movement on a regular basis in all areas of learning.

Simulations are also indicated by the brain research, and can easily incorporate movement. A simulation of a historical event, for example, can engage students in movement activities, acting out historical events, but furthermore can increase the capacities for perspective taking and activate emotional and moral impulses. Research on simulations have shown that the experience of perspective taking is able to increase the student's ability to engage in deeper and more meaningful dialogue than they were able to do in direct questioning. By transporting oneself into another person, it appears there is a greater flexibility of thought. Personal beliefs are able to be put aside, and the character can come through. This type of activity is very much like the expanded capacity that is created through play in young children.

Project Based Learning

Project Based Learning (PBL) is not a new conception, but was originally proposed nearly 100 years ago as a model for curriculum reform. Then called Action Based Learning, this approach was designed to overcome passive learning and fully engage the student (Kilpatrick, 1919). Currently there is a resurgence of PBL in our public schools from elementary through higher education, and PBL has even been viewed as a framework for educational reform (Solomon, 2003). Some project based approaches have been associated with significant benefits on student learning in both quantitative assessments (Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway, & Clay-Chambers, 2008; Jitendra, Star, Starosta, Leh, Sood, Caskie, Hughes & Mack, 2009; Keil, Haney & Zoffel, 2009) and qualitative measures (Azer, 2009).

In a review on the topic, Helle, Tyngala, & Olkinuora. (2006) point out that PBL has been associated with a number of “different activities with varying purposes” (p 287) and that PBL is still relatively undefined in practice. PBL has been divided into three main types of activities (see Morgan, 1983): (1)Project exercise, (2)Project component (or Project process), and (3) Project orientation. The three roughly orient towards, (1) Application of prior knowledge to project work (2) Development of problem solving abilities, and (3) Comprehensive project engagement as creation of educational content. Each of these approaches to PBL can be used in neuroeducation, but perhaps the most relevant is the use of the second approach, that is the use of the project as a component of learning and for the development of problem solving as a skill. This component could include socio-emotional goals as well as the development of cognitive abilities such as critical thinking or creative problems solving. The Project component PBL emphasizes the process of learning and so allows for self-reflection and metacognition (Askeland 1999). This aspect of self-directed evaluation is an important aspect of neuroeducation.

PBL encourages interdisciplinary approaches, integrating across disciplines to solve problems. This is seen as a necessary requirement for most projects if the intention is to go deeply and purposefully into an issue (Krajcik, Soloway, Blumenfeld & Marx, 1998). PBL can access the brains natural tendencies to think globally about issues, and can more readily be used for the development of cognitive abilities rather than focusing on content as it is separated out into discrete disciplines. As teachers experiment with PBL in their learning environments, it will be possible to evaluate how this approach can be best aligned with what is known from neuro and cognitive sciences in order to meet emotional, social, developmental and cognitive needs of the students.

Inquiry & the Process Approach

Jerome Bruner is recognized as one of the critical contributors to the field of MBE (Tokuhama-Espinosa, 2008). His earliest work focused on the development of effective and progressive curricular models, in particular as the co-creator of a social science curriculum called *Man: A Course of Study* (MACoS, 1970). This model, at its heart, used an inquiry process approach to teaching and learning. MACoS emphasized a new role of the teacher as a resource rather than an authority. The primary pedagogical aims of this approach included teaching students how to develop their own questions and be able to research them successfully through the use of first-hand sources. Students were given the skills to develop their own critical thinking through hypothesis building. Activities that promoted examination of issues and questions in which there was not one right answer were the ideal fodder for deepening of understanding and thinking about issues. The inquiry-based process-oriented classrooms encouraged open-ended discussion between peers within the classroom. Reflection and metacognition, (thinking about their thinking) was a central component of any lesson. In short, this approach was heavily focused on helping students learn to think, and developing an understanding of their own capacities to learn.

Inquiry and process based curriculum correspond to much of our understanding of the science of how the brain learns (Caine & Caine, 2006, 2011). The process of inquiry is such that each continual evaluation of a problem-space deepens a learners understanding through continual questioning and reformulating solutions. Caine & Caine (2011) demonstrate how this approach engages and shapes the brain through referring to the work of Joaquin Fuster on the perception-action cycle. The core of this relates to the human search for knowledge through the creation of questions and search for answers to those questions. Inquiry based learning delves into issues of the search for meaning, something that can often be lost in traditional discussions of skill development.

The process model of inquiry based learning has been contrasted with the more traditional outcomes model of education (McKernan, 1993). The current standards based model including the coming common core standards epitomize an outcomes based model, and forces this approach into place through the accountability requirements placed on public schools. A true process model would allow for emergent and flexible curriculum. Students might go deeply into a subject that is not going to be tested for years, or ever. But the conceptual learning that takes place far exceeds what would be possible if the outcome had been pre-determined. In the words of James McKernan, “To transform education into a simple lists of outcomes is a gross distortion of knowledge and the epistemology of a subject” (1993, p 346). The process approach contradicts the current structure of benchmarks and standards in that the process of learning does not pre-determine outcomes, learning is more individual, and directed by the experience of the student, not dictated by a scripted pre-set curriculum.

Play & the Arts

There is a long history of research speaking to the importance of play as the primary source of learning for young children with continued supporting evidence from the brain sciences (Singer, Golinkoff, & Hirsh-Pasek, 2006). Play is found universally in children across all cultures (Goncu and Gasking, 2006). Research on play has recognized for years its benefits on social and emotional development (Bussey & Perry, 1984), language development (Lovinger, 1974; Sachs, Goldman & Chaille, 1985) creativity (Dansky, 1980), self-regulation (Berk, Mann, & Ogan, 2006), and other aspects of cognitive development (Saltz, Dixon & Johnson, 1977; Vygotsky, 1976; Whitebread, 2010). Vygotsky (1976) believed that experiences through play were the building blocks of higher cognition. Perhaps his most influential work in this area was on the ability of play to enhance metacognition and self-regulation “In playing the child is always above his average level, above his everyday behavior....In such a situation the child tries, as it were, to leap above the average level of his behaviour.”(p. 86). Like the scaffolding of skill building provided by adults which allowed students to perform at a higher level than they were previously capable, play behaviors allowed students to perform at a higher level of their own doing, without the support of adults, or in other words to self-regulate their actions. The work of David Whitebread has researched the cognitive neuroscience of early learning.through play (Whitebread, 2010). Dr. Whitebread extends the work of Vygotsky on the development of self-regulation and metacognition through play.

The arts have been an area of interest in enhancing education for generations. Project Zero at Harvard started in the late 1960s and worked to understand the role of arts in education. We now have programs from the Dana Foundation, National Science Foundation and John Hopkins, that have focused not only on learning and student outcomes, but the impact of the arts on the brain. This area of study has become a center piece for several of the key participants of the MBE community (see Magsamen & Battro, 2011). The impact of art and music on learning, memory, motivation, and creativity are only some of the areas that are being addressed in MBE and educational neuroscience. Research on art and neuroplasticity, electrophysiology and cellular aspects of learning are helping to further the cause through demonstrating physical effects of arts exposure (Stewart, Hensen, Kampe, Walsh, Turner & Frith, 2003). The interdisciplinary research on neuroaesthetics is helping to combine findings from neuroscience, cognitive science and philosophy to shed light on the impact of the arts in human experience and their capacity to transform our educational system (Croft, 2011).

Arts hold the potential to utilize some of the existing grammar of schooling through bringing back a focus and balance in the courses offered in our public schools. Many schools already have music rooms, or theaters that have gone unused since the testing craze met the budget crises. Moreover, arts can be integrated into traditional classroom settings simply through the use of poetry or drawing. Much of the visual arts, such as video arts are now financially feasible as computers have become ubiquitous and students often have video access on their personal phones. There are also a number of approaches to teaching in the arts, such as the Studio Thinking Framework, that are currently available, and can be examined with respect to student outcomes (Sheridan, 2011). Finally artistic activities are easily translatable to many of the other themes and approaches suggested here already. PBL can include activities such as building models, artist artifacts from the project, or theatrical exposes. Arts naturally lead themselves to integration of subjects and artistic activities themselves can be easily created to be process oriented. The need to realign our thinking of art as an extra-curricular activity is true not only for our educational policy makers, but also for parents and communities (Magsamen, 2011). One of the advantages of neuroscience is that it can demonstrably show the neural benefits of the arts.

Complete Curricular Models Aligned with MBE

MBE supports the development and use of research schools to begin to build an empirical base and conduct interdisciplinary research (Hinton & Fischer, 2010; Schwartz & Gerlach, 2011). In addition to looking at individual approaches to education, it is possible to look at whole school models that have been developed over the years as alternatives to the traditional structures of a teacher directed model. Some such models include A.S. Neill’s Summerhill, the Sudbury school, Reggio Emilio, Monetessori, International Baccalaurate and Steiner-Waldorf. Progressive and holistic models have long been associated with better alignment with the brain. Interestingly, one of the first mentions of the word neuroeducation was in reference to holistic education (Sonnier, & Goldsmith, 1985) and one of the great leaders in progressive education, Wayne Jennings, with the help of one of the early neuroeducators, Leslie Hart, published a weekly brain and education newsletter for nearly a decade. Nonetheless, these alternative approaches to education have typically been relegated to the private sector since they don't always fit neatly within the rules and regulations of public education. With the advent of the charter school movement, a new outlet for alternative approaches to education to be implemented in the public arena was born. Waldorf and IB have grown particularly fast in the public sector, and therefore provide the opportunity to look at the impact of these two approaches on student performance and outcomes.

The Steiner-Waldorf approach. Rudolf Steiner developed a curriculum and pedagogical approach to teaching "based on educational theories founded on a real knowledge of the growing, developing human being" (Steiner, 1971, p 15). The first school taught the children of the Waldorf-Astoria cigarette company in Stuttgart Germany just following World War I. The schools using Steiner's approach, referred to as Waldorf schools, have now expanded around the globe. Many aspects of Waldorf align with the principles of Neuroeducation. Waldorf provides a developmental framework aligned with the systems level neuroscience understanding of the development of specific systems of the brain (Amso & Casey, 2006). Waldorf has been associated with a focus on developing judgment, critical thinking, and collaboration amongst other skills (Chauncey, 2006). In his *Foundations of Human Experience* (1923/1996), Rudolf Steiner discusses the concept of a threefold approach to teaching in which intellect, feeling and willing are dealt with intentionally by the teacher and in developmental stages. The aspect of *head, heart, and hand* as it is referred to, is most aligned with the aspect of the construct model related to the meta-theme of development.

In Waldorf, the earliest grades emphasize classroom practices corresponding to the *hand* or will aspect of the child. With respect to systems level neuroscience (SLN) the focus on the hand component corresponds to the development of the somatosensorimotor system. Working from an awareness that sensorimotor development is critical in the early grades (see Hannaford, 2005) Waldorf teachers include movement in academic and non-academic activities. Students are evaluated for their ability to demonstrate crossed dominance of the central nervous system, and activities are designed to enhance the cortical connectivity between the hemispheres, something attributed to reducing dyslexia (Eden & Moats, 2002). The *Extra Lesson* provides the techniques for teachers to help students develop cortical connectivity of gross and fine motor systems (McAllen, 2004). Intellectual development is delayed by the standards of modern education, and not only physical development but emotional and social development, take precedence to academic learning. With the demands of HST, school systems have been reducing or eliminating recess and free time including physical play from the school day. The failure to provide bodily kinesthetic activities reduces the opportunities for activity dependent connectivity of the somatosensorimotor system. The somatosensorimotor system includes as its central network the basal ganglia, which has been implicated in ADHD (Rommelfanger & Wichmann, 2010) as well as learning and motivation (Schultz, 2002). The failure for the development of the full connectivity of the somatosensorimotor system with higher cortical regions, including the frontal cortex, could lead to problems in motivation, attention and learning in later life, possibly explaining part of rising incidence of attention deficit hyperactivity disorder (ADHD). The focus of Waldorf on developing this system in conjuction with the period of development of the somatosensorimotor system (Gogtay, et al 2004) indicates a core aspect of neuroeducation, i.e. alignment of practice with critical periods of development.

The second period of development in the Waldorf approach focuses on the *heart*, or feeling aspect of the child. From the level of neuroscience, this period relates to the functionality of emotional system which corresponds to the anatomical network of the limbic system. The curricular goals of the *heart* aspect of Waldorf education relate to building relationships and positive emotional experiences through experiences of beauty designed to touch the emotional experiences of the child (Steiner, 1923/1996). The emotional system or limbic system is a connection of archicortical and diencephalic nuclei, including the hippocampus and amygdala, which play important functions in memory, context awareness, and pattern recognition as well as emotion and motivation (LeDoux, 2000). Adequate functioning of these regions is intimately related to socio-emotional wellbeing and in later life may serve as the foundation for higher moral reasoning (Churchland, 2011; Kohlberg, 1984). From the developmental level it is critical that the child be provided the experiences to make vital limbic connections within the lower cortical as well as higher cortical regions if these emergent capacities are to fully develop into the emergent functions seen in adolescence. The limbic system is particularly sensitive to stress. Overly stressful environments or failure to provide support for developing social and emotional skills can have significant consequences on the development of healthy emotions and limbic structures including social deviance, sociopathy and on the physical level, the loss of brain cells (Sapolsky 1992; Uno, Tarara, Else, Suleman, & Sapolsky, 1989).

The *head* aspect of Waldorf education, that which begins seriously in the middle school years and continues throughout high school, relates to the intellect and abstract conceptual learning in education. In conventional modern education the majority of all teaching is directed at the intellect, even in the early grades. In Waldorf, there is a directional developmental focus where teaching of academics enters the curriculum gradually as the students mature physically and emotionally. In SLN, there is no single neural system responsible for the intellect. For the sake of this paper the neural circuits of intellect are defined as a distributed functional network primarily involving frontal cortical regions. Often the skills associated with frontal cortical regions revolve around what neuro and cognitive scientist refer to as executive functions (Goldman-Rakic, 1996).

The *head* aspect closely relates to MBE with respect to the high level cognitive functions. It corresponds to the tertiary themes of neuroeducation, and related themes of expertise, moral reasoning, concept formation and critical thinking. In the third period of education, Waldorf focuses on developing sound reasoning, keen observation and a striving to know truth (Steiner, 1923/1996). Failure to provide students the opportunity to develop such a high-level skill-set leaves them poorly prepared for the world challenges that await them upon graduation. Critical thinking is one of the skills most sought out by employers, and yet the focus of standardized tests or test-based academics in general, does little to develop divergent, creative and critical thought.

There are other aspects of Waldorf that align with the conceptual model of neuroeducation defined here. The use of embodied cognition can be seen as the core component of learning the letters as introduced through a unique program of letters and movements through eurhythmy. Eurhythmy attempts to make language, emotion and thinking visual through physical movement. The movements are linked to particular sounds, and were designed to invoke the feelings of those sounds. Eurhythmists might act out poems or entire plays creating a mind-body link between concept, sound, and movement. What makes this different from dance is this focus on concept and the use of movement and form to represent a number of higher more abstract concepts that might go beyond words. This component of Waldorf education is not present in most schools, and this possibly reflects the lack of understanding of what importance embodied cognition and physical activities should play in the classroom with regards to learning. Nonetheless, regardless of the presence of eurhythmy, Waldorf schools value drama, role play, simulations and physical enactments of any content area. Because of the focus on head, heart and hand, physical movement in the early years is moved into drama and activities of embodied cognition in the later years.

In addition, Waldorf intentionally uses sleep to help build concepts (Maquet, 2000), presenting new ideas over a three day period. Waldorf also focuses heavily on nutrition, and minimizing exposure to screen-based media. Finally, Waldorf schools reduce stress and emphasize intrinsic motivation through eliminating grades, tests and often homework. On testing, Steiner said:

> When you have to cram for an examination you are assimilating a great deal in opposition to your interest. For if we only assimilated what aroused our interest we should not get through our examinations under modern conditions. It follows that cramming for an examination disturbs sleep and brings disorder into our normal life. This must be specially borne in mind where children are concerned. Therefore for children it is best of all, and most in accordance with an educational ideal, if we omit cramming for examinations. That is, we should omit examinations

> altogether and let the school year finish as it began. (Steiner, 1923/1996 p 123).

This is as true then as it is now, and yet, our entire school year is interrupted by formal state standardized tests. Public Waldorf schools are not exempt from this process, and as of yet there are no formal reports or scholarly articles outlining how teachers and administrators cope with the obvious conflict between state mandates and the core philosophy of the Steiner pedagogy. The research proposed here will begin to address this issue through interviews with administrators of Waldorf schools executed in the qualitative phase of the proposed study.

The International Baccalaureate approach. IB was founded in 1968 in Geneva Switzerland as a non-profit diploma program for students between the ages 14-19, providing an international education for displaced patriots. The diploma program soon gave way to a Middle Years and a Primary School Programme and went from being mostly enacted in private schools to being embraced by public education. Currently, more than half the operating 3,290 IB World Schools are in the public sector and this trend continues today.

IB follows many of the principle of neuroeducation. It is described as being designed to “help develop the intellectual, personal, emotional and social skills to live, learn and work in a rapidly globalizing world” (www.ibo.org). The IB Mission Statement is as follows:

> The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

> To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.
>
> These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right. (www.ibo.org/mission/)

In their introduction to the Primary Years Programme, IB institutes a Learner Profile that includes ten goals for the learner. (1) *Inquirers*: Students develop their natural curiosity. (2) *Knowledgeable*: Students explore concepts, ideas and issues that have both a local and global significance. (3) *Thinkers*: Students think critically to engage themselves in figuring out complex problems. (4) *Communicators*: Students express themselves and information through a variety of modes of communication. (5) *Principled*: Students act honestly and with a strong sense of fairness, justice, and respect for the dignity of the individual, groups, and communities. (6) *Open-minded*: Students appreciate their own cultures and personal histories and are open to the perspectives, values and traditions of other individuals and communities. (7) *Caring*: Students show respect and compassion towards the needs of others. (8) *Risk-takers*: Students approach unfamiliar situations with courage as well as defend their beliefs. (9) *Balanced*: Students understand the importance of intellectual, physical and emotional balance to achieve personal wellbeing. (10) *Reflective*: Students give consideration to their own learning and experience. These factors correspond to much of what neuroeducators aspire to in educational pedagogy. Furthermore, IB's Learner Profile describes several of the tertiary themes outlined previously. Based on this, it would be expected that students who had participated in IB would have better performance on tasks of higher cognitive functions. There is some evidence to date that IB Diploma students have better persistence and better college outcomes (McDonald, 2010). Although these findings support the idea that the IB philosophy and pedagogy can influence student outcomes, these findings do not address how IB affects students from the earlier grades. It would be predicted that IB students would have better skill sets in the tertiary themes based on their approach of meaning making and critical thinking, however presently these are only speculations.

There are other aspects of the IB pedagogy that are part of what is suggested by neuroeducation, for example, IB utilizes inquiry based learning, alternative assessments, theme based curriculum (Given, 2002; Jensen, 2008; Laster, 2009). Although not central to the IB programme, IB schools often use greater amounts of project based learning in support of inquiry. IB integrates curriculum through the use of the *six transdisciplinary themes* that span content areas and in the Middle Years Programme (MYP) through the *five areas of interaction*. For the MYP, three fundamental concepts are used to undergird the curriculum: intercultural awareness, holistic learning and communication. Each of these factors can be seen as components of a well-functioning neuroeducation curriculum.

Findings from studies in Waldorf and IB are suggestive; however, more research is needed to adequately assess the impact of these two alternative approaches. Experimental school models, like Waldorf and IB, offer opportunities to evaluate programs with histories of practice and scientific grounding. It is not the case that these should be considered the only approaches to education that meet some of the criteria of neuroeducation, but in the process of moving from the laboratory to the classroom, whole school models such as Waldorf and IB present an opportunity to evaluate the student outcomes in neuroeducation.

Summary of Critical Pedagogies

To summarize the many approaches that can, if used effectively, help to develop cognitive, social-emotional and physical development can be used as a jumping off point for evaluating effective pedagogies aligned with neuroeducation. Research on suggested approaches should be examined both for theoretical alignment with models of the science of learning, and for the impact of these approaches on student outcomes. In order to make these theoretical and practical connections there must be collaboration between those working on the side of education with those working in the sciences. If we are to change the conventional approach to educating we must move beyond was has been practiced in the past and embrace approaches with a greater degree of student freedom and involvement in the process of learning. We must also continually record and refine our understanding towards better appreciating the relationship between classroom practice and neurobiology. Attending to the use of effective pedagogies corresponding to periods of cognitive unfolding of skills and aligning content with sensitive periods to learning requires both continued growth of the knowledge base in the sciences and evaluation of how this knowledge can be applied in the classroom. Both the science of learning and the development of effective pedagogies as they were covered in the previous two sections of the literature review are like two sides of the same coin. These things must come together and continually renew each other in the creation of an ideal curricular model.

Section 4: MBE and Education Reform

MBE is concerned not only with creating an effective pedagogical approach in education, but also with the means by which that reform will take place. In that vein, MBE is concerned with educational systems theories and organizational issues including how policy directs curriculum. Moving the science to practice is a challenge faced throughout history, and is known as praxis. Praxis reflects the enactment of the ideal or theory. Therefore, the first step towards neuroeducation must be to create a shared theory based on the science. This must then be enacted, reflecting the praxis. The enactment will require engagement on a number of levels. This section discusses critical issues towards finding the necessary framework to fully enact a program of neuroeducation on a national level, while examining the role of MBE will hold on a national scale.

MBE as a Framework for Reform

The vision of MBE as being able to move forward a significant reform effort should be considered with respect to all those factors that are critical in any effective reform effort. Schools like Harvard and Johns Hopkins have developed teacher training programs focused on providing neuroscience literacy and brain-aligned practices (see Carew & Magsamen, 2010). There are initiatives at the level of national and international bodies including: the Society for Neuroscience creation of the *Neuroscience Research in Education Summit* (2009), the Dana Foundation *Summit on Neuro-Education* (2010), and the Organization for Economic Co-operation and Development (OECD) *Neuroscience and Education* program created in 1999 (OECD, 2002). Each of these initiatives plays an important part in advancing the field; as of yet, however, the work needs to be done on a more proximal level. Site leaders need to participate in professional development and research within their school and districts in order to understand how practices aligned with brain development are able to impact their teachers and students. This study will begin to address this dearth of literature by conducting research that includes site level analysis, as well as student outcomes.

Developing a New Role for Leadership

The challenges to manifesting this new vision of education are not minor. The strong cultural and structural framework that needs to shift in order to move beyond the mires of testing and content standards will require time and effort on numerous fronts. If we are to adopt a program designed to maximize human potential beyond reading and math we will need to find avenues for effective change. This will be the role of leadership that must occur on multiple levels. In his article, "Quandries for Neuroeducators" (2008), Howard Gardner proposes that these challenges should be met through the creation of the ethical educator acting as an educational leader in their field. Research from his team on the Good Work Project showed that many initiatives failed due to the lack of alignment of the ideal versus the enactment of one's work. Gardner emphasized that in creating members of this field of Neuroeducation we must arm them with the tools to maintain a high level of idealism through the four *Ms*—(1) mission, (2) mentors, (3) the personal mirror test – reflecting on self, and (4) the professional mirror test – reflecting on how your profession is acting in the world. Providing the new MBE professionals training in both the science and the leadership skills can better allow them to anticipate possible challenges, and give them the personal will to follow-through with their goals. Making connections between the research and the science accessible to teachers must be supported by educational leaders, administrators and policy makers if neuroeducation will find a foothold in the landscape of educational practice.

Although less is available on the role of the principal in MBE, Nunnelley and colleagues (2003) have provided some beginning guidelines for principals implementing neuroeducation. In the article they outline four basic categories of support: the learning environment, policy and procedure, professional development, and alignment with standards (Table 1).

Table 1. Four Critical Components for Principals. Adapted from Nunnelley et al. (2003)

Vision	Application
Encourage an enriched emotional environment by enhancing	Proper nutrition and hydration, a safe environment, a low-stress with high challenge atmosphere, a sense of belonging, the support for achievement, a sense of empowerment, the advocacy for every student, support for resiliency, a culture which recognizes emotions
Establish policies and procedures that support brain-based strategies by ensuring	Cooperation among content areas, flexible scheduling, sufficient time in classroom, review of lesson plans, broad-based learning opportunities
Provide professional development in learning more about brain-based teaching by supporting/providing	Seminars and workshops, a learning community for intellectual growth, on-site observations, a variety of peer learning and teaching, action research, adequate time and nonthreatening atmosphere for professional growth, high expectations for all teachers
Show alignment with standards by expecting	Discussions and prioritization, differentiated instruction for attainment of standards, the language of the standards, a wide variety of assessment strategies

The focus here refers to how principals can and must support this process through changes in school structures and policies. Some of the suggested activities for neuroeducation require engaging the entire staff, i.e. cafeteria staff, for nutrition, or other supports staff for creating a stress-free emotionally nurturing environment. The role of leadership in creating a program of neuroeducation includes giving often excluded staff roles in students' wellbeing, thereby creating opportunities to redefine the work place and encourage greater staff loyalty and job satisfaction (Wilson, 2007). This area, combined with the view of Gardner on the ethical educator, expands on notions of leadership that have been developed in the past. As of yet there is the need to develop a more formal the role of educational leadership in MBE as a reform effort, which will be a necessary next step in the development of the field.

Conflict, Naysayers & the Fear of Reductionism

Although historically there has been a great desire on the part of educators to find the grail of effective education through the understanding of the brain, this quest has been to date a long process of trial and error. In an introductory article to one of the seminal books on the subject of neuroeducation, Klivington (1986) discusses the role of the researcher in this endeavor of neuroeducation in an article titled, *Building Bridges among Neuroscience, Cognitive Psychology and Education*. Since then, the analogy of the bridge has been used by both proponents of this effort, as well as by its critics. Bruer's (1997) now infamous article entitled, *The Bridge Too Far*, began the serious criticism of the feasibility of the project of neuroeducation, and since then a number of researchers have contributed to the argument from both sides (Alferink & Farmer-Dougan, 2010; Bakhurst, 2008; Colburn, 2009; Geake, 2008; Samuels, 2009). Some of the arguments emphasize that neuroscience specifically is not in the domain of education, but rather it is the role of cognitive science to engage in the relevant tasks of understanding issues related to the mind (Cubelli 2009). Cubelli (2009) argues that "theories and models derived from studies in cognitive neuroscience are relevant for education, and may contribute to improve practice and to increase effectiveness in teaching experience, but they should be theories on mind rather than theories on brain" (p 563). It is the case that several of the authors who contest the value of neuroscience support the capacity of cognitive neuroscience, or cognitive science as relevant resources for guiding education

(Bruer, 2002). This type divisive thinking must be reviewed in the new era of transdisciplinary research. The lines are blurring between fields relevant to the endeavor, and well they should be. We are in a new era, when collaborative studies will add depth and dimension to our understanding of the complex mechanisms involved in cognition. MBE, as a transdisciplinary collaborative effort will require a coming together on multiple fronts to survey the landscape of the developing brain and mind as the new terrain of education.

The fiercest criticism, however, comes from the misinterpretation of the science by educators (Howard-Jones, 2008; see also Wolfe, 2006), a history that has been selectively reviewed here. In 1998, Bruer criticized the field of brain-based education as being abound with neuromyths. And despite effort by members of the MBE community to reconcile and clarify the findings from science, recent research shows that there is still a divide between what science says and how it is interpreted by educators (Hardiman, et al. 2011). Nonetheless, the efforts to redress this problem have been seen in the work of Sylvan and Christodoulou (2010), who have outlined a guide for educators looking at different brain-based approaches. Varma, McCandliss, and Schwartz (2008) discuss where the failure in communication between the fields exists, and where we can make advances on that front. With respect to creating collaborations and effective communication, there have been several articles suggesting a path towards this goal (Ansari, & Coch, 2006; Fischer, Daniel, Immordino-Yang, Stern, Battro, & Koizumi, 2007; Goswami, 2006; Hinton, & Fischer. 2008; Kuriloff, Reichert, Stoudt, & Ravitch. 2009; Pickering, &. Howard-Jones, 2007; Ronstadt, & Yellin, 2010). Such efforts include, teacher training in principles of MBE and science literacy (Blake & Gardner, 2007), research schools (Hinton, & Fischer. 2008), joint programs and collaboration with Universities and school sites (Kuriloff, et al. 2009; Pickering, &. Howard-Jones, 2007; Ronstadt, & Yellin, 2010), as well as the creation of summits and societies to provide forums for discussion (Carew & Magsamen, 2010).

Building Bridges & the Creation of IMBES

The types of assumptions surrounding the history of brain research in education reflect a core issue in neuroeducation, that of not adequately understanding the findings from brain sciences and an over-zealous rush to market of products with false claims. It was the scientists who finally stepped in to attempt to regulate the misuse of their own research. Howard-Jones (2008, 2010) criticized those scientists who were claiming that it was too soon to bridge the gap between research and classroom practice as indirectly contributing to the emergence of "brain-based" products that were created to make money and fill the demand of a growing market. In a recent article, Hardiman and colleagues (2011) have called upon neuroeducators to take the role of monitoring and clarifying the science for educators.

> It is the duty of the academic community to provide a high-quality alternative to purely commercial (and often specious) applications of "brain-based" research. This is what the public should expect of educators and schools. It is also incumbent on those with the power to do so to stop misinterpretations before they evolve into widespread trends of thinking. In the past, both educators and the public have made some bad inferences about the brain and how students learn.

It has been in the last decade that we have begun to see inroads in this area through the formation of teacher training programs, national summits, and the creation of the International Society of Mind Brain and Education (IMBES).

In 2007, members of the academic community concerned with these issues came together to form a society focused on advancing the connection between educational neuroscience, educational psychology and pedagogy. The International Mind, Brain and Education Society (IMBES) became a forum for dialoguing across the various disciplines and increasing understanding of each others' work. To that end, IMBES created a scholarly journal, giving a respectable platform for this work to expand. IMBES continues to expand came to represent a new vehicle for providing opportunities for researchers to not only interact with teachers, but also with educational leaders and policy makers. One primary goal of this collaboration was the reform of education to meet the criteria outlined by the science of learning while increasing research in the area of the science of teaching (Rodriguez, 2012; Strauss & Ziv, 2012; Tokuhama-Espinosa, 2011).

Educational leaders in the field also point to what has been discussed regarding the role of curriculum evaluation and MBE as it emerges with respect to the historical context of previous efforts to bring information from the cognitive and developmental sciences into classroom practice. Looking at MBE in relation to historical efforts of curriculum reform becomes important when recognizing the dynamics of reforming the institution of education. According to Ansari and Koch (2006):

> Thus, a larger conceptual framework for understanding MBE as a developing field is needed. This development occurs in the historical context of successful efforts to apply findings from cognitive and developmental psychology (among other fields) to the classroom; these findings are not to be ignored or excluded from the field of MBE, but built upon with the additional perspective of neuroscience. Indeed, we believe that MBE should be characterized by multiple methodologies and levels of analysis in multiple contexts, in both teaching and research, and by members who will in the future effortlessly translate among those levels (p 146).

MBE, NCLB & Social Justice

NCLB heavily depends on the use of high stakes testing (HST) often resorting to punitive measures for poor test performance, including impacting school funding and even administrative and teacher jobs (Rice & Malen, 2003). The tests that are used in this process are developed separately in each state with a range of student performance demands (Reback, Rockoff & Schwartz, 2009). The one thing that is consistent across all states is the federal demand that proficiency increases 10% per year (Popham, 2004). This type of growth curve is unfathomable, and sets the system up for failure.

NCLB has impacted all schools, but has had a disproportionately negative impact on students from racial minority and low socioeconomic backgrounds, and thus has become a significant issue of social justice (Amrein & Berliner, 2002). There is a longstanding awareness that cultural and socioeconomic variables significantly affect performance on standardized tests. Therefore, it is not surprising that a vast majority of schools in poor and minority neighborhoods are in the later stages of program improvement. Often when a school enters program improvement there is a desire for leaders to adopt measures proven to increase test scores. However, many of these *scripted curricula* require that the teacher become robotic in their delivery. Fidelity has been described as “strict adherence to the text, pacing guides, and teacher scripts associated with the programs adopted by the state and district” (Achinstein & Ogawa, 2006, p 3). Directives to maintain absolute fidelity to the script can limit educational options and opportunities. Particularly approaches aligned with neuroeducation, since they require responsivity to the needs of individual students. In evaluating educational change, in the observant words of Gordon Cawelti,

> A review of the most influential research of the past 50 years should encourage us to leave room for initial trials and innovative approaches. (2003, p 19)

The fact that NCLB has failed to reduce the educational inequities in our communities was deemed by some as predictable (Mintrop & Sunderman, 2009). Others predicted the negative consequences for teaching practice and most recently on wide scale cheating (Koretz, 2010). What is apparent is that this model is not the type of school system that will prepare us for a changing demographic and a rapidly advancing technological society. We need an educational system that will promotes creative approaches to teaching and learning. Rather, what we have is a rigid system of HST multiple choice assessments that have resulted in less creativity, the adoption of scripted curriculum (Achinstein & Ogawa, 2006), an increase in teacher directed models (Faulkner & Cook, 2006) and a significant narrowing of the curriculum (Cawelti, 2006). In many ways, the lockstep of subject matter to state standards prevents teachers and school districts from exploring alternative educational pedagogies that do *not* adhere to the pace and sequence of subjects to be tested. Now is the time to move away from this failed model towards the viable alternative presented to us by neuroeducation.

Gaps in the Literature

The emergence of a new field requires flexibility of thought and openness to new approaches. MBE is in a stage of experimentation, and as of right now and is still in the process of defining itself. It is an open playing field, and it is critical that we begin to map out the boundaries and topography of this field in order to move it forward. We need the translators, the daring, the divergent thinkers to be a part of this effort. There must be a coming together of the various bodies to meet the needs of the students facing this globalization of the world. MBE is one means of moving closer to a true collaboration between science and practice.

Through MBE there is a new-found bi-directional flow of information between the various levels of participation with an emphasis of moving academic knowledge into practice and a recurrent informing of academic theories based on the outcome of these educational practices. If we are to advance the field we must change the practices of researchers and teachers working in isolation. MBE is the means of creating the superhighway of information exchange.

Amidst this environment of change, the call for something effective to improve learning has started to meld with those who are calling for something completely different from the standards and testing experiment. There is a growing awareness on the part of educational leaders that HST is not measuring the important aspects of our teacher’s abilities or students’ educational experiences (Ravitch, 2010). It is through the realization by players at different levels that a new approach may be possible. This approach is one that is aligned with the true development of cognitive capacities with a sensitivity to biological as well as socio-cultural components related to maximizing an individual’s potential. This work finds its apex in the transdisciplinary field of MBE. It is my hope that through that through the collaborative effort of MBE, there may be a realignment of education with the brain. Through this we can begin to re-evaluate our present test based approach and replace it with an approach that treats the whole child as a developing human being in whom we find and nurture the unique, individual gifts and sense of meaning and purpose.

CHAPTER 3: Methods

The following dissertation research used a multi-level mixed methods design with three semi-sequential phases intended to bi-directionally inform the question development and analyses process. The act of creating a multidisciplinary field requires reaching across multiple levels of analysis to find points of connection between the varying fields (Willingham & Lloyd, 2007). The design applied here was planned to meet the approach of cross-disciplinary evaluation in order to find the connection between theory and practice and determine the viability, current status, and anticipated future of the emerging field of MBE as a framework for curricular reform.

Research Questions & Study Design

This dissertation began with the broad and open ended question, *How is MBE defined and what are its central goals?* This single question intended to allow the definitions and theoretical constructs to evolve from the data through the use of grounded theory (Strauss & Corbin, 1990). The first question was addressed through interviews wirh top members of the relevant fields of educational neuroscience, cognitive psychology, and MBE. As the definition of MBE emerged through the interview process it became clear that the least amount of clarity existed around the issue of curricular frameworks of MBE. This generated the second research question, *What is the consensus regarding a curricular model of neuroeducation?* which became the central focus of the remaining interviews. Academic researchers but also educational leaders working more intimately with teachers were interviewed on this subject in the hopes of clarifying a curricular model. This curricular model was then used as a template for evaluating two existing models of education to address the final research question, *Can we create a* *"proof of concept" by using existing models of education?* The third question, more than any of the others, was intended to address the problem of translating from theory to practice and to move the dissertation research beyond the theoretical and abstract problem of defining the field or the curriculum towards examining the practical issues of MBE at the level of classroom practice.

This research was conducted in three phases. The initial phase consisted of interviews with 26 experts administered over three separate blocks. Phase 1 addressed the first and second research questions: (1) Defining MBE, and (2) Clarifying curriculum. The final two phases of the dissertation research evaluated the classroom models of IB and Waldorf, first through the use of available online data, and second through a more in depth case study. Both Phase 2 and 3 addressed the third research question (3) Developing a proof of concept.

One primary concern of MBE is to effectively communicate and apply the important findings in the sciences as they relate to classroom practice. This dissertation was designed to look at classroom practice both from the view of academics and educational leaders in the field, but also from the classroom itself. This approach of examining both theory and practice is one that should be considered as an important component of any effective model building for this emerging field.

Phase 1: Interviews with Multiple Stakeholders in MBE

Members of the field of MBE working in academic and administrative positions were interviewed using a grounded theory approach (Glaser, 1992). Grounded theory provides the appropriate tools for engaging in exploratory analysis. In line with grounded theory, interviews were open-ended and themes surrounding the defining issues of the field were allowed to emerge. In addition both the evolution of the interview questions and the selection of participants evolved based on the emergent findings.

Participant selection was developed based on the need to saturate knowledge from emerging themes. Interview participants were selected in three blocks. The first block of interviews focused on defining the problems and purpose of MBE. The eight participants in Block 1 all held their primary positions in academia and were selected based on three initial criteria: Members of the Neuroscience in Education Steering Committee, participants at the 2011 IMBES conference, and founders in the field (those who had continuously published on the subjects of the brain and education for more than 20 years). The results from the initial set of interviews suggested the need to include perspectives of those working outside academia who were more directly involved with teachers and/or running schools. The second block of nine participants came from a broader background. Three of the participants held their primary post as academics, three worked in full-time consulting, and two had held administrative positions in K-12 education, although both administrators were retired. The final subject in the second block was a wild card who worked across several areas, founding companies and creating technologies designed to impact student learning. From the first and second block of interviews, curricular programs aligned with MBE were the most difficult to clarify, and saturation of this theme was unsatisfactory even after the second block of interviews. This led to the inclusion of members of progressive education community who had worked throughout their careers in the area of curriculum reform and/or had founded schools based on principles aligned with the learning sciences. For the third block of nine participants, three independent school founders, two consultants and four academics were interviewed with the conversation focused on curriculum.

Although the participating body expanded across each of the three blocks, academics were included in every block in order to continue to draw on their expertise. In addition, this allowed for clarification from their peers, on the emerging themes from each subsequent interview block. As such, the qualitative phase used a modified zig-zag approach between various constituent bodies, such that concerns and ideas from each of the respective groups were fed back into the conversation creating a deeper and richer data set (Creswell, 2008).

Qualitative Description of the Participants

Participants came into their positions through various routes (see Appendix A). Fourteen out of the 26 interview participants taught in K-12 classrooms early in their careers, although several of them had training in other areas and were not initially formally trained in education. Starting as teachers, the career path often took circuitous routes before it ended up in the multidisciplinary work of MBE and educational neuroscience. Also interesting were the number of participants who cobbled together programs, or were in transdisciplinary programs at their undergraduate or graduate universities. Many participants were self-taught, or had experienced collaborative learning experiences across fields, or worked in a sort of apprenticeship to create their own area of expertise and advance the field. In the words of one of the founders of the field, “We all had to learn on our own.” Some of the members described difficulty in getting others to accept their chosen research area as being one that would allow them to make a living. The participants were very active in the field, and four had books that were to be published within a couple months of the interview, two had new editions of previous books that had just been released, one had an edited book project in the making, and two had internet based programs that were set to go live within months of our interviews. Two had been featured in TED talks on education and eight were listed as thought leaders in neuroeducation according to the Delphi Panel conducted by Tokuhama-Espinosa (2008, p250). This high level of accomplishment is an indicator of the extent to which participants were extremely active in this work, including those who were retired.

When asking who were the participants of this study (and the field in general), these reports indicate an eclectic group of individuals willing to work outside the lines of the conventions of their respective fields and who shared a vision of advancing education through this collaborative effort. The first phase of this dissertation was intended to further clarify this shared vision of the field.

Interview Procedure

The interview was an exploratory examination of the following themes: (1) The definition of the field(s); (2) The roles of various participants the this process including scientists, teachers and educational leaders; (3) The individual and shared perspectives on classroom practice; (4) The context of these efforts, historically and in relation to current policies. The interview was unstructured but was meant to be responsive to these themes. Each interview started with a personal historical narrative and evolved into questions surrounding the themes and emerging issues generated from the conversation. In general, the interviews were designed to reveal personal and professional experiences of participants related to their own efforts and the efforts of the field in general to unite the findings from the learning sciences to education. In addition, participants were asked to speculate on how they envisioned the development of the field in particular with respect to classroom practices.

Data Analysis: Descriptive Coding Zig-Zag Design

Audio-taped interviews ranging from 24 minutes to 64 minutes were transcribed by the researcher, and then coded using the qualitative data analysis software HyperResearch™. Using a zig-zag design the interviews were collected and analyzed in separate blocks comparing findings, and using emerging themes as the impetus for future questions (Creswell, 2008). Initial analyses guided both the questions and the selection of participants for later interviews. For the initial block of interviews, data were coded using *in vivo* and descriptive codes (Saldana, 2009) in an open coding format. The second block of interviews used the existing themes and set of 210 codes generated from the first block, while allowing new codes and themes to emerge. At the same time, interview questions shifted more towards the classroom and away from policy. The third block of interviews focused on the challenges of developing and implementing alternative curriculums more aligned with the principles of human development. These data were coded without reference to initial codes and themes, so that a clear picture of curriculum could emerge. These codes and themes were only compared afterwards to the first two blocks.

The process of meaning making evolved from examining issues and concerns repeatedly discussed by participants that appeared to fall under similar themes. Codes were grouped, and when possible merged to create more cohesive groupings. After the first block of interviews, frequencies of codes in each of the categories were examined for patterns of responses across the academic fields. Based on the category groupings, initial themes and codes were merged, and new categories were created. Following the second block of interviews, the same process was undertaken, and final categories and codes were examined for code frequencies and general themes within the groups. As a member check, summaries of responses and/or direct coded and categorized quotes were s supplied to the interview participants for validation. Participants were asked to make any corrections and clarifications to their statements.

Phase 2: Evaluation of Existing Pedagogies Using a Naturalistic Approach

A necessary element for developing the curricular side of MBE is the evaluation of classroom practices for their impact on students. The multitude of variables impacting the classroom practice makes it important to validate the effectiveness of any practices. This can be done through the use of multiple measures, replication and triangulation of data (Creswell, 2008). In phase two, the school pedagogies of IB and Waldorf were evaluated using multiple data sets and sources obtained from the public domain. All national Waldorf schools and all California IB schools were considered in this evaluation.

School Selection Public Waldorf

A list of public Waldorf schools in the United States was obtained from the Waldorf Answers website (http://www.waldorfanswers.com/PublicWaldorf.htm#list) and from Oberman (2007). Schools were selected from the list given they met the criteria outlined in Table 2. The exclusion criteria for length of operation acted to assure the student body had had a sufficient exposure to the Waldorf curriculum. Three data sets were used to examine test-scores in Waldorf schools, and validate the unique profile of these schools.

The initial exclusion criteria for Data Set A were also applied to the two following data sets, but were expanded to exclude schools outside of California. This was done so that differences and variability caused by the comparison of multiple state standardized tests would be eliminated.

Table 2. Waldorf School Exclusion Criteria

Data Set A – 2008	**Data Set B - 2009**	**Data Set C – 2005-2011**
Charter less than 5 years (N=2)	Non-California schools	No available data from 2005/2006-2010/2011
Court ordered/alternative schools (N=1)	Plus All Exclusions as for **Data Set A**	Plus All Exclusions as for **Data Set B**
Grade range less than 6^{th} grade (N=8)		
Unavailable test scores (N=3)		

For Data Set A, scores by Waldorf students were compared to the district averages. For Data Sets B and C, there was the need to select control schools according to appropriate criteria (Table 3). Data Set B control schools were selected from the same districts and matched for socioeconomic variables (SES) and percent minority groups known achievement gaps. For Data Set C, the longitudinal study, because it used a within-subjects design, required matching schools with continuous enrollment of their student body from 2^{nd} – 7^{th} grade. This severely reduced the number of available schools to approximately 50 and therefore made it not possible to match across every demographic variable or within the district. For Data Set C, rather than matching schools for SES, or minority groups, comparison schools were selected based on performance. The schools with the highest performance ratings according to the GreatSchools.org rating system were selected as our final matches (see Appendix F).

Table 3. School Selection Criteria for Waldorf & Controls

Quantitative Data Sets	Data Set A	Data Set B	Data Set C
Waldorf Schools	All National Waldorf Schools (N=20)	CA Waldorf Schools (N=15)	CA Waldorf Schools (N=11)
Control/Comparison Schools	District Averages (N=20)	Matched in District SES & % minority (N=20)	Highest-Performing K-8th Schools in CA (N=11)
Data Sources	www.GreatSchools.org www.SchoolMatters.com	California Dept Ed http://star.cde.ca.gov/	California Dept Ed http://star.cde.ca.gov/
Dates Collected	11/2009-2/2010	4/2010	2/2011-8/2011

Note. Schools were selected after exclusion criteria were met.

In addition to quantitative test score data, qualitative data were collected from the GreatSchools.org website from May to June 2011. All Waldorf schools for which parent comments were available were utilized in the qualitative data analysis, resulting in a total of 23 schools (see Appendix E for list). Control schools represented all of the matched schools utilized across the quantitative data analyses for which parent comments were available on the GreatSchools.org website. All of the 26 comparison schools used from Data Set B and Data Set C had parent comments available for analysis (see Appendix F).

Waldorf Quantitative Data Analysis

ANOVAs. For Data Set A and B reading and math score data were submitted to individual between subject ANOVAs where Group (Control, Waldorf) and Grade (2nd, 3rd, 4th, 5th, 6th, 7th, 8th) represented the two between factors. Any significant interactions were further submitted to a post-hoc Fisher LSD. For Data Set C, data were submitted to repeated measures within and between factor ANOVAs where the between factor was Group (Control, Waldorf) and the within factor was Year (2005, 2006, 2007, 2008, 2009, 2010, 2011).

Treatment of missing data. There were several missing values in all three of the test score data sets. For Data Set A there were the following missing data values: 7th grade reading (N=2), 7th grade math (N=3), 8th grade reading (N=5), 8th grade math (N=7). There was also no 2nd grade test score data in several schools since NCLB does not require 2nd grade testing. Data from the following states did not provide 2nd grade scores: Arizona (N=3), Oregon (N=1), Alaska (N=1) or Wisconsin (N=1). No attempt was made to replace or estimate missing values in these cases. However, a missing value for a Waldorf school resulted in the elimination of the district score for that school so that scores were paired with their control values. Many of the missing values for math were due to the use of alternative testing in the Algebra subtest in 8th grade. For this reason, Data Sets B and C excluded 8th grade math scores.

For Data Set B there were the following missing data points: 7th grade reading and math (N=2), 8th grade reading (N=4) making the group totals (N=13 and N=11, respectively). Only five out of the 15 schools provided general math scores for the 8th grade, as mentioned previously, due to school alternate assessment of Algebra; therefore, 8th grade math scores were excluded from both this data set and Data Set C. Missing values from control schools were eliminated when no comparison values from Waldorf schools were available. No attempt was made to replace or estimate missing values.

For Data Set C, the use of repeated measures, made it necessary to replace missing values with appropriate estimates. There were three missing data points: two from year 2005 and one from 2011. The estimated values for these missing data points were determined by taking the mean difference between the missing year, and adding it to the closest available year. For example, the mean difference between 2005 and 2006 for Waldorf schools was -8, so taking the 2006 score and subtracting 8 provided the estimate. There were no missing values from matched control schools. Although estimated values were provided in order to run the repeated measures ANOVA, t-test values applied for post-hoc analysis of year-by-year differences showed that no significant differences in the data output were seen when the estimated values were removed.

Waldorf Qualitative Data Analysis

First coding: Hand coding. In the first stage of coding we examined 606 comments from 23 public Waldorf schools. These comments were coded by hand using *in vivo* and descriptive coding techniques (Saldana, 2009). Coded comments were assigned to one of three groups, or themes: (1) *Parent School Relationships*, which corresponded to the codes of: community, parent involvement, teachers, leadership; (2) *Academic Core*: second languages, academics, curriculum; and (3) *Whole Child Education:* 21 C skills, art and music, holistic education, and developmentally appropriate practice (DAP), love of learning, world citizens.

Codes within each theme were then labeled based on whether they were negative or positive with respect to perceived experience by the parent. Positive and negative codes were counted for each theme, and responses across themes were evaluated for patterns. Figure 1 shows a flow chart of the hand coding process. The same themes and codes were then used for the second analysis comparing Waldorf schools to the comparison schools used in Data Sets B and C. This second analysis applied the process of auto-coding and quantitative content analysis (QCA).

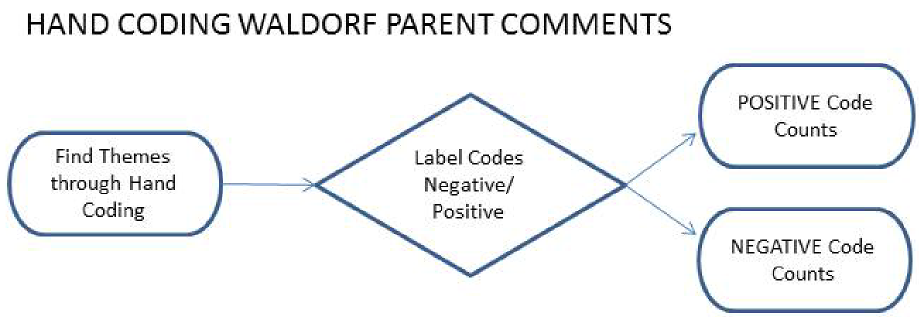

Figure 1. Flowchart showing the process of hand-coding and categorizing parent comments as positive or negative.

Second coding: Auto-coding. Auto-coding is an approach to content analysis that acts to minimize subjectivity. The use of predetermined key-words allowed for examination of patterns of responses in Waldorf schools compared to non-Waldorf schools. The same 606 responses from the 23 Waldorf schools used in the first coding were compared to the 1013 comments posted for the 26 comparison schools used in the quantitative strand of this phase of the dissertation. There was a higher average number of responses per school for comparison versus Waldorf (Mean counts= 39, 26 respectively) however, median counts per school were fewer for comparison versus Waldorf (Median counts= 11, 17 respectively). For the automated coding process, each school was entered as a separate case into HyperResearch QDA software and was coded using key terms relating to our selected themes generated from the first, hand-coding. The auto-codes were checked for accurate correspondence with the theme before being included in the final counts. Finally, as with our first hand-coding procedure, each of the parents' comments was separated into positive and negative statements (see Figure 2 for an overview of the coding process). Patterns of responding were then analyzed using quantitative content analysis (QCA).

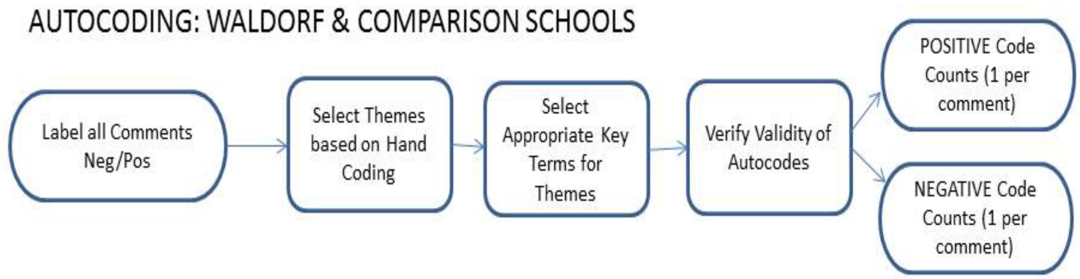

Figure 2. Flowchart showing the auto-coding procedure for qualitative parent comments in Waldorf and comparison schools.

QCA & factor analysis. The counts of positive and negative codes generated in the auto-coding process were changed to percent values for the quantitative content analysis (QCA). Percent values were examined for patterns of responses using an exploratory factor analysis, and then were evaluated between Waldorf and comparison schools for significant differences using independent samples t-tests. Although QCA is traditionally used for documents, there is a growing trend to mine data from blogs and internet sources (Berendt, 2010). Here QCA was used to make sense of parent comments through using code counts of positive and negative comments, and then applying a factor analysis to extract patterns. The use of a factor analysis is typical in basic content analysis (Weber, 1990) and although our absolute number of cases was small (N=50), the actual number of participant comments exceeded 1600 postings. Furthermore, there is some precedence for using a factor analysis with as few as 50 units of analysis (Arrindell & van der Ende, 1985). The confirmatory FA presumed themes according to the previously mentioned three categories: (1) Parent School Relations, (2) Academic Core and (3) Whole Child Education. Although our absolute number of cases was small in each of our two cases (Waldorf/Comparison N=50), the actual number of participant comments exceeded 1600 individual postings for Waldorf. The use of FA was intended to increase the understanding of the coded content provided by the qualitative parent blog data.

School Selection Public IB

A list of accredited IB schools was obtained from the official International Baccalaureate website (www.ibo.org). Schools were selected from all acreditied schools available on the list of California schools from the month of November, 2011. Private schools were excluded from all analyses. These schools were used for both qualitative and quantitative data analyses. IB has grown even more rapidly than Waldorf in the public sector in California and across the nation. From the initial selection of IB programs in California, a total of 39 schools, 19 with PYP status, 18 with MYP status, and 2 with dual status of both PYP and MYP. Because IB is growing so rapidly, an additional nine schools obtained IB status before the completion of this research. These were not included in the qualitative analysis, but PYP schools were used for the quantitative portion of the analysis.

IB follows a framework that fits within a variety of school models and cultures. All IB schools must be accredited through a review process that typically takes around three years. IB is applied uniquely in each school, state and country according to the needs of the student body it serves, and the mandates of the national and state policies in which the school resides. There is a far greater degree of variation provided by the IB framework than in Waldorf. Because of the natural variability in the way in which IB is implemented in schools, rather than having a separate control group, IB schools themselves were compared to each other across a number of variables.

IB Quantitative Data Analysis

ANOVAs. IB programs with PYP accreditation were submitted to between subjects ANOVAs to examine the relationship between IB status and performance on state mandated tests. Separate 2 X 2 X 4 within factor ANOVAs for Year (2010, 2011), Subject (Reading, Math) and Grade (2nd, 3rd, 4th, 5th) were analyzed for percent of students in three performance ranges: (1) Advanced, (2) Proficient and above (proficient + advanced), and (3) Below basic (below basic + far below basic). In addition to examining the Grade level changes in test scores, differences in performance for schools with longer IB accreditation were examined using overall mean scale scores on the CSTs. Mean scale scores were submitted to between factor ANOVAs using years of IB accreditation (<1 year, 1 year, 2- 3 years and 4-6 years) as the between factor. Any significant interactions were further submitted to Fischer LSD post-hoc planned comparison analysis. There were no missing data points for these analyses.

Difference Scores. In order to look more closely at how IB scores changed over time with respect to how long the schools had been accredited, difference scores calculated by subtracting 2010 scores from 2011 scores, were submitted to between factor ANOVAs using years with IB accreditation as the between factor (<1 year, N=7; 1 year, N=8; 2-3 years, N=5; 4-6 years, N=5).

IB Qualitative Data Analysis

Descriptive coding. Comments from parents using data from the national GreatSchools.org website were coded using descriptive and *in vivo* coding. Several aspects of IB align with neuropedagogy and sensitivity was paid to code these themes. On a school by school level there are significant differences regarding the extent to which a program might use principles from neuroeducation, or variables related to MBE. This study examined the relationship between parent comments revealing high or low use of MBE variables and the satisfaction of parents with their students' education. This was done through pattern analysis and hypothesis testing.

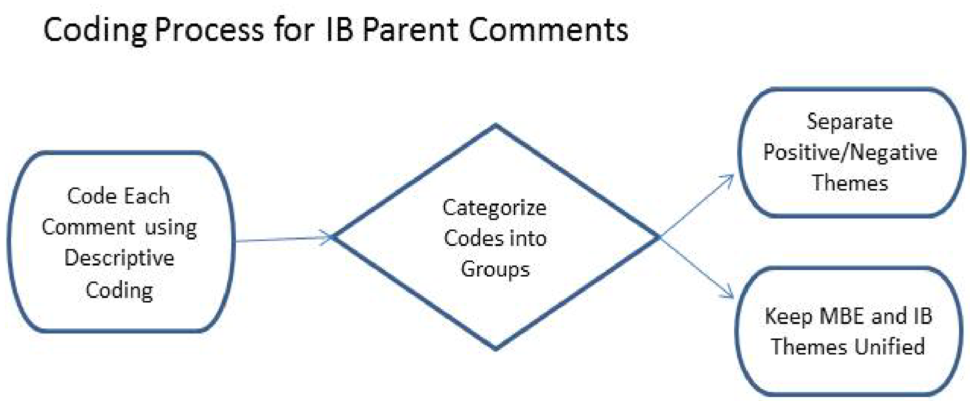

Figure 3. Flow chart for the coding process of IB qualitative parent comment data. Only general themes were coded as positive or negative, while themes relating to MBE remained unified for all quantitative analyses.

QCA & factor analysis. Like the Waldorf auto-coding data, hand coded comments from IB parents were grouped into themes and analyzed for interrelationships using correlations and factor analyses to examine patterns of responses (Miles & Huberman, 1994). Unlike Waldorf school data which also included comparison schools, IB school data were analyzed for patterns within and between the IB schools alone as the primary source of inquiry. In particular, this approach examined the hypothesis that the relationship between MBE variables and codes would be positively related to the overall parent happiness with the school. This approach to QCA and FA is supported when there are strong theoretical underpinnings to the data set (Neill, 2006) and can help to enhance the chances of finding significant patterns based on an existing hypothesis. Again, for a factor analysis, the total number of schools was small (IB N=38), however, the total number of codes from parent comments contributing to the data was high at 2429 codes.

Analysis of Waldorf & IB for Principles of Neuroeducation

The qualitative coding of Waldorf and IB parent comments used descriptive and open coding, and did not pre-select themes or codes as they were related to MBE or neuroeducation. In order to connect the findings from this second phase with the findings from the first phase of this dissertation, parent comments were examined for their alignment with codes and themes generated from the interviews with academics and educational leaders. IB and Waldorf school qualitative codes that met the criteria for neuroeducation or approaches supported by MBE were examined as a means of finding those points of connection that were most salient for each of the school models. Finding the connection between form or theory, and substance or practice is an approach to curriculum inquiry which has gained considerable respect (Shubert, 2008, p 399). This approach is especially relevant to developing the field of MBE which is currently seeking to bridge between theory generated from science to effective practice in the classroom.

Phase 3: Case Studies of Exemplary School Models

Rather than focusing on content knowledge, much of what is central to MBE focuses on capacity building and the health of the whole child, physically and emotionally, as well as cognitively. Phase three of this dissertation research was designed to look more closely at the impact of our two selected models of education, Waldorf and IB, with regard to student cognition and emotional development. Previous research in the two selected models have been shown that indeed outcomes in Waldorf and IB schools support the notion that these school provide support for capacity building and social-emotional health (Armon, 1997; Dahlin, 2010; Gidley, 1998; Mitchell & Gerwin, 2007; Ogletree, 1971; Payne, River-Bento & Skilling, 2002; Rivers & Soutter, 1996; Tan & Bibby, 2010). In order to examine the effectiveness of IB and Waldorf on student outcomes in the critical areas indicated by neuroeducators, a comparative case study of three schools, one Waldorf, one IB and one traditional was used to delve more deeply into issues of student wellbeing, cognitive development, and school experience.

School Selection

One Waldorf, one IB school, and a comparison school using a traditional approach were selected for a case study measuring factors relevant to neuroeducators, including social-emotional development and critical thinking. Schools were selected from best examples for Waldorf and IB serving a K-8 population from the state of California ranging from Chico to San Diego. The Traditional school was selected for convenience and served a 6-8 student body. The Traditional school was in the south, the Waldorf school central, and the IB school was the farthest north of all schools. Students in all schools participated in a series of surveys administered during the regular school day by their classroom teachers.

Survey Selection

Surveys were selected to answer questions that emerged from the literature and based on findings from the earlier phases of this research. Social-emotional factors representing secondary themes, and critical thinking and problem solving, representing tertiary themes in the model developed from the literature (see Chapter 2) also appeared throughout the interview data (Chapter 4) and in the parents' comments for Waldorf and IB (Chapter 5). Because this approach used a grounded theory to inform the later phases of the research, it was determined that standardized scales of social-emotional development and critical thinking should be administered as measure of student outcomes on themes relevant to MBE and neuroeducation. In addition, a scale of school enjoyment and a measure of attention were developed by the researcher.

Social-emotional scale. Social-emotional development was a central theme from literature on neuroeducation. Furthermore, the need for developing social skills in students to prepare them for the ever shrinking world and a globalized society is indicated by the *Partnership for 21 Century Learners* as a central goal for education (2008). Both Waldorf and IB integrate aspects of student social and emotional wellbeing into the curriculum. The survey instrument used to measure social-emotional development was the Trait Emotional Intelligence Questionnaire – Adolescent Short Form (TEIQ-ASF). The TEIQ-ASF is a 30 item questionnaire using a 7 point Likert scale designed to measure global trait EQ, modified from the long form to be used with children as young as 11 years of age (Petrides, Sangareau, Furnham, & Frederickson, 2006). The scale measures four subscales—wellbeing, self-control, emotionality, sociability—and provides a composite score. This scale was chosen to begin to address the extent to which we are able to examine the relationship between profiles of emotional intelligence that accord with educational experiences aligned with the principles of neuroeducation.

Critical thinking scale. Critical thinking is professed as a 21st century skill (Bellanca & Brandt, 2010). However, there are few empirical studies examining this as a student outcome. This study applied a short version of a well-established task of conditional reasoning, The Cornell Conditional Reasoning Task (CCRT), one aspect of critical thinking that reflects higher order thinking abilities in students. The CCRT, developed by Ennis, Gardiner, Morrow, Paulus & Ringel (1964), is a test of induction, deduction, evaluation, credibility assessment, and assumption identification. This test has been used in student as young as fifth grade, and is therefore suitable for the population examined here. The original task contains 72 questions. For the purposes of this study 20 questions were selected, and analyzed across three domains, Verbal reasoning, Numeric reasoning, and use of Prior knowledge (Appendix K).

Original scales. Besides the use of standardized scales, an additional twenty question, two part scale was developed by the researcher herself to examine (1) school enjoyment and (2) attention (Appendix J). Ten questions on school enjoyment addressed students' interest in coursework/school, enjoyment of courses/school, and the extent to which they felt what they were learning was interesting/important. These questions preceded ten question making up the attention scale developed based on standard checklists across a number of sources and from the researcher's previous experience working in the domain of attention research. Similar to other scales of ADHD this scale included questions on inattention, memory, and somatic awareness. Questions followed a four point forced-choice Likert scale and on final data collection the scales were analyzed for construct validity using factor analysis. Both parts of the survey were designed to have equal numbers of positively and negatively worded questions. Data from negatively worded questions were reverse coded before analysis. The advantage of creating a scale was that it allowed the researcher to ask question directly related to school and student experiences.

Goodenough-Harris Draw-A-Person task. The Goodenough-Harris Draw a Person task based on the work of Florence Goodenough (1926) and developed further by

Dale Harris (1963) has been used historically as a measure of non-verbal IQ, to evaluate developmental aspects of cognition and intellectual maturity and as an assessment of emotional wellbeing. Here it was used in an exploratory fashion and as a means of allowing students a chance to express themselves non-verbally.

Survey Administration

Schools were contacted at the beginning of 2011/2012 school year, and several conversations between the researcher and the school officials occurred during that time. The administration of the surveys occurred in June 2012 after the completion of the state mandated testing. For the two experimental schools, Waldorf and IB, surveys were sent via mail and instructions were provided via scripts to be read to students, while for the Traditional school the researcher provided the surveys in person. All 6th through 8th graders from the Waldorf and IB schools were invited to participate, while selected classes from the Traditional school were chosen by the principal based on teacher ability and interest. It was explained to teachers, either in person or in a letter, that the atmosphere of the test should be relaxed, that small amounts of talking should be allowed, but that students should not share answers. This was done to reduce test anxiety and create a light emotionally positive atmosphere, in an attempt to control for emotional factors shown to impact the outcome on our survey measures. Students were given 50 minutes to fill out the surveys. For the comparison traditional school, some of the teachers expressed concern at their student's comprehension level, and so it was decided that the questions could be read aloud to the students. Teachers were told they could help their student clarify questions, but that they should not direct them to any particular answer. Additional time may have been provided as necessary, in particular for the Traditional school classes.

Prior to administration of the surveys, students were given a list of the Participant Bill of Rights to keep and take home as well as the informed consent form. Teachers were encouraged to have a conversation with students about the process of research, including what it meant to have participant rights, and why these might be necessary. Students preferring not to complete the form were informed they could decline. No students, that this researcher is aware of, declined to take the survey. The list and description of each survey administered is provided below.

Data Analysis

Quantitative survey data collected from the three schools, Waldorf, IB and Traditional schools, were analyzed using correlational analyses and between factor ANOVAs or MANOVAs. Correlation matrices were used to examine relationships between the various scales and seek out any inter-relationships between constructs such as attention, school enjoyment, social-emotional development and critical thinking. ANOVAs were used to examine between school groups on the main constructs of each scale. MANOVAs were used for scales with multiple internal constructs. Significant main effects and interactions were analyzed using Fischer's Least Significant Differences (LSD) Post hoc analysis or multiple t-tests.

There were three qualitative questions at the beginning of the survey and the Goodenough-Harris Draw a Person task also required coding based on a rubric that was somewhat subjective. In order to reduce bias, scoring for the drawings was done in two phases by the primary researcher. Although it was subjective and the researcher had knowledge of which schools were being scored, guidelines from the original scoring manual were applied with as much fidelity as possible (Harris, 1963). However, because of the potential bias to judge the experimental schools more highly, the researcher intentionally used the individual schools themselves as internal references. Each school's drawings were scored, and the drawings were compared to only those within their own school so that the range of best to worst drawings was done with less potential for bias. The second phase of scoring compared original scores across schools, and ratings were either raised or lowered 0.5 of a point to better represent differences among the schools. There were two other open-ended questions: (1) What is your favorite subject in school? (2) What would you do as a career if you could do anything? These were analyzed for frequency of categorized content using Chi-squared test for independence.

Limitations, Assumptions & Design Controls

The research presented here has several limitations that may reduce the generalizability of the findings, in particular, with regards to the interpretation of the case study student data. The two experimental schools selected for the case studies were intended to be best examples not only of their proposed model (Waldorf or IB), but also with regard to their treatment of the themes of neuroeducation. The control school, however, was primarily selected for convenience. This portion of the dissertation is intended to represent a prototype of how research in neuroeducation can contribute to the evaluation of classroom pedagogies for student outcomes on more than just standardized tests.

With respect to the first phase of the study, which upheld a central goal of defining the field and in particular creating a curricular framework, there were significant limitations as to the to the theoretical framework, or conceptual model, ultimately created by this researcher. Regardless of the limitations, the act of crafting such a framework is a necessary first step to move forward the conceptual understanding of MBE. Members of the field of MBE have recognized this “lack of conceptual grounding” as an emerging field without a framework (Ansari & Coch, 2006; Carew & Magsamen, 2010). This is not to say that theoretical frameworks in neuroeducation do not exist at all. In fact, there have been a number of “programs” and “principles” developed in the form of brain-based education programs, for example, Meyer and Rose’s (2000) *Universal Design for Learning* (UDL), Caine and Caine’s *Twelve Principles* (1991), and Leslie Hart’s *Proster Theory* (Hart, 1983). Although each of these are respectable resources for understanding how to apply knowledge from brain research, the one thing that is missing from each these frameworks is explanatory depth with regards to the neuro and cognitive sciences. As a scientist first, a theory which does not provide for the inclusion of the rapidly changing and emergent finding from neuroscience and cognitive science will always be insufficient and incomplete. Hence, this was seen as an opportunity to create a dynamic model focused on the science. The limitations of creating a working model as a framework are seen as minimal compared to the potential benefits. In my view this model provides an interesting starting point for the development of a more elaborate and complete conceptual framework in the future.

Positionality & Epistemology

This researcher has no specific positionality related to the participating schools and members of the educational community; however, there is a strong lens through which this work is coming into focus and this reflects the epistemology of this researcher.

Those who define MBE support the inclusion of a number of disciplines beyond just neuroscience such as cognitive science, psychology, and anthropology (Fischer, 2009; Tokuhama-Espinosa, 2011). Because of my personal knowledge of neuroscience, both the model and questions asked held the potential of being ultimately biased. Efforts to reduce this bias included selection of participants in interviews (balancing between neuro and cognitive scientists), attempting to broaden the literature searches by focusing on work by cognitive scientists, and other relevant research in the field and encouraging topics that invoke issues of mind, a topic for which neuroscientist have in the past remained “agnostic”. Another bias of this researcher is a strong belief that the current focus on HST is misguided and potentially harmful to students’ development. In order that these biases were minimized in the data collection process, questions relating to NCLB and HST policies were couched in language that might have implied that the researcher found value in these tests, or minimally had no personal opinion regarding them.

This work began from the firm belief that a person must engage in and be met with certain educational opportunities for his or her full development. It was estimated that such an approach required the holistic engagement of physical, emotional and the individual self of each student. The choice of two holistic models, Waldorf and IB, were based on the perspective that they meet the needs of students developing nervous system. Many other possibilities existed, and this approach of evaluating school models is one that should be considered not just for holistic models of education, but also for other alternative models with strong theoretical grounding.

CHAPTER 4: Results from Phase 1

It has now been 15 years since the publication of the article “A Bridge Too Far” (Bruer, 1997) warning against the overzealous application of neuroscience findings in classroom practice and pedagogy. Since the publication of that seminal article, there has been sustained growth in the development of MBE as a significant force for bringing teachers and teaching to the forefront of the conversation on how neuroscience and cognitive science can inform classroom practices. MBE provides a shared vocabulary, and co-participation including teacher training and curriculum development to what in educational neuroscience was primarily an academic research field. In this respect, MBE represents shift in focus, and a balancing of power in the researcher-teacher relationship.

In 2008, Dr. Tokuhama-Espinosa published the findings from a Delphi Panel of experts to discuss the definition of the emerging efforts to bridge the gap between the laboratory and the classroom. Out of those conversations came a collaborative understanding of what MBE represents. This first phase of the dissertation research was designed to provide the current perspectives from academics in educational neuroscience, cognitive psychology and MBE on the role of various stakeholders in the processes regarding the issues and challenges of bridging the divide between research and classroom practice. In addition, the discussion was expanded to include voices of administrators and consultants to examine points of agreement or contention between the various stakeholders dedicated to informing educational practice through neuroscience. The initial conversations created a picture of the field while further conversations through separate blocks of interviews helped to define a clearer picture of how the neuroscience could and should be translated into practice. Three blocks of interviews in all contributed to the creation of a curricular framework for neuroeducation presented at the end of this chapter.

Major Themes of the Three Block Framework

This chapter separates the interview findings into three major sections that emphasized the following three topics: (1) Defining the Field, (2) Developing the Field and (3) Creating a Curriculum of Neuroeducation. These loosely correspond to the primary focus of each of the three interview blocks as they emerged as overarching themes. Defining the field was completed in the first block as it was most easily saturated. Although there was not complete agreement, the differing views that emerged were consistent between participants. Developing the field also had a great deal of commonality across the participants and saturated within the first two block. The longer period of saturation for Developing the Field reflected the complexity of the problem and addressed issues from policy, to changes in the role of teachers, and challenges for translating neuroscience. The final section of creating a curriculum was the most difficult to saturate, and it is easily stated that even at the third block of interviews, there could be a great deal more to add to this discussion.

Changing Themes from Block 1 to Block 3

The first coding performed on the first block of 8 participants resulted in 210 codes and 15 categories or themes. These codes and themes were used as a framework for the second block of 9 interviews, however, new codes were allowed to emerge and old codes and themes were revised to make up the final coding which consisted of 161 codes grouped into 17 themes. There was limited change in themes relating to non-curricular issues (Table 4). This was contrasted with the dramatic changes in curricular themes (see Table 5).

Of the ten non-curricular themes, three did not change from Block 1 to Block 2, i.e. Changes & Evolution of the Field, Definitions & Goals, and Personal Influences. Most of the themes actually were reduced, rather than expanded, so that it appeared that saturation had occurred. Only two new non-curricular themes emerged, Creating Community (not related to any previous code), and Institutional Behaviors, (refining the Block 1 theme of Policy-Testing and Reform). This reflects the relative degree of saturation of the non-curricular themes in these first two blocks of interviews.

Table 4. Transformation of Non-Curricular Themes from Block 1 to Block 2 Coding

FIRST CODING THEMES	TRANSFORMED THEMES
CHANGES & EVOLUTION OF THE FIELD	n.c.
DEFINITIONS & GOALS	n.c
PERSONAL INFLUENCES	n.c.
PROBLEMS IN NEUROEDUCATION	CAUTION & SKEPTICISM
CAUTION & SKEPTICISM	
COLLABORATION: MAKING THE TRANSDISCIPLINARY CONNECTIONS	TRANSDISCIPLINARY CONNECTIONS
FORUMS	
NEUROSCIENCE ISSUES	NEUROSCIENCE & RESEARCH ISSUES
VALUE OF SCIENCE	
POLICY-TESTING-REFORM	STRUCTURES & POLICY
	INSTITUTIONAL BEHAVIORS

Note. n.c. = no change

Over the three blocks of interviews there were a growing number of themes relating to curriculum issues and this was demonstrated by the splitting apart of themes and an increase in the number of coded phrases across each block (Table 5).

Table 5. Changes in the Curriculum Themes: Block 1 to Block 3

CURRICULUM THEMES	TRANSFORMED THEMES	
BLOCK 1	**BLOCK 2**	**BLOCK 3**
DEVELOPMENT & INDIVIDUAL DIFFERENCES	n.c.	DAP-HOLISTIC
		INDIVIDUALLY RESPONSIVE
PROGRAMS	APPLICATIONS & PROGRAMS	CONTENT
		MODELS OF EDUCATION
	CURRICULUM & INSTRUCTION	CLASSROOM PRACTICES OF MBE
STUDENT SKILLS-ISSUES	STUDENT ISSUES	METACOGNITIVE
	STUDENT_COGNITIVE	COGNITIVE
	STUDENT_SOCIO-EMOTIONAL	SOCIO-EMOTIONAL
	STUDENT_PHYSIOLOGICAL	PHYSIOLOGICAL
STRUCTURES	STRUCTURES & POLICY	CLASSROOM STRUCTURES
	INSTITUTIONAL BEHAVIORS	
TEACHER TRAINING/TEACHERS	TEACHERS	ROLE OF TEACHERS/PARENTS

Note. n.c. = no change from previous block.

The first block of interviews resulted in 5 themes made from 56 codes that were directly and indirectly related to classroom practice and curriculum. This expanded to a total of 10 themes and 72 codes in Block 2. For Block 3, curriculum codes further increased to 11 themes, with 110 codes. This growing number of codes and themes across the three Blocks demonstrates the intent of this researcher across the interview blocks to try to work towards saturation of the themes surrounding curriculum. It will be noted in the discussion regarding the belief as to the extent that this intent was achieved.

A further example of the code expansion can be seen when looking specifically at student issues which were similar across blocks (Table 6). The increase in code counts is rapid from Block 1 to Block 2, and more slowly increasing or slightly decreasing for Block 3. Interestingly, for all three blocks, there were more cognitive than emotional comments, and counts for physiological factors were the least frequent.

Table 6. Student Themes Repeated: Blocks 1 to Block 3

Student Themes	**Block1**	**Block2**	**Block3**
Student_Cognitive	37	77	57
Student_Emotion	14	42	37
Student_Physiological	9	12	17
Development & Individual Differences	40	51	74

First Block: Defining the Field

The first block of interviews included eight members of the academic community who worked in transdisciplinary efforts to integrate and synthesize research across the different fields. These codes and themes were then used in coding of the second block of interviews and new questions were designed to further saturate the less well developed themes. Although formal coding of the first block of interviews was not completed until the full data set from this block was obtained, as questions and themes emerged, there was an attempt to clarify these in subsequent interviews. This was part of the grounded theory approach applied throughout the data analysis.

Second Block: Developing the Field

The second block focused on how to develop the field as relating to finding means of linking or bridging the various critical fields especially with regard to classroom practice and pedagogy. These issues were difficult to pinpoint and needed clarification and were the focus of both the first and second block of interviews. It seemed necessary in the second block of interviews to expand the conversation to include those working with and in schools as educational leaders and consultants who worked more intimately with teachers in creating effective schemas for working in the classroom. This allowed the researcher to understand the envisioned means of the creating the necessary interconnection for bridging this divide between fields.

The coding of Block 2 data was followed by a recoding/re-categorizing of the entire first block of interviews. When necessary codes were renamed, and groups and themes were reorganized to meet the emerging concepts. Although similar questions were directed towards the academic and non-academic participants, the follow-up to responses allowed for each group to share their area of expertise and a number of new codes and themes emerged from this second block of interviews. The evaluation of the level of saturation of themes indicated that the area of curriculum and classroom practice produced was the least well developed. As such, the focus of the final block of interviews became the second research question: *What is the consensus on a Curriculum of Neuroeducation?*

Third Block: Exploring a Shared Construct of Curriculum

The third block of interviews pushed beyond those who were recognized members of the MBE community to include founders of experimental schools. The purpose of this was to understand some of the challenges in creating a new model of education. Creating a school that might run against the grain of current practices in education, as was implicated for neuroeducation from the first two blocks of interviews, suggested that input from those who were working at the level of creating effective schools could be useful in this process. Because these school models also show greater alignment with aspects of the neuro and cognitive aspects of learning, such as attending to personal interest, and intrinsic motivation, responses from leaders of experimental schools were included in the discussion of creating a curricular model. However, the main goal of this outreach was to discuss the challenges and opportunities of for creating an alternative education program, and how neuroeducation would fare in this regard. The school founders interviewed here supported many of the principles of neuroeducation, spoke positively to the ability of MBE and neuroeducation to highlight the best practices of their schools, and one participant was even in the midst of writing a book on the implications from brain research to teaching.

The drilling into the theme of curriculum was the core component of this final interview block, and information from school founders were used with caution in making assumptions about a pedagogy of neuroeducation. Questions from this third block of interviews focused on programs, alternative schools models, and implementation as well as student cognition and social and emotional development.

The third coding resorted back to open coding and none of the codes or themes from the previous block were directly referred to in this final coding. Nonetheless, there was considerable agreement between the three blocks about pedagogy, curriculum and content, in general. In addition, although the third block focused on curriculum, issues and themes from the previous interviews (i.e. policy, assessment and community) came up as they related to the ability to build and implement a scaled up reformed model of curriculum. This was especially true of the school founders, who provided new perspectives, and more richly informed those earlier themes. As such, codes as they related to the earlier themes were applied to the final analysis of each theme presented here under the previous sections of Defining the Field, and Developing the Field.

Results for Defining the Field

Recently, David Sousa published an edited book providing a collaborative sampling of components of MBE from many perspectives (Sousa, 2010). In this book, Sousa equates MBE to educational neuroscience. In his opening remarks he states, “This book is the first to bring together some of the most influential scholars responsible for giving birth to a new body of knowledge: educational neuroscience” (p 1). Although Dr. Sousa argues that educational neuroscience and MBE represent part of the same discipline, in many ways MBE may in fact represent a unique field of study with separate goals and a broader scope than educational neuroscience. Historically, educational neuroscience has been an academic discipline focused in large part on the basic research of brain and learning that holds relevance to education. The research conducted in Departments of Neuroscience or Departments of Psychology rarely have had associated teacher training programs. Compare that to the first program in MBE originating at Harvard’s Graduate School of Education. This program, housed in a department of education, was immediately involved in teacher training, as well as having a research program involving research schools where curriculum studies could proceed in a cohesive manner. Is it the case that educational neuroscience is simply expanding? Or does MBE truly represent something novel? Is there an advantage to having two separate disciplines? Or would it serve the system better to combine these programs under one roof of educational neuroscience? And where does this leave programs of educational psychology or cognitive psychology? Has the separation of psychology and neuroscience become passé?

In the original Delphi Panel, 56% of participants saw MBE as a separate field or discipline. Thirty-eight percent thought it represented a sub-discipline of (cognitive) neuroscience and should be called educational neuroscience, and 13% viewed it as including aspects of educational neuroscience, with MBE as a separate branch. (Tokuhama-Espinosa, 2008). The participants of the interviews here also presented with a range of opinions regarding the definition of MBE in relationship to educational neuroscience.

Explanatory Value of Terms: MBE versus Educational Neuroscience

The first series of question defining the field of MBE and educational neuroscience addressed whether these represented an individual or a single field of study. What was clear from the responses was that there were differing opinions on the use of and definitions of terms. Some felt that the term educational neuroscience was synonymous with MBE. The majority, however, did not see these two as being equivalent, and the strongest contrarian responses came primarily from those who were in programs of academic laboratory research as compared to those who worked more closely with teachers.

Those focused more on the academic laboratory sciences felt that MBE had a different agenda than they did, especially in that MBE included a program of teacher development, and focused on community outreach.

> I think [MBE] has a kind of different agenda than what we are trying to do. (P7)

> What [MBE] started off wanting to do was to bring a neuroscience message out to people that are practitioners, trying to get the communities to talk to each other, where ideas are exchanged or more research is inspired to try to make a transition from basic lab stuff to classroom practices. (P8)

On the other hand, there were several participants who defined MBE as fitting under the umbrella of educational neuroscience, but noted that the group represented a small and separate endeavor with a slightly different focus than educational neuroscience had traditionally engaged in.

> In other words, MBE is a synthesis across cognitive and developmental psychology, the neurosciences to some degree and educational theory and its recommendations for practice. And I consider that an important part, probably the best developed effort within educational neuroscience. (P1)

> When I think of MBE I think of a specific group of professionals who have been working very assertively within a group to try to create headway and do work on the topic. (P10)

In direct contrast to this view, there were those who felt that MBE was the overarching schema and that educational neuroscience was only a component part, since MBE included not only neuroscience but cognitive science, psychology, anthropology, etcetera, to quote one of the participants who was intimately involved with the International Society of Mind, Brain, and Education:

> So we may borrow from sociology, we may borrow from anthropology, and of course, learning science, any place where we can find a positive

> impact, because there are a lot of things working in a classroom, not just psychology, not just neuroscience. (P5)

This perspective held that MBE was like "wearing a different hat", and it could be found in a number of departments or disciplines. This definition of MBE places it in the domain of translational science. Viewing MBE as a translational science that bridged across disciplines distinguishes the importance of the translator, something that has not been given formal recognition previously. By professionalizing the process of translating the science, the oversight provided could act to assure that teachers and educational leaders were provided accurate and up-to-date information to guide their decisions. By providing a framework for translation to happen through MBE the field can move forward with integrity.

Participant 10 gave an extensive account of why educational neuroscience was his/her preferred term, and yet recognized that within the efforts of trying to make sense of the field, there were developing mindsets, "crystallizing" concepts, and that the field itself was not yet at the point of having concrete definitions, but that we should allow all voices to be heard. With this, the selection of the terminology used should not be a popularity contest, and participants stated, none of the groups or approaches were inherently wrong or better. The determination of the necessity for a separate term should rather reflect the contributing value of each as fulfilling a particular problem space. A term does not hold unique explanatory value should fall away, however, if there is reason to believe that MBE is unique in its scope and goals, it would serve the scientific and education community well to preserve this term. Exemplary quotes from the three views are presented in Table 7.

Table 7. Positions on the Terms Educational Neuroscience versus MBE

Position 1: Educational Neuroscience as the same as MBE	Position 2: Educational Neuroscience as differing from MBE	Position 3: MBE as a translational science
I think educational neuroscience is…it's about the widest net, the widest net linguistically that I can think of that could be cast that would include all of these different philosophies and perspectives on the issues.(P10)	In my mind educational neuroscience is not about creating a particular brand of teacher education program. It's about doing research that tells us something that contributes to our understanding of educational questions specifically. (P1)	I am attracted to what I believe is wearing a whole different hat. The whole idea is that we need a new kind of professional in the world today who can cross those lines and talk to all those different people, and to me that is an add on to any of your other professional formations. (P2)
My definition of neuroscience is very broad because ultimately any and all behaviors no matter what it is are brain based. That's just the way things are, so even if something says it's a developmental psychology thing, or a cognitive psychology thing, or a neuroscience thing, it all deals with the brain, if your studying how the brain learns anything, it's neuroscience (P8)	The MBE definition is not so much neuroscience in a narrow sense but a biologically inspired approach to educational problems in research and theory as well as in practice, so I think educational neuroscience, is like part of the MBE broader program. (P11)	I think we need to understand…that scientists are not necessarily educators and educators are not necessarily scientists. While there are a few who crossover reasonably well, most do their good work in their fields and then rely on the other field. (P13)
Educational Neuroscience sounds like what it is neuroscience that applies to educational activity the pedagogy. In recent articles I have seen the term educational neuroscience more frequently. So it is getting a foothold in the pedagogical jargon (P25)	When you talk about MBE, you are talking about not only about how we learn best, but how we should teach. And the teaching element is not in any of these other areas. (P2)	You have lots of people doing this [work], but they're kind of siloed off. MBE exists to keep the silos intact….but also lots of windows in the silos, lots of communication" (P5).

Neuroeducation, Brain-Based Education & Other Terms

Historically there have been a number of terms that have been applied to curriculum aligned with the brain sciences. These included most frequently brain-based and brain-compatible learning and more recently the term neuroeducation. These terms were associated with the practical application of neuroscience in education, in particular with regards to pedagogy and practice.

There were apprehensions expressed by the participants regarding the use of these terms. Of particular concern was the negative impact of educational fads claiming to be aligned with the brain sciences. These programs were seen as marketing ploys that had damaged the field. They were thought of as being marketed to teachers as a quick fix, and rarely having any scientific merit. The majority of participants associated these fads with the term brain-based education, and within this discussion there was some disagreement as to the extent to which this term has been detrimental to the field. Some felt that the term brain-based should be avoided altogether since it was historically associated with neuromyths or ineffective products.

> What brain-based education basically was was a marketing program to sell a bunch of educational products…with claims that the recommended teaching methods and programs and so on, were grounded in the neuroscience research usually without any reference to neuroscience research. (P1)

> The beginning of brain-based education and brain-compatible teaching and all this kind of nonsense terms that, you know, brain-based education, and then you had kidney-based last year, and then it's brain-based. (P3)

> But what people often call brain-based, my concern is that they are not brain-based, and it is going to take some time for the empirical work to catch up to the public perceptions that we know so much, when in comparison to what it looks like we know, we really know so little. (P10)

> It is just that much of what comes out of the brain-based education literature and products is not really grounded in sound science. (P12)

Although some felt strongly about completely avoiding this term, others felt it should just be regarded with some caution, and that the commercialization of the term was a predictable outcome of using any word that held marketing value.

> Usually brain-based is a marking term, so we don't really use it. It sounds very iffy. (P5)

> Like every other new term in education, some people manage to seize upon it for all sorts of goofy ideas and then proclaim their practice as brain-based. A new term would suffer the same fate. (P16)

Yet others, especially those that had used the term in their publishing or consulting practice, felt that the focus should be on the fidelity of the program and not the terminology per se. The accessibility of language was seen as a problem for teachers, and the fact that the term brain-based appealed to teachers made it a useful way of discussing the issues critical to the use of the learning sciences in educational settings. In general, it was the interview participants who were more closely tied with teachers and schools who felt the language of academia was extremely technical for teachers, an issue that could potentially bar them from participation. It was thought that the use of more “lay language” and theoretical examples could help eliminate some of this problem in communication.

> It doesn't really matter to me the terms that are used, what matters to me more is whether somebody is offering something that has fidelity with both the practices in education and the research in neuroscience. (P13)

> I don't find the terms brain-compatible and brain-based offensive. They simply mean schooling that is compatible with how the brain learns. This has been a most useful concept in examining education practices. It undergirds constructivist and experiential learning. (P16)

> Now what is also very often is that [scientists] use the most incredible language to articulate the most obvious things in the world… but if the research is inaccessible to the teachers, if the language is blocking the teachers out we are not going to get anywhere. (P15)

The term neuroeducation was the least well defined. However, it was used in the interviews by several participants, and there was some enthusiasm expressed for the term. In addition the term neuroeducation has been used in both past (Sonnier & Goldsmith, 1985) current publications (Serpati & Loughan, 2012; Hardiman, et al. 2011) to refer to a number of concepts. Given that neuroeducation was the least well understood in its definition and purpose, it may hold as yet unclaimed potential to evolve as a respectable term that describes the pedagogy of teaching aligned with the brain. Neuroeducation could serve as a replacement for the term brain-based which had for most a negative connotation.

> When you use these term like neuroeducation, that's a term that the folks at Harvard brought up and were offering that as an alternative to brain-based education, because brain-based education is kind of a bad name... (P1)

> I have one colleague who is very emphatic about calling it neuroeducation, and he has very exact reasons why he thinks it should be termed that and not educational neuroscience. (P10)

Others inherently associated the term of neuroeducation with the curriculum or classroom practice and saw it as something that we were striving for, but had a far way towards achieving.

> I think we don't know what neuroeducation is. I think it's a tough term to use right now because I think if we were to somehow design education based on what we know about the brain, we would have very little in our curriculum. (P24)

In the literature, neuroeducation is often paired with the term neuroeducator (Fuller & Glendening, 1985). The term neuroeducator has been used by Howard Gardner (2008) to describe "a professional who is grounded in both the theories and research of neuroscience and in the practice of education" (p 165). The use of the term "professional" rather than specification as "teacher" uses a more open definition than in previous literature (Cruickshank, 1981). In this case a neuroeducator can refer to a teacher, administrator, or academic researcher. The terms neuroeducation and neuroeducator deserve further evaluation of their unique explanatory value.

It is certain that redundant terminology will create confusion; however, without a clear representation of the various concepts and goals of these emerging efforts the capacity to organize in order to create reform will be handicapped. This researcher feels there are grounds for using each of the terms – MBE, educational neuroscience and neuroeducation – based on the belief that they represent different schema. As a first definitional schema created from the conversations, this researcher proposes the following distinctions. Educational neuroscience is predominantly a field of academic research in the neurosciences pertaining to educational issues, MBE best represents the translational science designed to bring knowledge from educational neuroscience and related fields to the teacher and into practice, and the term neuroeducation holds the most potential to define the pedagogy and curriculum produced from the translational work. These proposed divisions should not be thought of as rigid, but fluid and with overlapping boundaries. The extent to which these definitions can be clarified with respect to those shared goals and for those common participants will likely correspond to the degree to which the field will advance towards achieving those goals.

Defining the Limitations and Boundaries of MBE

There were a number of concerns especially by those in the laboratory sciences that much of the research was not yet in a place to be applicable to classroom practice. These issues were discussed under the themes of *Caution and Skepticism*, and *Neuroscience and Research Issues* (see Table 4). The limitations of attempting to apply the science to how we educate, or bridging the fields of neuroscience and education, were a serious concern on several levels. However, these fears were balanced by the enthusiasm and hope that the research would be able to if applied correctly make effective improvements in our education systems. These issues reviewed below represent the primary concerns reflected in the interviews, and suggest some of the conceptual and pragmatic issues the field faces as it moves forward.

Bridging research into practice. Besides disagreements surrounding the terminology of the new field, there was a more basic dispute concerning the capability of bringing the science to the level of the classroom, which was essentially divisible into two main views (Table 8).

Table 8. Positions on the Applicability of Neuroscience to Classroom Practice

Neuroscience Not Yet Applicable	Need to Bring Neuroscience to Teachers
I think it is practically too early, even in the more advanced areas… to map that out in terms of what that might mean for classroom practice. (P7)	There are too many problems in education that haven't been solved by educators, so the idea that you need to reach out an d be nurtured by information from neuroscience and psychology just makes sense. (P2)
A lot of the neuroscience in education is a nice idea…but…it is going to take some time, and it is starting to happen, but it is a big change. It's a qualitative change. (P8)	I think right now there is a more general acceptance that research can and should inform education. I think back in 1997 when Breuer wrote "A Bridge Too Far" there were those who were on the bandwagon saying neuro-cognitive science has nothing to tell teachers… I think now, we've come far enough to say, 'No, there is really important information that teachers should know' (P6)
So that is the concern with emphasizing educational neuroscience as a domain of serious academic endeavor, carefully constructed studies, warranted theoretically grounded research paradigms, and avoiding rushing off to create marketable products. (P1)	I often say that in the profession we've been like doctors who are training patients without having a basic course in human anatomy and physiology, for teaching human brains we need to understand how they work … I think that the brain research is giving us an answer to some of those questions and some strategies. (P23)

The first view, held in particular by participants working in laboratory research, was that it was too early to apply neuroscience to the classroom. These participants cautioned against the rapid application of tentative science findings into classroom practice, and emphasized that the focus should remain on the science, and not on creating a curriculum. This was countered by those who saw the value of sharing these findings with educators as outweighing the limitation, and that this was an important foundation for working in the teaching profession. The debate between the two camps separated between guarding the level of the science at high esteem versus the necessity for making a step towards curriculum as small as it might be.

For several participants, there was a certain amount of skepticism as to what the science was really providing above and beyond what was already known by educators and within the educational literature. Interview participants spoke to the idea that teachers were better prepared to tackle most of the important questions in their classrooms, and that scientists might in some ways only provide information after the fact.

> As a matter of empirical evidence, if you want to know what works in the classroom, looking at the brain isn't going to help as much as looking at studies that look at what works in the classroom. (P1)
>
> Anything that's really useful…I don't think that it came as a great surprise to any educators, you can't be working with two dozen kids as a 3rd grade teacher. You can't be working with 30 or so 8 year old kids, for like 25 years, a thousand hours a year, day in and day out, and not develop a functional understanding of what works and what doesn't work.…All of those kinds of things, that good teachers do, they don't know what brain system is involved with it but they know what works and what doesn't work. (P3)

Another issue discussed both by scientists and practitioners related to the difficulty of translating methods, especially imaging data, from the laboratory controlled research setting, to the messy, real-time, chaotic classroom. The difficulty of translating science into practice, and the difference between laboratory research and classroom practice was recognized as a considerable hurdle when attempting to make these leaps between fields, and was considered a central challenge for the field.

> The classroom is very, very messy, but it's realistic. If you look at things you are able to control, you have a lot of control in the laboratory and very little control in the classroom. (P5)

> There isn't a lot of easy stuff to take from neuroscience research directly into the classroom, there's also a problem with people willing to adapt or adopt what they do now to what neuroscience maybe explicitly says they should be doing differently…Stuff in the field often doesn't seem to fit quite as well as it does in the lab. (P8)

> That is a hard thing…one of our biggest challenges in MBE is that when people study a single element, or a single pattern it is divorced of context, it is divorced of society, the context of parents all these things of schools, so we have to make that leap from the laboratory and put it in context.(P2)

> I think in terms of neuroscience it is incredibly exciting, but like I say, when it hits the teaching model it just dies on the vine. (P9)

On the other hand, when asked to respond to the statement from some participants that there is little available right now that can be translated into curriculum, one participant replied "What has curriculum been based on in the past? I would arguably say much less" (P20).

Maintaining the integrity of the science. Despite these issues there was a general sense of optimism surrounding the headway that was being made through multiple avenues. Participants felt there was a growing social awareness that the science could and should drive the curriculum. What this meant, however, was that we must guard against watering-down the science, and be consistent in allowing the empirical work to drive the development of new curricular models.

> In my mind what is setting parameters is the empirical work. The empirical work is really where we make some things concrete. Opinions are respected, and I think every voice should be allowed, but I think the empirical work as it progresses is where the conversations ought to be. (P10)

> Having that dialogue is fine, but you have to be talking about the science. I don't think there is any point in trying to tidy the science out of the picture. It seems to be entirely counterproductive. (P7)

The difficulties of doing this was not seen as easy, but neither was it seen as insurmountable. Indeed, the conversations indicated a great number of activities that could be done to make the connection between the science and classroom applications. The number of undertakings and programs that were currently being engaged in by the participants (see Participant Description, Chapter 3) attests to the fact that this work of finding the points of connection is being undertaken on multiple fronts.

An Emerging Definition & the Birth of a Field

There has been considerable growth in the combined efforts that make up the field of educational neuroscience and MBE. With this growth comes the challenge of how it will take form and "find itself without being confined" (P5). When asked about what shouldn't be included in the field there was a near consensus that nothing should be off-limits in terms of topics of research this early in the game, only poor research and neuromyths were brought up as something to be avoided, and some topics deemed as worthy of research were seen as things that at the moment should not be brought up in teacher training.

> I don't know anything that should be hands off. Careless research should be hand off but that's true in any field. (P1)

> So I don't think anyone is ruling anything out apart from trying to get rid of some of the misconceptions that currently exist. (P7)

> It excludes nothing as far as education is concerned in terms of the topics you can actually study on the bases of biological/neurological knowledge. (P11)

> Let's talk about what should not be included. Simplistic explanations should be avoided. (P5)

The work in all areas of linking the neuroscience to classroom practice was described as being in its early phases. The field was described by one participant as being in the period of incubation, and another as being in its infancy. Therefore, it was important to be open, provide a broad platform, and to define the field with integrity.

> We are way too early in the game to make anything hands off. You know within the bounds of ethics and the appropriate treatment of human subject and all the responsible permissions that go around doing the work. But in terms of the nature of exploring links to questions or framing questions I think it is too early to judge. (P10)

> It is just in its infancy. Or maybe it is beyond infancy, but I don't think it has even reached adolescence yet. (P4)

All participants agreed that the field was growing, and that there was incredible receptivity for the work. "This is a movement, it's not just about [one] thing. The tide is rising …all these boats are rising higher" (P4). As the various inter-related fields contributing to MBE and educational neuroscience continue to expand it is important that the science maintains its level of rigor. As one member put it, "[this] is going to be a hot topic. Let's just hope we can do it professionally and responsibly and with the kind of theoretical coherence and methodological precision found in any serious [endeavor] worthy of the name science" (P1).

Results for Developing the Field

The second overarching theme in the interviews related to developing the field into a viable source of effective education. Questions surrounding *how* this initiative would emerge and could impact educational systems including understanding the roles of major stakeholders, finding ways to address current challenges and cultural views of education, and clarifying the necessary processes in achieving these goals all made up the overarching theme of developing the field. The field was seen as developing rapidly, especially in the growth in the sciences. Participants saw the role of MBE to make connections between the science and practice through various organizations and actions that would encourage the appropriate development of the field.

Passive Growth: Expanding Knowledge Base

The field was seen as growing by all those who were interviewed. When asked how they saw the field unfolding and advancing, there were two synergistic paths. The first and rather unexpected way in which change was seen as happening was through a *passive expansion* of our knowledge base and an increasing engagement of teachers with this knowledge. This reflected a natural evolution expected to happen with the "changing of the guard" of those who were indoctrinated into the old ideas of teaching and learning into those who were now entering the field with much greater knowledge about the neural and cognitive processes underlying learning.

> I think it is necessarily going to grow as more and more research deals with the brain. The whole level of sophistication or the IQ or the understanding about the brain…is increasing immensely over the past two decades, and that's liable to continue to increase, and as a result a whole bunch of things are going to improve not just in education but in society. (P8)

> The other thing that you see happening almost everywhere is the teachers are becoming increasingly interested in the brain, actually they are beginning to understand that their students have brains and that their brains are things that work in particular ways, and are not just neutral receptacles of knowledge that you can pour in to. (P11)

> Another way we are going to change is a lot of the veteran teachers, like me, we're dinosaurs. We're getting out. We're retiring. The other teachers that are coming in, they have the right training, the right views of learning. (P15)

> So if you look at that 60 year development, it was very, very slow. It would be like if you had a subtle increase in knowledge for 50 of the years, and this rapid increase in knowledge in the last 10 years. So if you take older people who are running the schools, whose whole orientation is that things don't change all that quickly, and you put them in charge of a school in our society where things are changing very rapidly, the old guys don't know how to deal with that? It's going to be the next generation that comes along that's going to figure it out. And I'm optimistic about that. So if you have people coming in who don't have all the baggage of how systems remain conservative, then they can just really rapidly change it. (P3)

Although the field was seen as something that would necessarily continue to grow, the fashion in which it would unfold was viewed as being the responsibility of members of all of the relevant communities. The need to guide the vision towards something with integrity and that would improve the quality of our educational system and not to allow it to be swallowed up by the existing structures was one of the critical challenges facing the success of MBE as a serious reform effort. There was agreement that the successful future of this multi-pronged endeavor would require a concerted effort by all the parties involved through active, collaborative engagement.

Active Growth: Transdisciplinary Connections

The active growth of the field made up a large portion of the themes relevant to Developing the Field. The active role of participants incorporated all of the ways in which the field encouraged connections between the key players. For the scientific research there was the ongoing need to help develop and deepen the understanding of the relationship between the biological sciences of the brain and the cognitive processes of the mind. While for the teachers there was the need to create connections through both science literacy and moreover to provide the translational science required to communicate with a non-academic community. The conversations that surrounded these issues further emphasized the need to create relevant research questions and problems that would translate into the classroom. As such, much of the active growth focused around building opportunities for communication and collaboration between the various stakeholders.

The challenges and opportunities for creating a transdisciplinary field or "bridging the gap" comprised the bulk of responses related to Developing the Field and were coded under the theme Transdisciplinary Connections. This theme outlined ways in which connections could potentially happen, or where they were already happening between researchers, teachers and educational leaders, as well as between researchers within the various disciplines of education, cognitive psychology, and neuroscience.

The top five most frequent codes under the theme of Transdisciplinary Connections focused on ways of making the connections through forums that included aspects of professional development across domains, communication and collaboration on small and large scales, and central issues that spoke to the needs to translate across the fields through multidisciplinary programs and activities. The frequency of the top five codes are presented in Table 9, each related specifically to how the connections between participants could shape and advance our shared knowledge. This next section will review these five top codes as they are related to other issues of developing the field.

Table 9. Transdisciplinary Connections: Top Five Codes from Block 1 & Block 2

Forums	***Communication***	***Collaboration***	***Translating***	***Multi-disciplinary***
42	32	28	27	27

Forums: Creating an Infrastructure of MBE

The most frequent code within the theme Transdisiplinary Connections was that of Forums. Forums included professional societies, but also more informal conferences. The major professional societies mentioned included the American Education Research Association - Brain Neuroscience and Education – Special Interest Group (AERA, BNE-SIG), the International Mind, Brain and Education Society (IMBES), the Society for Neuroscience (SfN) and the European Association for Research on Learning and Instruction (EARLI). There was an indication that the infrastructure with regards to these organizations was in place to be able to do the necessary work required for the active growth of the field, but some pointed out that perhaps the full potential of these groups had not yet been maximized.

> I think we have these big behemoth associations and organizations that kind of have already captured the appropriate audiences and I think in some ways we are not fully leveraging those organizations to their fullest capacity. (P10)

Participants also mentioned a number of informal activities that were being engaged in in order to build the necessary connections between the various constituents. These included workshops, university conferences, national summits, and "learning lunches" where local university members could share and discuss their related findings. These activities were focused around four groups: (1) university members from differing disciplines, (2) interfacing teachers and researchers, (3) K-12 school-university partnerships, and (4) engagement with the broader community including policy makers and parents. All of these efforts were deemed important, and emphasized the imperative to work on multiple fronts in order to bridge the divide between these disparate groups.

The Delphi Panel research project (Tokuhama-Espinosa, 2008) produced a list of journals publishing articles relevant to educational neuroscience and MBE. The interviews conducted here did not include direct questions about publications, however when asked about potential forums, publications were mentioned as important means to reach the various constituent bodies. Journal articles and an overall increase in amount of work being published in the brain-learning sciences were seen as a vehicle for the growth of the field. Historically, the journal Educational Leadership was mentioned as having had a positive impact on the field by introducing educators to these ideas initially and this was attributed to its editor at the time, Ron Brandt.

> Ron was really interested in the brain sciences, and what he did was, he published a lot of articles on that…a lot of educators got to know about what was going on in the brain sciences because so many of them were, especially the administrators in education, they read Ed Leadership… Ron did a really good job of making sure that no one wrote an article with big applications that weren't warranted. (P3)

The importance of a journal like Educational Leadership, that had a broad audience which included educators and administrators, was seen as something that had helped advance the field. Although the journal *Mind, Brain and Education* was the most frequently mentioned publication there were some doubts as to its ability to engage a broad enough research base and reach the right audience.

> The people who read the journal [MBE] probably may not be the best audience to effect change in terms of taking certain things into the classroom or educational practices or teacher training. (P8)

> What would be helpful would be some good journal out there. I know there is Mind, Brain and Education, but I think we need a slightly wider field of journals that can be published in a more coherent fashion and I think if that started to take off I think that would be a more persuasive thing as far as funding is concerned as well. There is very much that kind of publication side to be considered actually. (P7)

> I think also very important, is finding a way to communicate. Right now, I read the MBE journal. That has in it a lot of really good research results… but why aren't teachers writing in it too? Why not see if we can start working to get researchers to write more in the way that teachers are going to get it? (P15)

Other publications included books that translated the science into a context that could be used by a wider audience. *What Works Clearing House* and parent magazines were some specific genres of publications that were seen as capable of communicating with a broader audience and forwarding the agenda at the level of education. Publications were also mentioned as vehicles for getting the attention of policy makers, and being able to encourage greater amounts of funding. However, once again there was a caution that many publications, in particular books claiming to be related to the brain sciences and teaching, needed to be viewed with caution and that many such publications had little scientific merit. The solution to this challenge of weeding out poor science was to provide greater science literacy to teachers to provide them with a greater capacity to recognize quality research and not be drawn into an approach simply because it claimed to be brain based.

Communication: Personal Connections & Meaning Making

The next most common code under the theme Transdisciplinary Connections was Communication. Communication was also related to two of the other top six codes: Translating (4th most frequent code) and Vocabulary (6th most frequent code). Communication took place in many ways, and was often much more informal than through organized forums. Interview respondents referred to personal connections made through casual encounters that lead to further collaborative activities. Networking with those who were doing related and interesting work, and having conversations in personal contexts were examples of experiences that had resulted in interview participants working across their disciplines, and this type of informal networking was seen as a natural way for growing the field.

Several participants brought up the lack of communication, or a need for greater communication between various stakeholders. In particular, these comments related to the need to increase communication with teachers. This was seen as something that could be done in a variety of ways, such as bringing scientists to talk to teacher in both formal and informal settings. For example, in the initial years of the AERA-BNE SIG, most of the panel presentations were invited scientists. This was seen as both a necessary and strategic approach since there were so few people versed in both education and the neurosciences. Those who consulted with schools suggested bringing over scientists from the departments of biology, neuroscience, or cognitive science to speak to pre-service teachers and explain their work. Another consultant held regular meetings with teachers who worked as a group in a type of professional learning community. Each year, the group invited top neuro and cognitive scientists to speak on a selected theme. The scientists not only presented their research, they also participated in the two day retreat and answered questions posed by the teacher-researchers. Hence, it was more than just teachers being talked to, the theme of communication related to conversations including teachers as critical shareholders. This relationship was described as one that needed to occur through creating a bi-directional reciprocal interaction where researcher and teachers were listening to each other and moving towards one another in an attempt to find common ground. It was deemed necessary that scientists find the real-world questions that could be addressed in the laboratory through communicating with teachers. This was coded separately as Reciprocity and referred also to reciprocal interactions between the various academic domains, as well as moving from the classroom back to the laboratory to inform questions.

> I think too much of what has gone on has been…scientists standing up and lecturing for three hours and telling teacher what they've found, and teachers sitting there dutifully absorbing that and thinking they have nothing to contribute when in fact they have the key information to contribute. So I think the first thing to do is to create more of these partnerships…so that there is a real respectful dialogue so that teachers don't feel like second class citizens in relationship to scientists, and scientists don't feel like gods in relation to teachers. There has got to be a coming together. The scientists don't have to completely capitulate. The teachers need to come towards the scientists as well, but they can't come as far as what is currently required. (P15)

> What we have found is that the teachers are very engaged by this work and we have held a number of open meetings where what we try to do is attract a mix of practitioners and policy makers in order to hear something about what science might have to offer, but not just in that kind of one-way fashion, but we have tried to do this in a way that we want to hear from them what they think the science might usefully be actually focusing on. (P7)

> It is not just to go from science to practice, it is also to let practice inform science as to which of these theories actually have practical application and can be refined in a more complex context. (P5)

> One of the things that I think every good educational researcher should do very seriously is talk with teachers and listen to teachers, but also try to create an atmosphere in which researchers are not only listening to teachers but also in which teachers are listening to the researcher. So I really find it very very important to know what the teachers think about these issues. (P11)

Collaboration: Working Together

The third most frequent code under Transdisciplinary Connections was Collaboration. Participants gave recommendations as to how the field should advance through collaborative research efforts, creating a joint task force, teacher training, multidisciplinary academic programs, and forums both local and global. There was a significant awareness of the need to form joint programs and to engage in collaborative work. The focus of where this collaboration would occur, however, diverged between research scientists and participants engaged in teacher training. Members of IMBES along with consultants and administrators tended to be more focused, not surprisingly, on ways of bringing this information to teachers and to the classroom, where as collaborative efforts in the sciences related more frequently to collaboration between academic programs in cognitive psychology departments and neuroscience departments. One area of collaboration particularly important for building the empirical base for validating practice was the creation of consortiums of schools, or research school networks where teachers could collaborate with scientists and these findings could be shared within the collaborative groups as a means of demonstrating effective teaching and learning. Several of the participants were already engaged in working in such collaborative networks of schools, and others were in the process of creating school consortiums. Collaborative school networks were venues for piloting programs and interventions. This aspect of collaboration will be critical for the process of developing and validating a curriculum of neuroeducation.

The Importance of Translation

The code of Translating also came up frequently under Transdisciplinary Connections. This was seen both as a challenge for the field, and as a fulcrum point, as some researchers viewed the entire field of MBE as that of a translational science. Several of the participants, in particular those who worked as consultants, described themselves as translators and translators were seen as having a pivotal role in this effort. Participants commented that teachers should not be expected to become scientists, and it was seen as critically important that information from the sciences be accessible to teachers.

> In other words, if the idea is to turn teachers into being able to read the science that is currently being produced, it is not going to happen. It's just not going to happen. Teachers aren't going to spend that much time to learn how to read that. (P15)

This was one of the primary difficulties in bridging this divide, and that was in being able to translate the science for teachers. There were mixed feelings about the way in which research had been translated in the past and there was the feeling that it was a prodigious endeavor to make sure that information was justly representing the science. At the same time, the task of translating was seen as a shared goal, and a necessary component of advancing the field.

Translating was seen as more than simply finding shared vocabulary, however, it is about what sense is given to the scientific work. One participant pointed out that the translators are the first line of defense for truly impacting education through affecting the basic understanding of the definition of learning. Given that MBE may be defined as a translational science, the decision as to what will be included in the translation, and what will be laid on the sideline will come from those in the position of translating. This made certain groups vulnerable to the focus and goals of the translator.

> I see educators needing translators but also being vulnerable to translators as we all are when they go to talk to people in the medical field or a car mechanic none of us is an expert in all arenas. (P13)

Some participants spoke about how even with the wealth of knowledge currently available, educators sometimes have difficulty seeing the value of the neuroscience, since it appears to lie far outside their beliefs regarding what is important in education. The true translator was seen as someone who would be able to make sense of the science not just on the level of scientific phenomenon, but to frame it an existing view of what education can understand about itself from and in relation to the science.

> Well, I think the main challenge is to translate or transform knowledge about the brain in educational action …What the practitioners would like to know is, what can we do with this knowledge in order to actually improve our educational activities? And that, I think, is one of the major challenges. Of course there are major challenges on the scientific side which is to discover how the brain does it. How does the brain learn? How does the brain change, and so on, but that's more like a purely scientific challenge. But from an educational science point of view, the main challenge is to transform the neurobiology knowledge into educational action. (P11)

> I think it is the translators who really have to deal with the meme of education. Because the research can be interpreted in multiple ways for groups, but it is really left up to the translators. (P9)

Creating Shared Vocabularies

The code Translating was related to the code Vocabularies in several of the interviews. Participants stressed for the need for a shared vocabulary between the various fields of neuroscience, cognitive science, psychology and education. This was viewed as a particularly difficult task given the wide range of subjects and the vastly different knowledge base of each of the stakeholders.

> There are two different worlds and two different ways of doing things and different vocabularies, and there has to be some people who can bridge that gap. …It maybe that no one is going to be really bilingual, because it is not even just bilingual, there are lots of different languages, more than just neuroscience and teaching. (P5)

> Getting those people together to try to talk back and forth with people with whose work they're not familiar with in the different fields …is surprisingly difficult to do in practice because the language is different and people don't see each other's questions as relevant to their work. (P12)

In addition, there was thought to be a general distrust between the separate groups which limited their ability to effectively communicate and collaborate.

> There is a long-standing, before my time, suspicion between the practitioners and the researchers. The research is saying, ‘you know the practitioners haven't listened to what we discover’, and the practitioners is saying, ‘the researcher doesn't know what it's like to be in schools, they've never been in them. So you have that distrust, the whole thing is weakening but it's been around for such a long time that it is difficult to overcome. (P25)

In creating a shared vocabulary, it was seen as critical that each of the fields was aware of the different theoretical frameworks, what each of those meant in order to better improve understanding. In this sense, it was not only the challenge for the teachers to understand the methods and terminology of the sciences, but also it was seen as critical that scientists who were working to bridge the divide avail themselves to understand the terminology and vocabulary of education. One participant told the story of a rather famous scientist presenting an entire lecture in which he mistook the meaning of the *whole language* approach in the teaching of reading to mean *sight-words*. From this there was the recognized need, not only for teacher literacy in science, but also for scientists engaged in this work to be versed in the educational literature. This led to the conversations around the need for shared vocabularies for scientists and educators.

There were several suggestions as to solutions to improving these communication problems. The creation of a joint programs between the cognitive and neurosciences was underway at several universities and was seen as a means of increasing the understanding of each other's work and adding multiple layers of research towards solving certain research problems. This suggestion was more frequent in the academic interviews, whereas the importance of reaching out to teachers came up more frequently when speaking with educational leaders and consultants. Solutions revolving around involving teachers included first and foremost professional development both in pre-service teachers' formative development, in consulting, and in continuing, in-service professional development.

Teacher Literacy & Professional Development

The need for making connections with teachers came up under nearly every one of the major codes for Transdisciplinary Connections. Both academics and educational leaders believed science literacy and knowledge about how the brain learns was vital information for teachers and should be included as part of a teacher's basic training. Several participants mentioned the challenge for teachers to interpret findings from neurobiology and neurophysiology and especially pointed to confusion surrounding neuroimaging studies. Understanding the methods of neuroscience was deemed necessary if teachers were to understand how findings from the field could be used to effectively inform education.

> [We should be] educating teachers more directly about neurophysiolology and functional neurobiology, so that they have more than just a surface level understanding, but then also educating teachers about the techniques of neuroscience so they are better critical consumers. (P10)

Teacher professional development was seen as a central component of MBE, and as previously mentioned differed from the focus of educational neuroscience which was more closely associated with academic research. Several participants mentioned the

MBE program at Harvard's Graduate School of Education as the first step in really making change, but emphasized that it was still a small part of our current system of education. One participant mentioned that the MBE courses at Harvard should be a required part of all teacher training, and not simply as separate program for a select few. Although the science knowledge was seen as expanding, there was the feeling that the schools of education had and have been slow to catch up.

> I've been around a while, in the schools of education, and in my experience they have not, many of them, and in fact the majority of them, have not embraced this notion of educational neuroscience. I have had education professors tell me that there is no foundation to this stuff. I've had them tell me that they never went through it and they don't know how to teach it… and what I think will cause a major shift in reform is to get the damn schools of education to recognize that there is all this research out there and expose the pre-service teachers to it instead of doing it as an in-service… That's why, you know that the dropout rates is 50% for beginning teachers over five years. That's 10% a year! Why are they leaving the profession? When we do an exit interview with them, they say they don't feel supported. When they get there [into the classroom] they don't feel they were trained well enough before they got there. So what's happening is that these schools of education are sending teachers out to deal with 2012 brain with a 1970s kitbag and it isn't working. So if you want to make reform, start at the schools of education. (P25)

> Where I think we need new novel new developments are teacher education programs and university commitments to use the interdisciplinary nature and treatment of this work. That is kind of the weak link. I see that even in my own experience. I see students coming in at ______ _____ we have a doctoral PhD in Education and you can focus on Educational Psychology and if you are working with me you can claim Educational Neuroscience but there are not strong overarching programs that have been set down and address a wide scale. So I think the training piece and the literacy piece are important. (P10)

> So we need a policy that understands the value of supporting teachers' development. We don't need to make them into neuroscientists; that's not even feasible. (P1)

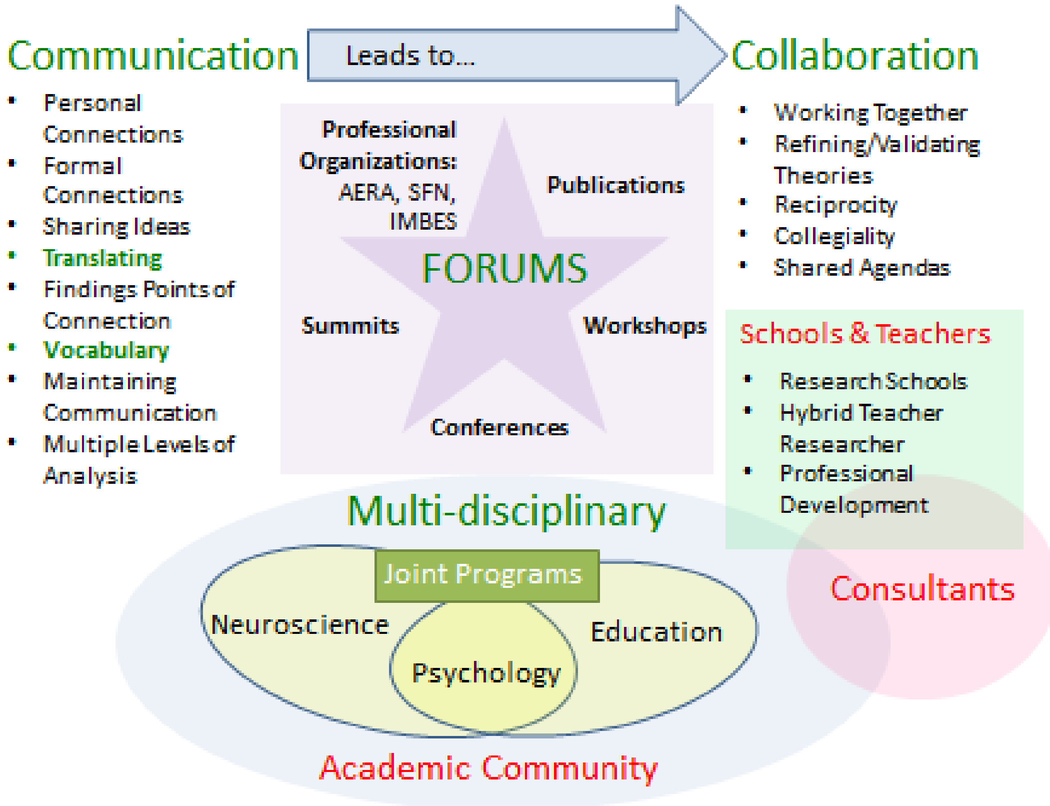

Figure 4. Axial coding from the theme *Transdiciplinary Connections*. Although the codes *translating* and *vocabulary* were both top codes under this theme, they are included under communication. Forums provided a central point of communication that if maintained leads to collaboration. Major stakeholders included members of the academic community, consultants, and educational leaders, including teachers, administrators and policy makers. (Codes are in Green, Contributing Stakeholders are in Red).

Summary of Transdisciplinary Connections

Figure 4 shows the interplay between the various codes under the theme of Transdisciplinary Connections. In summary, Transdisciplinary Connections described ways of developing the field of MBE, educational neuroscience and neuroeducation via engagement in interdisciplinary and multidisciplinary efforts. Creating forums, developing a shared vocabulary, and communication, and collaboration were the central means of making these connections. True collaboration and reciprocity were viewed as the only apt approach towards being able to build any effective school reform based using empirical evidence. It was important that teachers improve their science literacy, but also that research be translated in a way that made sense to educators, and this meant that a new player was entering the game who was versed in both the science and in the education literature. Researchers and teachers working in a partnership, communicating bi-directionally with mutual respect, and creating forums for being able to advance the field were the major shared goals of the various participant groups under the theme Transdisciplinary Connections.

MBE within a Framework of Curriculum Reform

Ivor Goodson discusses an analogy of change in education reform as occurring on multiple levels with each level working within different time-frames and involving different motivations and influences (Goodson, 1995). Applying this model to the emerging fields of MBE and educational neuroscience it is possible to see how these multiple levels interact and influence one another. Research is expanding rapidly, in part because of advances in technology, and yet the timeframe for science is still much longer than that of education. Science requires validation, research projects may take years, whereas changes in our schools and classrooms take place year by year, or even month by month. A five year proposal for a research plan is reasonable, but in the classroom, you must meet the individual needs of that student on a weekly and even daily basis. Examining educational change from this perspective it is possible to see where the different energies are taking place, and how we might begin to create effective cross currents to engage these layers. The process of understanding the points of intervention and interaction between the fields in order to create dynamics and effective change emerged as a central challenge for the field.

Challenges to Development

There were a number of challenges to the successful development of the field that emerged from the interviews and many of these related to policy or institutional behaviors. In their article "Bridges over Troubled Waters: Education and Cognitive Neuroscience", Ansari and Coch (2006) outline several challenges for developing the field (see Table 10).

Table 10. Challenges for Developing the Field

Challenges for Developing the Field from Ansari & Coch, 2006, p 150	Codes from the Theme *Transdisciplinary Connections*
Lack of common language and background,	Communication Translating Shared vocabulary
Few existing points of contact,	Collaboration Points of connection Reciprocity Shared agenda
No forum for interdisciplinary interactions,	Forums
Hostility towards change, Funding issues	Keeping original fields in tact Levels of analysis Multidisciplinary Multiple roles Differences of opinion Complexity

Interestingly, nearly all of the challenges discussed by Ansari and Coch were brought up by the interview participants as challenges but also solutions. The exceptions were the final two challenges mentioned: hostility towards change, and funding issues. In particular, hostility towards change was perhaps the most common theme seen as barring the success of MBE as a reform effort.

Ansari and Coch did not directly speak to issues related to the current culture or context of education including conflicts with existing policies. Perhaps this challenge could be seen as related to hostility to change. Indeed, interview participants brought up the fact that the testing and textbook industry was a multi-billion dollar business, and that the connections between the developments of policy that conflicted with these corporate interests would face considerable resistance.

Addressing the systems and structures of education at the political and economic levels appeared to be more closely associated with MBE than with educational neuroscience. Although in some ways, both were connected with these issues, and efforts had been made across the board to engage policy makers in attending to this work. The difference appeared to be the extent to which the focus of the work was at the level of leadership or basic research. For those who worked as administrators, school leaders, and most especially school founders, the role of leadership was central, and they felt the need to work quickly for changing policy. Those who worked in basic research also spoke of working with policy makers, but were typically less hostile towards the existing system, perhaps since they did not experience directly the challenges of trying to implement programs aligned with cognitive development in the face of standards and high stakes testing.

Participants more closely engaged with schools were frequently incensed at the current use of HST and the destructive nature of the NCLB policy. One of the school founders had in fact completed a book on the origins and purpose of HST, in particular in relation to corporate interests. This project had so deeply impacted this participant that in response he/she opened a school utilizing a model of education from the civil rights era. There was a certain disbelief that the system of NCLB and testing had managed to be implemented so thoroughly without much of a fight, and that it had continued to remain in place over ten plus years. Furthermore, there was a sense that things were not changing, that teachers and educational leaders were not responding appropriately by fighting these mandates, and that policy makers simply continued to renew failed policies even in the face of considerable hostility by teachers and educational leaders.

> The _______ school is my response to high stakes testing. I tried to organize against it in the beginning, and I felt like I was Chicken Little running around saying the sky is falling, the sky is falling. I felt like I was being treated like Chicken Little saying the sky is falling, and it really was falling, and if we do something now, now is the time before it is in place to stop it. Once it has grown roots, it is going to be nearly impossible to uproot it. But the teachers were all saying, 'No, no. I need to learn how to raise my student's test scores. I have a moral responsibility to raise their test scores'. (P26)

> These things keep on coming up periodically, and so we've seen them come and go and when the No Child Left Behind approach came in the 1990s I said this will last for three years and then it will go away, but it hasn't gone away yet, unbelievably it's just been renewed and renewed, and so therefore has just become incredibly destructive. (P18)

Although not directly addressed, the role of corporate, political and economic interests did come up in several of the interviews. These were seen as central to the state of education today, the fact that it had been derailed from an approach that was more progressive and based on the principles of learning, and most importantly that any change effort would face considerable resistance if it interfered with the political and economic interests that had shaped it in the first place.

> But then you have to know the political history. The other problem with just looking at education on a scientific scale is that that is not really what drives it anyway. I mean you have to be honest, what really has driven the education law that we have, and has driven the development of the school system that we have, it doesn't have much to do with science. It's really politically and economically driven. And so you have to understand your history… You can't just deal with education in isolation. (P19)

> What happened next was this incredible, I would say, marriage, or whatever you want to call it, between the political world and the school world, or the education world. The publishing companies just came in and, as you know they make every year billions of dollars off text books, especially the bell weather states like Texas, NY and California. They make billions of dollars saying one textbook per course. And now the textbook companies put a teacher's guide with the text book, then the testing is aligned with that, …it doesn't matter how corrupt the whole thing is, or how unreasonable, or unjustified, educators are so cowed-down most of them are afraid of losing their jobs… But the publishers are very powerful, huge publishers bought up all the little publishing companies that were fabulous and innovative and unique, and we lost. We became this streamlined thing and even now those publishing companies are not going to let go of their domain, their main money market. (P9)

Constraints by Structures, Culture & Policy

Structures and Policy was the most frequently coded theme of all 17 categories from the first block of interviews. Specific questions about NCLB from the first set of interviews indicated that across-the-board researchers were unhappy with its implementation, although the degree of disapproval varied considerably. Because of the rapid saturation of the theme, fewer questions were directed to this issue during the second set of interviews. Consistent with the conclusion that saturation had been reached, those commenting on NCLB from the second block of interviews shared similar views, although perhaps these views were even more pronounced regarding NCLB's negative effects on student learning and curriculum issues.

There were some clear, shared visions across the various participants surrounding issues of policy and structures. First, there was a general consensus that MBE and educational neuroscience *should* impact policy, and that it would not be an easy process. Policy was seen as representing one front on which this movement could act to affect necessary change in our schools. In the second set of interviews, the theme Institutional Behaviors separated from Structures & Policy but was still significantly linked through dually coded comments. Institutional Behaviors were seen as definite points of resistance to change as institutional behaviors were intimately connected with cultural beliefs and personal habits of behavior. Given that a curricular program of neuroeducation challenged the meme of education, it was thought that there would need to be a shift not just in the written policy, but in the cultural belief systems constraining our thinking around how education as an institution can and should operate. Policy, structures and institutional behaviors represent one important area of interaction for teachers, researchers and educational leaders to connect in creating this new vision of education.

Combatting the Meme of Education

Besides policy barriers, there were strong cultural influences that were seen as a hindrance to the effective implementation of a curriculum of neuroeducation. Participants believed that one of the greatest obstacles to seeing MBE as a successful reform was the societal "meme" of education. The term meme relates to the cultural belief system that is passed from person to person. Very like the gene transmits physiological traits, the meme transmits cultural traits. Coined by the evolutionary biologist Richard Dawkins in *The Selfish Gene* (1976), social and cultural memes continue to hold considerable credence in social theories today. As for the interview participants here, many of them used the term meme, and others referred to cultural and personal belief systems that dominate thinking about education and hold the system in a kind of stalemate with regard to significant change. The meme placed conventional education as the only way to educate, and the influence of this thinking was so predominant, that most felt that if neuroeducation were to be even remotely possible, it would be necessary to first change people's perceptions about effective learning. The meme was described as teacher directed, information transfer, focused entirely on cognitive aspects of learning, and ignoring emotional and physical aspects of learning. Neuroeducation was seen as conflicting with the meme of education, and hence would need to work at shifting the cultural mindset if it were to be successful.

> So I think step number one for any kind of real change is cracking open the eggshell and transforming the general meme around what the meaning of learning is. (P14)
>
> So I would say that the first thing that we are doing is that we, really, as a nation, we have to shift our notion of learning. (P9)
>
> Teachers tend to teach as they were taught and if the teaching was being lectured to and memorizing and regurgitating, that is what teaching is. You know it is hard to break those old patterns. (P15)
>
> People have pointed out that decisions are made by people who went through the system and were successful in the system, and they tend to think, I mean I have heard them say 'well if the kids would just buckle down like I did, then they would learn'. (P16)
>
> We parents we are conditioned by that conventional education model we have already been powerfully conditioned and so it's hard for us to see, it is just so commonplace for parents to say, well I went to public school and it wasn't great but I made it through, I'm okay now, whatever, I've got a nice house, I've got a job I'm a successful person, it didn't screw me up too bad. (P19)
>
> So if they've had 40 or 50 or 60 years to believe something and if you show them that its wrong, even if they can see that it is wrong they won't

> change their beliefs. So to try to get people to think differently about education, a thing that they all went through, and to think differently about it is very difficult. (P3)

Policy & NCLB

The importance of the MBE and educational neuroscience community in contributing to discussions on policy was agreed upon by both practice and research oriented participants. To that end, several participants stated they had personally been involved or invited to be involved in policy discussions. More than one of the academic participants spoke to the fact that their collaborative group always ensured that there was at least one attendee at their conferences who worked at a political level, and that they as a group had reached out to several high level political figures to move forward the agenda of academic research in this area. There was some enthusiasm that engagement with policy makers could help shift the system from the current test oriented approach to one that was more sensitive to developmental and biological aspects of learning. One participant who had worked in the creation of progressive schools spoke of his participation in lobbying legislature to create charter school laws in his state that he felt had contributed greatly in being able to provide an alternative educational program better aligned with the principles of the learning sciences. He mentioned that having access to good hard evidence provided from educational neuroscience and MBE was the necessary ingredient to be able to influence policy makers and high-level educational officials. It was also thought that changes would come through making connections with key members of the political structure who could carry the torch, so to speak, for the cause of neuroeducation. Another participant who had worked to open several small high schools in her district spoke to the need to maintain involvement by organizing groups all the way through to the end of the project and beyond. This participant also spoke to the need to create strong horizontal connection with parents and the community as a matter of any type of effective reform effort.

Others were less enthusiastic as to what one could accomplish in the realm of policy. Several participants pointed out that historically scientific research had not been used to write policy and that although the body of science research was available and even presented to officials it had fallen on “deaf-ears”. Others described the reality of the decision making process as a matter of politics. One participant stated that he had participated in policy round tables, but found that the decisions had usually already been made before coming to the table. This participant felt they were simply using his name on their documents to make it look as though scientists and outside members had contributed to the process. In agreement with this, another participant stated that the work had to be done “not just in testimony before a committee when it’s considering some bill, but in personal contexts with key people” (P16). Regardless of the level of enthusiasm for the potential success of engaging in policy, there was a strong belief across the board that findings from the neuro-cognitive sciences should influence policy, and some participants were hopeful that through acting at the level of policy we might be able to move away from test-driven mandates towards a system based in the growing knowledge from the brain and learning.

With regards to the current policy of NCLB, none of the participants were happy with the way the policy was enacted, and many participants were against the proposed approach from its outset. Participants commented that NCLB did not attend to what we know from the learning sciences. There was considerable concern that the policies of

NCLB were resulting in a narrowing of curriculum and specifically resulting in a loss of many of the activities known to engage students and promote neural development, such as movement, play and the arts. Several of the participants pointed to the fact that NCLB did not take into account any of the emerging research from educational neuroscience or cognitive science in its inception, but was based on conditioning and behaviorism.

> We couldn't believe that this could be a model for education because from our perspective most of it lead to direct instruction. It lead to, instead of educators becoming more educated about learning, it was basically based on behaviorism. (P9)

> I think they don't take into consideration learning sciences at all. I don't think that there is anything about this policy that thinks that's important, or that it's necessary. It's non-existent. It's not even a part of the conversation. The mandates in No Child Left Behind are regulatory and compliance oriented. They are not a recipe for how to get there. They're just a compliance demanding getting there, so the recipe where the prescriptive nature of how do you help a child's learn to learn and be a better learner, and be a problem solver, that sort of goal is not at all articulated in the policy of No Child Left Behind. I don't think that's the goal. That might be a sort of implied goal but it's certainly not explicit. (P20)

> The way that the law is being written and tested and so forth is pretty awful, I think. It doesn't show much understanding of modern principles of learning, brain based learning, for example, and modern practices and research and so on. (P16)

Others pointed out that NCLB may have started with good intentions, but that the way it was implemented was one that did not align with what we knew from the learning sciences. It was also seen as failing to give indications about the process of learning and experiences of learning that would build motivation and love of learning.

> And I think that the initial ideal that leads to establishment of some of these programs is not to be argued with. Everyone is for mom, and apple pie, and education. But it's a question of how it gets implemented, and what ends up on the cutting room floor. (P4)

> I think NCLB has good intentions but, in the execution, has become a little too heavy handed. I have seen NCLB as an attempt at creating certainty in how kids are doing and how kids are learning, but what it is only giving us is certainty of what they are retaining at a given point of time…in my mind we have to shift towards the learning experiences themselves and balancing the content assessment with the process. (P10)

Yet others pointed out that NCLB was implemented to deal with ongoing problems with low performing schools in hope that by drawing attention to the schools would help to fix the issues. However, there was little faith that this approach would achieve this goal.

> So I understand the motivation for it. I think they are trying to fix a lot of the weaknesses in the education system we have now and I think it is something that they should try. I think they are going to try it and discover that it is not working the way they had hoped. (P8)

> To just diagnose the problem over and over again with testing isn't going to help anybody. It's not that we shouldn't be accountable, teachers and schools should be accountable but making them accountable is not going to fix the problem. (P12)

Several participants who worked in schools or with teachers stated that NCLB had made it more difficult to engage in those programs of neuroeducation they had developed and implemented over many years. In particular it was stated that NCLB had resulted in an emphasis on only those things that could be tested. Interview participants shared a view similar to that expressed by Fischer (1999) that MBE could potentially assist in shifting the focus back to the processes of learning through providing research findings showing the powerful impact of neuropedagogies.

> What happened is that over the 10 years that NCLB was instituted, it kind of morphed into the thing that if you can't measure it, it is not important. (P3)

> I hope… that we can start to define successful schools more broadly than simply a score on a reading or math test…and…I think that the field of neuroeducation…can have a very important role in that. (P6)

Standards & Benchmarks

There were mixed feelings about the use of standards and benchmarks. For many, especially those implementing programs through consulting, there was a feeling that the current standards were constraining what was possible in the classroom. This was partly attributed to the large volume of material required the standards and benchmarks. This was thought to prohibit teachers from being able to go deeply into a subject, or to provide time for creative activities or reflection, all contrary to what would be indicated by a brain-compatible approach.

> From Greece to Los Angeles, I hear the same thing from teachers, and that is, "Wow, Dr. _______, we would love to use your model every day it is so innovative, so creative." And those that have used it love it. But what they say is, "We can't teach like this all the time because we would never get through all the curriculum." So that's a big problem. We are asking teachers to teach too much in too little time, and they know they can't do much more than rip through the chapters. (P6)

> There are so many attempts now to standardize everything whether it's how things are taught or what's taught. A lot of the flexibility is being lost. Teachers are spending a lot of time just trying to get done what they have to get done in the classroom…because we are so busy now fighting with all the standards and making sure the [HST] is passed and keeping the curriculum at a level that assures the most success for the most kids rather than trying to keep a curriculum that is really going to help the children advance, think, and take the country and society up to a level that it needs to go. (P8)

> I just think anytime you go too far in terms of systematizing things you're missing the boat right away. You're missing the point. The point being, children really are different, and children in East Los Angeles don't necessarily need the same things that children in Bangor Maine need and so on, so I'm pretty anti-system because you're so fundamentally already creating a problem. You're going against, you are talking about the brain and the way children learn, and you're going against it. Learning is organic. You have to let it happen. Each child is going to have their own trajectory, and you can't have it both ways. You can't create a system and say now children at age 7 all need to know this and children at age 8 all need to know that and it all happens in this step-by-step order. (P19)

Others saw standards and benchmarks as potentially beneficial, if they were to be more focused on skills and the process of learning than on curricular content and facts.

> We do have to have some kind of benchmarks but those benchmarks can be designed in a way that makes them dynamic and flexible and sort of process oriented instead of outcome oriented so that were really supporting some standards of processing. (P12)

> It good to have benchmarks, sure it is, benchmarks can be a learning opportunity for teachers, if they stay as benchmarks. If they don't turn into 'and this is what the kid absolutely has to do and I am going to test for it'. (P24)

Others saw standards as inevitable and that it was therefore necessary to create programs that would work with the standards. For example, one participant was currently engaged in a multimillion dollar project to create a framework for teachers based on the neurosciences that would include lesson plans that aligned with state and now federal standards. It was pointed out that this was the most effective way to disseminate neuroscience information as it would be in a form that teachers could easily use.

> If you want to bring new material to a teacher it's really a waste of time unless the material that we're bringing them is something that will nicely fit into, and be in sync with the standards of the state in which the teacher is teaching. So it is a real plus that, a couple years ago, we took the extra effort to make sure that the core concepts would fit into the different educational standards. It enhances the probability that the teachers will be willing and able to adopt them. (P4)

Common Core State Standards

Far from the hopeful expectations of educational leader Larry Cuban (1997) when he stated "the centralizing impulse of federal school reform has ended" proclaiming the demise of the attempts to create a national curriculum, the standards based reform efforts have only doubled their impact with NCLB, and we are now looking at the very real implementation of what for all intents and purposes will dictate a national curriculum, the Common Core State Standards (CCSS).

> When I confronted Duncan at an education conference and I said to him I represent alternative educators and we want to know if you are going to get rid of No Child Left Behind because we find that it is counter to the kinds of things that we do, and it handicaps innovation. He said in a very revealing statement to me as he was doing kind of stream of consciousness, “Well the name No Child Left Behind is toxic, we will probably change the name.” (P18)

The idea of national standards is one that has generated a great deal of controversy in education circles. There was a similar range of responses regarding the CCSS by the participants interviewed here, with comments stretching from enthusiasm to disdain. Those who viewed the CCSS positively felt that the CCSS were better aligned with the goals of neuroeducation than the current standards.

> I’ve read a lot of the national standards recently, and I think they are pretty good, because a lot of them are skills that you need to develop. (P15)

Others felt that the CCSS could potentially be good, but it would depend entirely on how they were implemented.

> I think having standards and having global standards has in every country that we know of has been important in elevating the education of the user. It's how Finland got it together. It's what Canada did. Around the world this has been one of the solutions, and so I don't think it's a bad thing, but to the extent that it becomes more teach to the test then it's terrible, and to the extent that it doesn't broaden out and include other topics, it stays at reading and math, it's terrible, and to the extent it that we just see it as another burden as opposed to a learning opportunity for teachers and children, then it's terrible. Overall I think the [CCSS] initiative is probably a good one. (P24)

> Of course it depends on how they will be used. If the common core standards are taken to mean rigid rules that everybody has to learn with no flexibility in the curriculum then you're going to end up with big trouble for a whole lot of students, and I don't have any way of predicting how that's going to go. I know how people are concerned about it. The key

> thing is that we need to be allowing people to learn differently and encouraging them to learn using the pathways that work for them rather than forcing them into one traditional way, like with a holy book. (P21)

Others, however, felt that the CCSS was more of the same, or even potentially more strident.

> That is a major fight we have on our hands right now with the national standards being adopted. The national standards, they lock people in pretty badly. Here in our state they are going to established something called common core courses, in which every course that is taught in every school in every grade level will be given a title and a number, and who taught it and what sections were taught, and what students took it, in other words, it is going to create sort of a lock step concept. We are meeting with people in the department, several of us are, trying to point out that this may have some dire consequences, it may just lock schools in, and teacher in, and it will be back to a state of ordered curriculum. (P16)

The discussion of CCSS was not mentioned in many of the early interviews, as it had yet to become a reality for most states. Now with more than 40 states agreeing to adopt the CCSS, it will be important that those in the academic and research community evaluate these standards, and assist teachers and schools in finding ways to address the student needs as indicated by a curriculum of neuroeducation.

High Stakes Testing

Much of the commentary around HST was extremely negative. Participants commented that testing was “ridiculous”, a waste of time and money, negatively impacting schools and curriculum, teaching students that there was one right answer to a question, diminishing creativity, and misaligned with the general needs of the student. It was also pointed out by several participants that the current tests were primarily content based and utilized a multiple-choice format. Given that the most frequent code relating to students underlined the importance of focusing on capacity over content and on higher order cognitive processes versus fact memorization, it is not surprising that the majority of interviewees considered testing to be misaligned with neuroeducation. Participants disliked the current testing program for its focus on lower order thinking, and summative content knowledge. So as one participant put it, "you wind up with high-stakes tests for low end skills" (P1). Multiple-choice tests on a whole, as they were currently utilized, were seen as driving curriculum and teaching towards lower level content and a more scripted formulaic pedagogy based on recitation and memorization of fragmented information rather than on how to apply that knowledge. In commenting on the success of their efforts to implement principles of neuroeducation in schools, several consultants spoke to the challenge of doing this under the severe pressure of raising test scores.

> But what happens so often is, that we will go in and people will say, "This [model] is fantastic. We need to go here. This is absolutely what needs to happen next," but when we leave, the district closes in with incredible direct mandates and the bottom line is test scores, and the only way the teachers know how to raise the test scores, because they are not being supported in other ways, is to teach directly and to make kids competitive, memorizing fragmented work that really doesn't lead to learning. (P9)

Participants pointed out that the shift of focus of schools to testing took away from curricular areas thought of as central to a good educational program. The use of high-stakes multiple choice tests were seen as competing with the goals of neuroeducation and as misaligned with our knowledge coming from the learning sciences. One of the school founders further pointed out that HST was having a negative impact on the capacities of alternative schools and curriculum aligned with the brain to even stay in operation.

> If we go back 10 years or so and re-take a list of the very best public alternatives that we know, of most of them have been shut down by their local authorities, and that's the reason why, not because they were failing

> in terms of the criteria that I've talked about, and I’ve met many of the kids from those schools and they were fantastic. But they weren't being judged on those things. (P18)

This statement is consistent with the closing of the first Waldorf Public School in Milwaukee Wisconsin. This school was based in an urban center, and although it worked hard to create an environment consistent with the Waldorf philosophy and the principles of developmentally appropriate practice, the challenges of being in a poverty stricken area in conjunction with the delay in academics resulted in poor test scores in the early grades, and the eventual closing of the school. The realization that programs of holistic education aligned with brain development cannot survive in urban schools districts due to testing mandates shows the injustice of these policies for our public school children in lower income areas.

Narrowing of curriculum. One of the primary concerns surrounding HST was the narrowing of the curriculum and elimination of the activities that engaged students, stimulated intrinsic motivation and made learning enjoyable. The one-pointed focus of districts and schools on passing multiple choice tests in reading and math was seen as having cut out many of those aspects of the curriculum that would actually be most supportive of learning.

> The NCLB high stakes testing program is dependent principally on multiple-choice tests, so curricular areas that can’t be objectively measured tended to get reduced or eliminated. By cutting out those curricular areas, the heart of what education is all about got cut. (P3)

> Standardized testing which is driving teaching, which is sadly taking away from the arts from sports from languages things that we all know create better well-rounded individual. (P2)

> One of the things that has happened is that we have gotten narrower and narrower in what we consider the core curriculum and that is really

> unfortunate, and now it is mostly literacy numeracy and some science, and for example music and the arts and drama are left out, and that's just it's a tragedy. There are so many ways that music and the arts including drama can be used to make kids learn and to help them get interested. (P21)

> The last thing in the world that you want to take out of school is music, art, dance and all the things that are involved with creativity but that's the kind of things that have been taken out. Physical activities, physical education, play, this is where kids learn, but these things are being taken out of the curriculum. Kids learn more from play than almost anything else. (P18)

One right answer. The multiple choice format was thought to teach students that there was a single right answer for each question. This was seen as contrary to the general concepts of creativity which promotes divergent thinking and coming up with as many ideas as possible. In addition, it was thought that the rigid structure of needing to find one answer reduced certain cognitive and even social skills such as the ability to solve real life problems, to negotiate or find commonalities amongst things. If this assessment is true, it is worthy to examine the use of testing as not just a misuse of time and money, but perhaps demining students in those areas that are most critical for effective brain compatible curriculum.

> High-stakes testing because of costs is created mainly through multiple-choice and in order to do that there has to be just one correct answer and that's convergent thinking. Convergent thinking is an emphasis on finding one answer to things and it focuses on that and that inhibits creativity. Creativity requires divergent thinking looking at multiple options, making decisions about similarities and differences, learning to compare and contrast which is a better option. Realizing the world is not black and white and most of the problems you're going to face to be successful citizen in this world are grey. Yet we teach kids and train kids to look for the one correct answer, and life isn't that way. (P25)

> And so by the school focusing on the producing correct answers, incorrect answers, you develop into a society like we have now, where the Republicans and Democrats in congress can't agree because they have

> never learned how to negotiate. They won't accept anything of the other side. Where our side is right and their side is wrong. They both think that. The reality is that they're not going to come to anything that way. What they need to say is, what are the things that we can agree on, and we can disagree with some of the things you want to do, but I am willing to give up this if you are …Well that kind of negotiating goes on in all of life. What you need to develop are negotiation skills in students. We are not doing that in school. With NCLB there are correct answers, there are incorrect answers, and then nothing in between. (P3)

Statistical problems. The work of James Popham (2004) pointed to the fact that the statistical approach designated by NCLB would create unattainable goals for student achievement and would result in the majority of schools being labeled as "failing" by the end of 10 years. These predictions have panned out and now more than 50% of schools in California are in Program Improvement (California Dept. of Ed., www.cde.ca.gov). Several of the interview participants took issue with the statistics applied to the current testing policies, pointing out that from a simple statistical point of view, these tests were completely inappropriate.

> I don't know if you are familiar with this whole process, but students have to increase 10% in performance every year. There is no learning curve that goes up 10% every year unless it is a mechanical learning curve. Some sort of mechanical object that you have to reprogram all the time, I mean it is just crazy. (P9)

> I have tried to explain to various teachers, that in spite of all the assertions that these are criterion referenced tests, they are not, they are norm referenced tests. So that if one school goes up another has to go down, and that every test item has a p score and the p score is the percentage of people who get that item correct, and if that p score changes, then they take the item out and they replace it with another one that gets the 5% correct or the 10% correct. (P26)

> One of the biggest problems I have with testing is confusing essentially psychometric questions with socio-metric data or vice-versa. To crudely simplify it, you cannot draw generalizations from a single case. If you know what a generalization reliably is you can find a single case to illustrate it. You can't just come upon a single case and assume all single

> cases are like that case. Right? Similarly you cannot draw some generalization with much value for individuals unless there is little to no variance in this general tendency. And of course as we know that with most anything that you measure human beings on there is a normal distribution of variance that is quite extended. (P1)

It was thought that although presently the federally mandated tests measured low level skills, it could be possible to design multiple choice tests to assess higher level skills, and so as one participant stated, “We shouldn’t automatically demonize all multiple choice tests” (P5). Principles of testing that had been developed to assess higher cognition were seen as a good place to intervene in the testing policies. Two participants mentioned the work of Theo Dawson and his program DiscoTest (P5, P15). This program was seen as a possible point for intervention since it provided an approach to testing that was better aligned with the processes of learning.

> So instead of just creating tests because we can, because the technology is there –by the way, technology has driven the way that standardized testing has evolved rather than learning – DiscoTest has tried to reverse that so that learning is the driving force behind how we test and how we do standardized testing. (P15)

Along this line, assessment was seen as a potential place to impact policy change especially given that it fit within the “grammar of schooling” (Tyack & Tobin, 1994).

> Pretty much assessment is the tail that wags the dog and I think that's probably the smartest place to work. (P17)

Other Policy Issues

Merit pay, although not addressed directly by the interviewer, was brought up by some of the interview participants. Comments suggested the idea using merit pay as undesirable in that the policy would drive teachers away from utilizing the principles of learning in lieu of teaching to the test.

> It's awful that teachers feel driven, that their merit pay is tied to their kids test scores. That is just ridiculous. It takes away the entire focus of what learning should really be if you are trying to form citizens you hope to be successful in the future. (P2)

> That is probably the toughest nut to crack because that has got a vice grip. They are going to look at individual teachers and say did the kids learn grammar etc, and if not the teachers will be rated poorly. Their salary will be dependent on it, so that will probably drive them to do more teaching to the test. (P16)

Summary of Developing the Field

Summarizing the issues critical to interview participants in relation to the potential for successfully developing the field of MBE, it is clear that there is a great deal of work ahead. Nonetheless, there was a great deal of enthusiasm, and much of the concerns brought up by Ansari and Coch (2006) as challenges for the field were discussed by participants as truly active and viable avenues in which the field was being built. The theme of Trandisciplinary Connections, in particular proved to be a roadmap toward the creation of the necessary connections between the various stakeholders. The creation of practicable connections between the science and practice of education was supported by those who worked with teachers and students as a necessary first step, and n was viewed as far better than the current alternative of working without the guidance from the neuro and cognitive sciences. Piloting programs and working with research schools represented the first small steps towards generated a validation of curriculum. Reaching out to policy makers on individual bases as well as in group forums represented important steps that were reportedly underway according to interview participants. Surrounding the theme of developing the field there was a general enthusiasm, and shared beliefs on how to move the field forward. The challenges of policy and economics aside, the collective will towards making effective change was inspiring to this researcher, and makes one believe that this field holds great potential to serve effectively as a reform movement.

Results for Creating a Curriculum

At the end of the Delphi Panel analysis, Tokuhama-Espinosa (2008) in her thorough investigation into the field commented that “special attention should be paid to the practice goals as these are the least developed and most vulnerable of goals” (p 442). The goal of understanding an effective practice or curriculum of neuroeducation as aligned with the brain sciences is one that is necessary to form a construct definition or model that can be used by teachers and educational leaders. Findings reported here reflect the difficulty of this task, but can be envisioned as an important first step in creating such a model. Much of the process of creating a curricular model was done through analyzing the points of agreement across the various participants, seeking not only to find common themes, but to define the continuum of responses across specific issues related to the creation and implementation of a neuropedagogy.

The difficulty of finding a shared view of a curriculum of neuroeducation appeared through the interviews and as mentioned is reflected in the difficulty to saturate themes on this subject (see Table 5). In response, the interviewer directed the attention of the questions over each block towards increasing clarity regarding issues of content, pedagogy and curriculum. Each consecutive block of interviews was designed to gain greater precision as to a shared vision of curriculum. In addition to focusing questions on curriculum, the second and third block of interviews selected participants who were closer to teachers and students with the intention of providing a broader perspective on classroom practice. The data were analyzed for repeating themes and shared views. Contrasting views were also highlighted throughout the results section as evidence of the broad nature of a curricular vision of neuroeducation.

Searching for a Shared Vision of Curricular Themes

In searching for a shared vision amongst participants, the researcher looked not only at the major themes, but at the frequency of major codes, in order to determine what was deemed important across the various constituents. The frequency of code counts for curricular themes across Blocks 1 and 2 to Block 3 showed several similarities. Four of the six top codes were similar or identical as the original coding (Table 11).

Table 11. Top Six Codes for Curricular Themes

Block 1+2	count	Block 3	Count
Individual Differences	35	Content	21
Content verse Skill	26	Curriculum	19
Creative Problem Solving	23	Individual Differences	16
Socio-Emotional	21	Concept	13
Models of Education	20	Socio-Emotional	11
Holistic	18	Creativity	11

The code of Content was separated from the previous Content versus Skill and expanded to include a broader range of issues. As a separate code in the third Block of interviews Content moved from position two in frequency to position one. Individual Differences as a code was highly complex in that it related to a number of different themes and codes and ranked as position one for Blocks 1-2, and in position 3 for Block 3. The theme of Creative Problem Solving in Block1-2 corresponded to the more narrow code of Creativity in Block3, and Socio-Emotional appeared as one of the top six codes in both Block1-2 and Block3. Because of the consistent concern surrounding these four codes, they will be analyzed in depth individually here.

Most Frequent Code: Content

Content was the most frequent code in the third Block of interviews. Most participants felt that content was a secondary theme. Comments about content related to the fact that there shouldn't be any critical content, content should be culturally and individually responsive to the student and content needed to be selected to attend to the principles of learning including, context, universality, and scaffolding. In general participants felt that neuroeducation in general spoke more to the delivery of content than to content selection specifically.

> I base most of my work on pedagogy, how we teach not what we teach. (P23)
>
> I think it is absolutely critical to not have any critical content. (P18)
>
> Kids don't need content from you what they need is shaping, they need packaging, they need teaching of how to goals of thinking, of new paradigms, they need connecting, they needed resource building, they need capacity building. (P17)
>
> What we have to teach is a whole lot less important than how well they can learn. We just can no longer assume that what we think kids should learn is more important than generally how well they can learn. (P14)
>
> I'm not concerned about content. I have my own favorite content, but it's not the content that's the driving part of who we are. The way we make sense of the world that's what we all share in common, how to makes sense of physics or history or English. The processes that we use that's what's common to all of us. (P22)
>
> I think the educational neuroscience comes in how that curriculum is delivered. What are the methods that are used to deliver it? I think it comes more in the training of the teacher, more than in what particular topics go in the curriculum. (P25)

Regardless of the failure to pinpoint specific content, interview subjects provided guidelines for choosing content that could be considered essential to a program of neuroeducation. In general, neuroeducation was seen as contributing to the building of cognitive capacities. The selection of content designed to build problem solving, critical thinking, creativity and other cognitive capacities was seen as an effective approach to curriculum development. Furthermore, the development of cognitive capacities was seen as a universal goal for all students, while specific content could be tailored to individual cultures. Marrying the development of cognitive skills with content selection was seen as a high level goal for education and part of creating an effective curriculum of neuroeducation.

The marriage of content & capacity building. Much of the discussion in the first coding of content as content-versus-skill fell back on the idea that neuroeducation was about developing expertise, developing a skill or ability, be it cognitive, emotional or even physical. Selection of content was seen as a tool for being able to build cognitive capacities which was seen as the primary contribution of our understanding of the development of neural processes to education. Although some interview participants brought up the idea of having classes on building a cognitive capacity, like a creativity class for example, the majority spoke of marrying content from traditional disciplines with the development of cognitive capacities such as creativity, collaboration, critical thinking.

> Traditionally we have been very focused on ‘do you know the content’, as opposed to, what is the cognitive capacity of the child and how can you enhance that, and what are the feedback loops and mechanisms for how you build that…They're not mutually exclusive in terms of being able to teach math while building cognitive skills and so thinking about

> something like working memory you can create working memory in activities that use math as content. You can look at attention and you can look at different kinds of collaborative processes, building something that is content-based. I think marrying cognitive skill development with content is a very satisfying source for learning so I don't think that they are mutually exclusive. (P20)

One repeating theme in the selection of content was that content should provide experiences that allowed the student to see the larger picture. In other words, content should be based on concepts that are universal and enduring, that inspire creative innovation, that build on problem solving and critical thinking abilities, and produce transferable learning across disciplines It is clear to see here how selection of content can encourage engagement of higher cognitive functions. A number of participants stated that we needed to move away from fact oriented lessons towards concept orientated lessons where teachers are the presenters of opportunities to discover knowledge rather than memorize it. Fact based knowledge was seen as a waste of time, given we could hardly begin to presume what was in store for the next generations as adults.

> If there was someone that asked, ‘Is there one major thing that you think has to be done to curriculum to make it more brain friendly?’ and my answer is, ‘Yes!’ and that would be to focus more on concepts and get away from all this fact accumulation because I think the curriculum is jammed with information that people already know they can find somewhere else and there is not enough in understanding the concepts behind what they are learning. (P25)

> I think we teach way too many discrete facts without giving kids the big picture. In other words I think we should probably be teaching more concepts and less individual facts. If we try to teach kids lots and lots of facts many of them are going to change in the next month or six months, but if we teach kids the larger concepts which are true across all time, we're giving them a basis, a curricular basis if you will, for their future, because we don't know what their futures are going to look like. (P23)

Participants spoke to the importance of providing a content that was rich and had multiple layers of meaning and could be used to integrate the content across disciplines creating transferable knowledge. The current fragmented approach to subject matter was something that was seen as a missed opportunity to create deeper, more meaningful learning experiences. It was pointed out by more than one participant that students often could appear to have learned something in the classroom, but they could not apply what they had learned to problems outside of class. This was seen as a failing of the current system focused on quickly obtaining a skill divorced from context in order to pass a test. This was seen as needing to shift if we were to build successful citizens and not simply good test-takers.

> Even though we're in just math class or reading class or whatever does not mean that people in math cannot or do not talk about other subjects or concepts that are transferable and to me it's when we don't transfer or highlight the transferable fundamental concepts we miss an opportunity. (P13)

> What we need in education is probably a more integrative active meaningful engaging kind of experience where learning transfers between and among topics and even goes outside the classroom. (P24)

> I think content is a majorly important thing but it's not the ability to take it in and regurgitate it, it's the ability to understand it, to be thoughtful about it, to have it transferred to other areas where we use it for growth. (P20)

> Howard Gardner has a quote somewhere where he says that the majority of our best students can't use what they learn in school outside of school when faced with a new unanticipated problem or situation. They can do what the teacher expects in the classroom, but when they get out of the classroom… I would like to see what they are learning in the classroom applied to problems in their worlds. (P23)

> Kids, they learn stuff, but they can’t actually do it, implement it under natural conditions or spontaneous conditions. (P9)

Along these lines there was the sense that the current education system was promoting practices encouraging fact-based learning as opposed to concept-based learning. This was associated with a teacher directed approach, where students were passive receivers of information rather than active participant in the co-creation of knowledge.

> So they're basically telling students what to do, they are training them in skills, but they are unrelated to a whole, they are unrelated to what they do and know to do. (P9)

> You have just stifled that main goal of having kids that know how to come up with their own problems, think creatively, identify difficulties, because you are actually concentrating on the level of just knowledge and comprehension as opposed to can I analyze the situation, can I synthesize it. Can I take this information and transfer it to a new situation or not? (P2)

Depth versus breadth of curriculum content was an important component of content as a theme. The excessive coverage of fact-based content was seen as limiting the depth to which the information could be engaged in in the classroom. The failure to delve deeply into content can be attributed to the failure to develop meaningful learning experiences that could be remembered and transferred to later learning experiences. Part of the problem was seen to be due to our current structure of standards based education which forced teachers to cover an extremely large deal of material in a short period of time, and the failure to spend enough time on a single subject, practicing and developing mastery and expertise.

> One thing that the cognitive sciences have shown repeatedly is that if you want to see change you have to practice. We know that. We know that intuitively, and yet we don't really act on it in any rigorous or committed way and that is, I think, because we are distracted by things like the standards, the standards that require teachers to do just so much. (P22)

> To me the first step in that is that we have to address the problem of the inch-deep, mile-wide curriculum, because teachers just rip through it. They don't have time to delve deeply into any content area. We're trying to do too much in too little time. So I think we have to be clear about what we want children to be able to know and do and show, and then we have to give teachers time to let children experience that curriculum that content and those skills in ways that are less traditional than we do now. (P6)

Building mastery & expertise through content selection. Learning was seen as being hierarchical when examined from the perspective of developing mastery or expertise. To build mastery and expertise in curricular disciplines was seen as one of the primary goals of effective education. One important component of a curriculum that was highlighted for success in this endeavor was to focus on depth rather than breadth of content. The current standards and benchmarks were seen as driving teacher to cover material superficially. The saying an inch deep and a mile wide was applied to our current standards based curriculum. Several of the participants stated cutting down on content in order to go more deeply into the subject matter was a necessary step in the creation of an effective curriculum focused on mastery.

Another component of expertise was building up to the mastery of higher order skills. This suggested that initial exposure to content would be highly scaffolded and include lower level tasks in order to provide the foundation for the higher order skills. There was a caveat expressed by one participant relating to the relationship between the hierarchical organization of learning, and that was that although there was a need to gain lower order skills to work towards higher order skills, it was not the case that there was some pre-set sequential order that everyone had to go through before higher order thinking challenges could be introduced. The building of the appropriate challenge level related both to the manner in which scaffolding of learning could be created to meet the student at the upper edge of their ability and the choice of content for a given developmental level as it related to the unfolding of cognitive capacities as a part of the natural biology of critical periods of learning. Participants felt that both the ability for selecting content in a particular subject in relationship to development, and the building of scaffolded learning experiences to build mastery were areas in which the cognitive and neuroscience of learning could make a great contribution.

> So if you think about going from interest to mastery, it's really about content evolution. It is the center of higher learning. (P20)

> Healthy learning [is] learning that results in a kind of dynamic fluid scaffolding that extends the capacity for learning. (P14)

> You'll see a lot of people have done work trying to unpack how development unfolds in different kinds of content areas, [and] that's truly the cognitive science end. (P22)

> Higher order skills are predicated on the lower order skills. Lower level skills are necessary to allow for higher order skills. But it's the higher order skills that are objectives, and sometimes we get caught up in this belief, but again contradicted by developmental research, that you have to teach all of the lower level skills before you can go up to the higher level skills. (P1)

Expanded content. Similar to the concern expressed by participants that NCLB and HST were resulting in a narrowing of curriculum, participants spoke to creating a curriculum of neuroeducation that included a wide range of content that would engage and enrich the students' learning. In this sense content reflects more than daily content, or specific selection of texts, content includes available coursework, extra-curricular content, and what we often consider electives in traditional schooling.

> What was in my curriculum would be greatly expanded. It wouldn't just be reading and math even though I understand the utility of that and the

> importance of that, I think that just learning to read to read if you never read to learn isn't good enough. I think we need to think in multiple modes. We need to think in terms of the arts, music, social sciences and sciences, not just reading and math, and so I would have a pretty full-based curriculum. (P24)

Emotional content. Participants felt that content could and should serve the purpose of meeting the emotional needs of the students. In this way content could serve the dual purpose of building not only cognitive skills, but social and emotional skills. Emotionally relevant content could be something that had personal meaning, or could be related to historical events that generated a sense of compassion and purpose in the student. The use of hero stories has a long history of practice, and serves as an emotional anchor for students as they learn about history through the struggles of others. Understanding the emotional experiences of those historical figures was thought to better fully engage a student in their learning. This view of emotionally laden content selection moved the issue of emotional content away from discussing personal and psychological issues directly, to using analogies of problems students were facing in their communities and personal lives through historical events and relevant literature.

> You have to meet their emotional needs. That doesn't mean you have to wipe their nose, what it means is that you have to try to find ways to incorporate emotions into your content so that they get a feel for what this topic is all about. (P25)

Thinking differently about content. The importance of beginning to shift our view of content with respect to the learner was a more general view of how to better understand content selection. Rather than viewing content in a static, singular discipline oriented manner, seeing content as a means of promoting experiences within students that would be meaningful, encourage the development of cognitive capacities, and promote a love of the learning was the goal of a curriculum of neuroeducation. This view revolved around the idea of thinking differently about content. Content was not something that should be memorized for a test, but was part of understanding life and creating a broad conceptual understanding of the world. The conventional approach to content has been through the teaching of discrete academic disciplines. The focus has been on covering all of the material decidedly relevant in each of the disciplines. This approach was seen as part of the old meme according to the interview participants. It was seen as focused on the accumulation of facts, and not addressing the process of learning. In some ways it was seen as limiting the ability to focus on deeper more meaningful engagement with the curriculum and content. The need to think of content as a means of encouraging creativity, socio-emotional wellbeing and processes of learning was thought of as a cornerstone of neuroeducation.

> We are used to thinking of content as being the end of learning, as opposed to using it as a tool to build other kinds of things. I really think it's how we've thought about content, not the content in itself, that's really worth an interesting discussion. I think content is a hugely important aspect of learning, but I think the ability to be able to understand content, and use content to innovate and create and build and to be a thoughtful person, comes back to building strong cognitive skills. And that's just it. We don't do a lot of that. (P20)

Second Most Frequent Code: Individual Differences

Individual Difference was the most frequent code in the first two blocks of interviews and was the third most frequent code in the third block. Nearly all participants advocated for a greater sensitivity towards individual differences in the way we educate. One of the founding members of IMBES saw this as the central focus of curriculum reform based on MBE.

> One of the primary changes that we advocate for in creating curriculum is that we switch to a curriculum that assumes that people learn differently rather than one that assumes that everyone learns the same way. So the focus on differences are a central part of what we do. (P21)

Individual differences were recognized as impacting every layer of the school system, so individual differences in learning, teaching, context, in motivation even as they changed over time were an aspect of understanding learning relevant to neuroeducation. Individual differences at the level of the state, city, community, and individual student were all seen as critical when thinking of an effective model of education that would meet the needs of all students. In fact, in relation to creating an effective model one participant stated that the only effective model would have to be one that provided the most flexible possible in order to be able to address the multiple layers of individual factors that would be relevant to an effective curriculum. Another participant emphasized that the practice of systemizing a curriculum that would be followed by all schools and students and presented in a specific sequence would be to immediately diminish the ability to respond to the individual needs of a unique group of individual students. Any program aligned with the principles of neuroeducation was thought to be one that would be responsive to differences in students, schools, and communities.

In relation to other themes, individual differences shared a connection with a number of other variables from development, to motivation, to policy and standards. The theme of Development and Individual Differences from the first block was transformed into two separate themes of DAP-Holistic and Individually Responsive (Table 5). This represented a shift from more biologically oriented concepts towards more cognitive and psychologically oriented codes. Codes under the theme of Individually Responsive were strongly related to themes representing the concept of the self, or in other words, the individual. Issues of student directed learning and personal meaning were not coded with individual differences in the first two blocks. Rather, the code student directed was under the theme of Curriculum and Instruction, while the code personal meaning/motivation was dually coded in the student issues related themes of Socio-Emotional, and Cognitive. The shifting of the focus of individual differences as a code within a theme is highlighted in Table 12.

Table 12. Changing Themes Including Individual Differences across Blocks

Theme: Development & Individual Differences	Theme: Individually Responsive
Block1 & 2	Block 3
Individual Differences	Individual Differences
Holistic Ed	Student Directed
Special Ed	Motivation
Development	Meaningful Learning
Plasticity	Personal Interests
Learning as a growth process	Personal Meaning
Natural ability cut off	Empowerment
Natural learning	Individual Self
Gifted students	Personality
	Relevancy

Note. Codes are ordered by frequency from highest to lowest

Developmental variation. For the first two blocks of interview coding, Individual Differences was paired with development. This corresponded to the biological aspects of both physiological and psychological aspects of the individual person. The third block of interviews separated this out into the more psychological or cognitive components. However, these biological aspects of learning and development were highly related to individual differences. The interviews from the academics in the neurosciences tended to focus on the biological aspects of individual differences.

> On the other hand, if you look at the neuroscience work that is focused more on developmental variation and response to environmental contingency, you come away with a very different metaphor, the idea of learning as a growth process, literally, the growth of cellular and neural structures and response. This isn't any empirical question. It's about reviving the notion of learning as growth, as opposed to learning as programming, or learning as conditioning, or learning as transmission. These are all metaphors that have been used historically to explain what learning is all about. From my end, what I'd like to see is educators make use of the neuroscience research base and more broadly a biological understanding of human beings a biological kinds and what that implies in terms of development, in terms of change over time, in response to environment, in terms of learning as growth, and active growth and greater tolerance for variation in response. (P1)

The idea of shifting the metaphor of learning as transmission to learning as a growth process showed how the processes of learning as provided by neuroscience could potentially be used to shift the meme of education. Individual differences in the rate of learning were seen as being poorly addressed in our system of standards and benchmarks. The current demand that all students reach a given level based on age and grade was seen as unrealistic and incongruous with the basic understanding of individual differences in developmental neurobiology. In particular, the requirement for children to reach reading milestones in order to pass standardized tests was seen as conflicting with data on the enormous variability known from the science regarding the rate at which children develop reading including sensitivity to dyslexic children or delayed readers who often develop the capacity to read as late as the age 12 years old, or even later. One participant spoke intimately of a young boy he/she knew who was having trouble learning to read, although he was in the best learning environments. This became a personal concern for him/her and created a sense of passion towards the need to address the problem in our one-size-fits all system. This personal concern was reinforced by comments from other interview participants regarding the natural variance in reading development and the misalignment of NCLB.

> I wish that we made more accommodations for these kids. He's a very, very bright little boy he has a huge vocabulary, he has a wonderful memory. He's smart, he just can't read. Our schools do not do well with these kids, because reading literacy is the primary measure, there's a wonderful book out called the gift of dyslexia and it turns out that that kids with dyslexia often have increased visual spatial skills, and if we had a culture that didn't require us to read if you could put things in bars and graphs and spatially they'd be at the top of their class. (P23)

> The variability, if you correct for socioeconomic status, the variability in reading development among kids is immense. They do not all get it at the exact same number of weeks from birth. And to expect them to do so the way one size fits all programs such as those that were advanced under NCLB is misguided. (P1)

> Different kinds of kids may actually learn to read in different ways. Neurologically they might be ready to do different aspects of the process …The extreme example is dyslexic kids who have problems phonologically decoding and at age 13 learn to strategize by learning vocabulary in the very specific domain that they are interested in. (P12)

Some of this difference was seen as part of a natural variability in the maturation process. Several participants referred to data supporting evidence of self-remediation of reading "deficits" as the student matured. This aspect of self-remediation supports the idea that the inability to read at an early age is *not* a dysfunction. The development of costly intervention programs for this group of slowly developing students may be a misuse of funds. Rather, the neuroscience suggests we should be focused on providing an educational environment that supports multiple ways of learning and knowing.

> They did longitudinal studies and what they found [was that] upwards of 25% of the control group would self-remediate within two years from their so called reading disability without any special intervention. (P1)

> [Adult dyslexics] said that they had learned to read when they were about 12 to 14 … and what we think is actually happening is that the kids are getting *old enough* to figure out how to read and so they've basically learned how to read on their own by analyzing what's required in the reading task and that's how they're making the breakthrough. (P21)

The failure to attend to difference in maturational rates of learning to read was seen as potentially damaging to a student's self-esteem and natural drive for learning. In this way individual differences were connected with socio-emotional themes and student motivation. A shift in the way we view learning differences was seen to be important to prevent potential emotional harm to students who did not fit the traditional mold.

> My main concern is that we have a lot of kids who don't fit the mold, who march to the beat of a different drummer. Eventually they'll be fine when they get to high school perhaps maybe college [as long as the] school system doesn't mess up their self-esteem before they get there. (P23)

> To force a kid to try to take off and read before they are developmentally ready, which doesn't necessarily correlate to age, is to endanger their life… The number one consequence is that they blame themselves they see that as a reflection of something wrong with them and that causes shame…It is undermining their ability to do what it is they are ashamed of. So millions of millions of kids are, I think in this country there are 100 million people whose lives are pretty severely distorted because of the unhealthy learning trajectories coming out of the reading experiences. (P14)

The code of Individual Differences was related to the code Strengths-Based Approach in the way in which neuroeducators tended to view what others termed disabilities as potential strengths. From dyslexia to ADHD, these so-called disorders were viewed as part of natural variability, and were seen as being associated with not only negative problems such as greater distractibility, but with positive attributes as well, such as creativity or greater visual-spatial awareness. The relationship between seeing so-called deficits as individual differences with some advantages, as in the reference from one participant to the book, *The Gift of Dyslexia*, would represent an important first step towards creating a curriculum sensitive to the unique needs of all students. The term twice exceptionality was used by several of the participants. Twice exceptionality referred to students who were gifted in two or more areas, and yet had learning difficulties in another. These gifted students were seen as suffering in the traditional educational model for lack of awareness by teaching and educational professionals. One way suggested by participant to approach this problem was to provide multiple experiences in order that those who may learn differently could have the opportunity to be successful in the school setting.

> So what we need teachers to appreciate is that kid is not reading like the rest of the kids it's not just that he overcame a deficit and now he can do it he is still neurologically doing something very different. So we need to allow for that in the educational space, and in fact encourage it. (P12)

> One policy change that I would like to see is to recognize that kids learn differently and therefore every school district needs to provide two or more different approaches to learning. Those might be continuous progress. They might be free school. They might be Sudbury. They might be open education, etcetera. You know give parents and kids a choice rather than saying one size fits all. (P16)

The creation of the new category in the third block of interviews that included the code of individual differences with codes of motivation and personal interest was based on the apparent relationship between these items as they were discussed during the interviews, in particular in relation to the interview responses from the school founders. For those who had worked designing school programs, the practice of allowing students to guide their own learning experiences, meet their own academic needs, develop their own personalized learning experience, and empower the students to plan and act, were all factors seen as related to building the intrinsic motivation of the individual student. In connection with this was the belief that student's brought their own curriculum with them to school, had their own learning goals, and that learning was "aggressive". Intrinsic motivators included student curiosity and their intrinsic desire for creativity and problem solving. These were seen as parts of our natural learning systems. It was believed by this group that students need not be forced to do anything, but that their own learning systems would drive them to want to learn more, and to seek out those experiences that would provide them with the learning they personally needed. Looking at the functional anatomy of the brain, it is clear to see that learning and motivation are coupled through shared neural systems. The work of Wolfram Schultz demonstrated that learning is associated with significant changes in activity of the dopaminergic cells innervating both the dorsal and ventral striatum, as well as projections to the frontal cortex (Schultz 2002). These are the same systems activated by drugs of abuse, and are part of the *drug-reward circuit* in the brain (Wise, 2002). The motivation circuits connected with learning are hence, so powerful, the term aggressive seems acutely accurate.

It was pointed out that forcing a person to engage in activities they were not interested in diminished their intrinsic motivation. This is supported by the literature on motivation, and is one of the reasons that many educational psychologists discourage the use of extrinsic motivators (Deci & Ryan, 1985, 1987). Such intrinsic motivators include rewards and punishments but also include, as was pointed out by one of the participants, grades and competition, all factors which make student focus on achievement, not for the sake of learning, but for the sake of getting a grade, or reward, that has nothing to do with their intrinsic interests.

> If you force kids to learn things that they are not interested in you tend to extinguish this natural ability to learn. (P18)

> Just deal with motivation for instance. It's so clear now that the motivation to learn, the motivation component is enormous, right? Cognitive psychology, what's the most key element? It's motivation. . Nobody does anything without motivation. You have to start there, and it's so clear now that the only motivation that counts for anything, in terms of real learning substantive and lasting learning, is intrinsic motivation. If motivation is not intrinsic not much happens. You're just back to conditioning. You are just conditioning children to remember certain pieces of information, to put linear ideas together, this kind of thing. You can call that learning but I think really it is conditioning. Children don't need to be motivated. They are motivated. They're born motivated. Motivation is just instinctive. It's built in to every breath we take, unless somebody screws with it and conditions us out of that, conditions us to behave in a way that we depend on extrinsic motivators. (P19)

Student selected & directed curriculum. With regards to individually responsive curriculum, one of the most frequently cited manners in which this type of curriculum, individually sensitive to each student, could be achieved was through allowing a greater degree of student selection and direction of content. Providing students with this choice was seen as being able to meet the goals of to personal meaning, relevancy and emotional connection as they related to content. In addition the importance of allowing students to be participants in selection of content was seen critical for engaging intrinsic motivation, and reducing resistance to learning. Meaningful learning was thought to depend on this engagement by students in the learning process. Several interview participants had worked in schools utilizing student directed learning in their programs with great success.

One suggestion made by participants in allowing for student selected content was to permit the inclusion of popular culture into the classroom, popular music, for example. Another participant reported a personal experience of allowing students to select the books for their course that was read by the whole class with discussions led by the student who selected the content. Several participants emphasized the need to allow students to develop their own questions that would be addressed in a project or class lesson. Building on the student interests as they expressed them, and not forcing children to learn those things that they did not find interesting was seen as a means of increasing the ability of students to learn and be engaged in the learning process. Using student directed material was also thought to allow for the discussion of real issues that those students faced and were concerned with, providing both emotional salience, and a greater likelihood that students would be able to transfer the knowledge towards their personal lives and the outside world. This was seen as a major challenge for teachers, since historically the role of the teacher had been the director and source of knowledge. The need for teachers to give up some of the control and give students the chance to be the directors was a central repeating theme of a good program of neuroeducation.

> I can be responsible as a teacher for teaching them how to read and how to wright and how to think better to improve those abilities. But I don't have to keep a stranglehold on what they read, and what they write about and what they think about. I can allow them to follow their own interests more, and pursue things that matter more to them. (P15)

> They cannot imagine really letting students make choices, or having students ask their own questions without having to answer them. Or when they actually see that students can possibly ask their own questions and research it they'll still say I am going to do this and this and then I will allow them to do that. (P9)

> It is the teachers who are doing all the problem solving in school, making all the decisions. The kids are never involved in any decision making, even about the mundane things, about how to walk to the library, or all of these other kind of thing. So when are they going to learn how to make critical decisions when they grow up? …So the idea is to change the phenomenon from a top down authoritarian school model, where the adults make all the decisions, to a more collaborative kind of a school model where as much as possible the kids are involved in helping to make decisions in the school. (P3)

Individual Difference as it was coded under both themes from the separate blocks related in interview transcripts to policy issues. Both researchers and educational leaders found that the current policies created a single goal or bar which everyone was expected to reach. The current policies were seen as a one size fits all, focused on bringing all students to the same level, not attending to differences in learning rates or abilities, and failing to provide anything for gifted students. There was a sense that the current system and our current culture was afraid to admit that people were different. That it was somehow taboo to suggest that some students may not be able to perform a task as well as another. It was deemed important to shift this idea and to embrace individual differences if we were to really meet the needs of each individual student. Some approaches suggested by participants for addressing this issue were creating personalized learning plans for each individual student, differentiation of lessons, and providing student directed curriculum in which a student could work at their own pace and at their own level. Tailored lessons for individual students that presented challenges designed to meet them on the edge of their learning was something envisioned as part of understanding they dynamics of learning as would be understood from the cognitive sciences. In relation to these highly specialized programs, technology was seen as a useful tool to provide individualized and scaffolded learning experiences.

Using technology for individuation. Technology is touted as one of the cornerstones of the Partnership for 21st Century Skills initiative (2008). The growth in available technologies was seen as something that could aid in the increase in student directed learning, especially with regard to the opportunity it provided to student to seek our fact based knowledge on their own from online sources.

> I think that ultimately more and more of the informational learning, that is learning to read learning to do math, learning to do the memory recall of factoids and all that kind of stuff is going to be done more and more by technology. And that the purpose of classrooms is to create a dialogic environment for team learning and collaboration. (P14)

> We desperately need is to look at that whole notion of perception and allow students to ask their own questions to do the research, now with computers so available, and experts online, they can go to those sources, and what teachers do is they guide that process and also challenge students. They really have to be well educated in order to facilitate that kind of learning. (P9)

> Most of the time I work with schools where teachers stand-up and deliver, and I have been saying to them for years that you have all been replaced by Google that you are all obsolete. Kids don't need content from you. (P17)

> One of the things I think technology has done is that it's taught kids to be involved in learning. So the idea of just sitting and listening doesn't work anymore. We want a lot more of what we called flipped instruction. Where in fact the kids are doing more of the grunt work and finding out what they need to know and the teacher acts like a guide. I see that as being a predominant strategy. (P25)

There was general agreement that technology was here to stay, and that it would be important to understand why digital learning was so powerful. Neuroeducation was seen as needing to continue research on how technology interacted with motivation and more importantly, in how student interaction with technology contributed to neural changes in brain structures and functions.

Technology was seen as a means of providing immediate feedback to students. The use of the timing of interactions between the student and the content, better meeting the students "meaning needs" and the ability to scaffold learning on an individual basis using technology based in gaming and artificial intelligence was a central goal of one of the participants. In many ways technology was seen as a means of providing structured learning experience, especially in the absence of sufficient numbers of teachers or other support for student learning especially in this age of large class sizes and limited time to cover material.

> But where is the time? Or where is the money to hire more teachers who do have the time? It is not there. So that is not going to happen. What we have to do is figure out something else. And one of the things that I think is going to pay off, it's not going to completely solve the problem, but I think it will help to solve the problem, is taking advantage of the internet, and computer availability for children. (P4)

> It's about how you think and engage with kids you really don't need a lot of this fancy stuff. It doesn't mean that this fancy stuff isn't useful and helpful especially in an age when classrooms are over-crowded and we don't have enough teachers for the kids, technology can provide, if it's used well, like with CAST, Center for Applied Special Technology. If the designs are good then it can provide a proxy for something he would love to have, which is the teacher for every student, so you can modify the learning materials to suit the needs of the learner if it's done smartly. But there's no such thing as a quick fix. (P12)

> Kids take to videogames like ducks take to water. The videogames pose a problem there is a challenge, and they practice and rehearse as long as it takes and they become better at it and they get feedback about how well they did in the video games. (P9)

There was the belief that video games could be built based on the principles of learning and designed to assist in particular skill building. The idea that computers could take the place of teachers for some of the early skill building process, or that teachers should be the guides and not distributors of knowledge is consistent with the hierarchical nature of skill building. The new paradigm of neuroeducation supports a very different role of teachers in the classroom, and this can be supported and made possible through the availability of vast amounts of knowledge through the internet.

Because of this shift in available source material to the internet where anyone could post anything, it was thought that an additional focus of curriculum in this age of technology must be in how to use electronic information and discriminate good from bad sources.

> The kids now are so used to electronic information, or dealing with people through electronic information, through Facebook, and they are doing a lot of social networking. And they are dealing with friends, so they kind of have a notion of when they are emailing or they are Facebooking each other and twittering each other. They know they are friends and how legitimate anything they say is. But when they switch over they are doing a project for a class assignment and they have to gather information off of the internet, they are gathering it from people they don't know. They don't know whether the source they have is credible or not. And the question is where in school do they teach kids how to assess the credibility of electronic information, The question is that how is the school going to figure out how to teach kids the credibility of information. They haven't and it becomes a big issue. (P3)

On the whole, technology was seen as a support for teachers, and not as the solution to the real problems of engaging students in higher order thinking and changing the paradigm of education. Several participants spoke to the problem of using technology simply to support the old way of doing things, and that technology was not necessary to engage students in a program of effective education. There was the belief by participants that some educators or policy makers viewed technology as the answer to all the problems. However, according to the participants in these interviews, technology would not provide a significant improvement in our student's learning experiences unless it was used in a manner that would benefit the higher order aspects of learning, and not just to repeat the old meme.

> I think we're a little off center in that new technology will likely provide some opportunities but how we use them is really the key issue not whether or not we have them. (P13)

> I think technology is certainly going to influence, however, as far as the curriculum is concerned there are still some pretty basic concepts of time and patterns and change that will do kids well. (P23)

There were those who spoke about the impact of technology on brain development, neural connectivity and function. There were some concerns that this could potentially be damaging and one participant, because of the impact of media and technology on the brain, believed that all screen based technology should be restricted until after the age five.

> It's an interesting question because there are people like Joseph Chilton Pearce who says that things like TV actually tend to be destructive and that they create images for kid’s minds instead of their minds creating their own images, therefore they stop being able to create images as well of new things. And of course now you have kids everywhere looking at screens where the images are created for them. There is a question about what the effect will be of that on kids’ ability to be creative. In general, technology is a nice tool that can't be ignored. It's going to be part of our future but it just has to be done in such a way that it is not forced on kids. I believe that if kids are free to really play and be active they won't spend all their time in front of screens. (P18)

> While I am a huge fan of integrating learning with technology I am adamant that kids under the age of five should have zero exposure to it. In other words, no TV, no video games, anything with an on-off switch or a battery, kids under five should have no association with. I think it is counter to good brain development. (P17)

Third Most Frequent Code: Social-Emotional Development

Of those codes appearing the most frequently, socio-emotional appeared in the top five in both Block 1-2 and Block 3 of the interviews. This code spanned a wide range of commentary, but the one point of agreement was that neuroscience shined a bright light on the issue of emotions in learning. This is not surprising given the more than 50 years of research on learning and emotions. Since the 1950s and 60s with the work of Hans Selye (1950) and others, our understanding of the interaction between the physiological and psychological effects of stress and emotions on processes of learning and memory, as well as neural plasticity, adult neurogenesis and hippocampal degeneration has continued to expand. The fact that much of our educational practice is completely insensitive to these processes demonstrates how we ignore the available science, and frequently work against our natural capacities for learning in our public schools today.

Nearly all the participants agreed that socio-emotional aspects of education were a central part of the research in educational neuroscience and MBE and that an effective program of neuroeducation would need to meet these emotional needs.

> The effect of affect on cognition, well, most people think of emotion as this sort of side issue rather than as a fundamental issue to attend to. Neuroscience has the opportunity to change our definition of learning. It can help change our thinking towards recognizing emotion and cognition as inseparable co-participants in learning. (P14)

> What's more important, what they don't accept is that probably the most important things that schools can do it to teach social development, social skills. People don't lose their jobs because they don't know the multiplication table. They lose their job because they can't get along with other co-workers. And so the development of social skills, to learn how to get along with people, in the long run is far more important than anything else we do in school. (P3)

Emotions were also linked to motivation and engagement with the curriculum. By making curriculum emotionally relevant, it was thought that students would be able to better attend to the material. This was seen as part of the basic biological nature of the hierarchy of needs and the ease of learning being directly related to what was important to the student at the most personal levels.

> When you understand the hierarchy of information in the brain you realize that after survival, that comes first always, emotional information comes next, and then dry facts about the world, which they may or may not find relevant to their lives, come last. So if you want them to learn the bottom stuff which is what you are going to test them on, then you have to deal with the things on the top. You have to make sure that their survival needs are taken care of that they are safe and secure environment, and you have to meet their emotional needs. (P25)

> I had spent a lot of time as a teacher and thought it was pretty important for what was going on the classroom to matter emotionally to the kids, because otherwise there wasn't really much motivation for learning…As Damasio says, emotion is the rudder for thinking, and we were saying, 'Yeah, OK we think in service of emotional goals, and our emotional needs, so if the kids feel these then maybe they're more likely to get turned on to their learning as opposed to seeing it as this thing they need to get through to get on with their life.' (P15)

> I was an award winning teacher, but I noticed my students, what stopped them, were more emotional issues that they were facing. (P9)

> Soft factors are: the relationship with teachers, the level of trust, the level of safety and security in the classroom, and within the school, for some kids that is a critical issue. Our bodies, what we are learning about our biology tells us that this is all primary information and if we ask our nervous system, this is all primary information, and yet, within education we have peripheralized certain factors that could end up being the game changers in terms of the quality and how people learn and how they experience things, retain information and grow into productive lives. (P10)

Some of the suggestions as to how this would occur would be through increasing the teacher cognizance of the importance of attending to the emotional presence of their students. Other suggestions related to content selection that would engage student's emotions, in particular through the use of the arts, as mentioned previously. In addition, there was an awareness of the biological link between emotions and memory, both as it was related to creating meaning for a student, and with respect to the beneficial effect of positive emotions, while negative emotions were known to inhibit higher order thinking.

> We know that emotion is real a catalyst in the learning process, and you can use it to your advantage because those things with a positive emotion are remembered longer, but under stressful situations the thinking part of the brain literally shuts down. (P23)

> If you want to keep their attention you have to present stuff that makes sense. You've got a have stuff that has meaning. Meaning often comes through emotions, and so getting kids involved emotionally has a big impact. (P25)

Emotions were also related to the challenges of learning difficult material, and it was thought that awareness of this relationship could assist in student resiliency and behavior management. Given that certain learning challenges could be stressful to students, causing negative emotions of fear and anxiety, especially if they were behind their peers, it was expressed by participants that it was important for teachers to understand how stress influenced both learning and student misbehavior.

> When stress research came along I began to see the connection between stress and classroom management and misbehavior. The misbehavior of students is quite often a result of the stressful environment they are in. (P3)

> I think that for reading related difficulties, we are taking about this incredibly high-speed, abstract, incredibly confusing, artificially confusing processing challenge that requires great emotional resiliency to handle the frustration that is involved without quitting. (P14)

Fourth & Fifth Most Frequent Codes: Creativity & Cognitive Capacities

Creativity and Creative Problem Solving were in the top six codes for both Blocks 1 & 2 and Block 3 of the interviews. This reflected the belief by all of the participants that the focus of education should be on capacity building, particularly related to the 21st century skills such as, communication, collaboration, critical thinking, and creativity.

One of the founders of IMBES associated the MBE effort with the goals of 21st century skills, and saw this as a project consistent with the goals of MBE.

> That's one of the things that we are advocating for. We're working with the initiative focusing on 21st-century skills. They involve things or advocate things like teaching kids how to develop critical thinking which John Dewey argued for 100 years ago. He named it reflective judgment and he wrote how [it] could really make a difference in kid's development of thinking skills. So that is the kind of position we advocate for and we are working with groups trying to promote this more diversified curriculum. (P21)

The idea that curriculum could be designed to encourage the development of higher order 21st century skills was a central vision of a program of neuroeducation. Creativity in particular, as it related to thinking and problem solving was seen as a necessary component of a good curriculum if we were to shift our focus towards maximizing student abilities. This shift was seen by several participants as an issue of social importance, and that if we were to meet the needs of a radically changing world, it would be these skill sets that would give students the ability to respond to an unknown future.

There was concern that the current system was producing just the opposite effect. More than one participant spoke about decreasing levels of creativity in our schools. Others pointed to research indicating an inverse relationship between creativity and performance on standardized tests. There were several who pointed out the negative impact of HST on creativity based on the need to find one answer to the problems presented on multiple choice tests. This was seen as opposed to one of the primary components of creativity, that of divergent thinking, of coming up with multiple answers for a single problem.

> High-stakes testing which is usually a summative assessment because of costs is created mainly through multiple-choice true-false and in order to do that there has to be just one correct answer and that's convergent thinking. Convergent thinking is an emphasis on finding one answer to things and it focuses on that, and that inhibits creativity. Creativity requires divergent thinking, looking at multiple choices, looking for options, making decisions about similarities and differences, compare and contrast which is a better option, realizing the world is not black and white and most of the problems you're going to face to be a successful citizen in this world are grey and have options, and you have to make choices. We teach kids and train kids to look for the one correct answer. And life isn't that way. There are *not* too many major things that we have to face in life that have one correct answer. If there were maybe they'd be solved already. So I do think high-stakes testing has been a hindrance to creative curriculum development and more creative teaching in the classroom. (P25)

> There seems to be an inverse relationship between programs that force kids to do better on tests and their creativity. It's not only that we are talking about the United States. They found that the higher that they scored on the PISA test the less creativity. (P18)

Not all of the participants felt that we were in the position to be able to build these capacities, and similar to those who commented that it was too early to bring most findings from neuroscience into the classroom, there was the belief that we were not yet in the position to realize how to improve cognitive and executive functions based on the data from the sciences.

> We're learning more about, for children, what it means to build attention and memory. So I think we're getting there, but I just think we're very far from it right now. (P24)

Nonetheless, the majority of participants emphasized that we must begin to try to build these capacities and as such, there were a number of approaches suggested to doing this. Universal concepts, pattern recognition, project based learning, arts integrated curriculum, simulations, and playful learning were all considered as means of contributing to deeper learning experiences allowing for divergent thinking, creativity and the ability to translate ideas from one subject to another. The majority of participants felt that creativity was something that could be developed in classrooms, and that the neuroscience could help to inform that process.

> Take creativity for example, now there is one good thing that we discovered, how the fact that creativity is not a fixed trait, the way we used to think intelligence was, and if you talk to people like Mary Helen Immordino-Yang and a few others like that, who look at creativity as a fluid characteristic, it means we can teach creativity. The curriculum can enhance creativity by the conceptual approach. It doesn't do it by the factual approach. (P25)

Creativity and critical thinking were grouped under the theme of Student_Cognitive, along with the codes of attention, decision making, executive functions and pattern recognition to name a few. One important aspect of learning that can be derived from the brain research is the influence of patterns in the processes by which the brain makes sense of the world. This aspect of learning has significant implications for curriculum and classroom practices. The use of patterns in curriculum design was brought up by several of the participants.

> Keep in mind that the brain is a lean and mean pattern-making machine. It's always looking for patterns. And so you encourage that. You encourage the brain's natural tendencies by showing how things in one subject relate to the others. (P25)

> I think if I were teaching history and social studies it would be about learning patterns of behavior, it would inspire children to ask questions, to form hypotheses. (P24)

> Another thing that I think is important and resonates more with neuroscience is a general algorithm that the neocortex follows and that is one of pattern recognition. So pattern recognition unfolds in a lot of different ways in our abilities to detect words from noise in the background, the formation of words, visual input, all of the ways in which we try to make sense of our environment is slowly understood by pattern detection and then these patterns become more sophisticated over time. (P22)

These top codes reviewed above related an overall picture of the shared vision of the most critical components for a curricular model based on the understanding of the developing nervous system. The next section reviews some of the less common codes, but important key factors suggested for a model of neuroeducation. In addition, this next section attempts to synthesize divergent beliefs into a wholistic framework of an effective approach to curriculum.

Curriculum, Pedagogy & Programs

The difference between content versus curriculum and pedagogy was the focus on techniques that would be used to engage students, or rather the delivery of content. Although some viewed curriculum as no different than the selection of content, a distinction can be made between curriculum that is determined by objectives for learning content versus process or praxis oriented curriculum that focus more on the immediate engagement of the student with the natural process of learning (Stenhouse, 1975; Freier, 1972). In many ways conversations around curriculum were the same as those around content. However, if we include the discussion of programs and interventions that were considered aligned with the brain, and that were either fully developed, or were presented as conceptual ideas, it was clear that there was a wide range of curriculum and programs that had the potential to fit under the category of neuroeducation.

Overall there was the sense that applying the ideas from neuroscience to classroom practice should be based more on principles of learning rather than a particular method or technique. There were some commonalities about what would be necessary for a program of education that utilized findings from neuroscience. Most participants expressed the idea that any program that was going to be effective was one that would be flexible and work off of general principles, rather than utilizing techniques or formulas that claimed to be applicable anywhere with the same results. This was related to previously developed codes surrounding individual differences.

> Every place is different, the students are different, the culture is different, the parents are different, the needs are different, and I guess if you're going to say what's the model, the model is the most flexible thing possible. (P15)

> One thing that we are learning more and more about the brain is that there are huge individual difference and there probably is no one thing that is going to work for everybody. (P8)

> Instead of using the term best practices, which means everybody does this and they will get this outcome for each child, we may be talking about promising principles, principles derived from the literature, from practice, from science, around which individual practice has to be adapted and created around. (P5)

> So this is instead of telling them what to do it is teaching them how to think it is teaching them what the questions are and how to look at learning and how to understand. It as a process of developing a person not just teaching them things but growing a person into their own individual who has coping skills for dealing with the world when they get out. (P12)

This corresponded to the overwhelmingly negative response by most participants to the use of scripted curriculum. Some of the participants brought up the subject themselves as examples of poorly designed approaches but when asked directly to respond to the issue of scripted curriculum the far majority of responses clearly indicated that scripted curriculum was not consistent with their views of an effective curriculum.

> It is just atrocious it is just appalling. I was introduced to that by a teacher at one of our workshops that we gave out a case study that we were working on in small groups. There was one teacher who said in reference to the case, 'You know probably this teacher had to teach like this,' and there was a sort of collective mouth-drop around the table. They said, 'What? Why would anyone script that when all the people in the classroom have different needs and some might need that step they are

> told they have to leave out?'…To think it is going to work for everybody, it is just nonsense. (P15)
>
> You've got this idiotic structure where you're saying meet these certain levels, and cookie-cutter teach in this fashion, and here is a 'teaching for dummies' textbook, follow this page by page. (P2)
>
> It's dorky. (P5)

This negative view of scripted curriculum corresponded to what has been already discussed regarding the critical nature of attending to individual differences in any effective neuroeducation program. The use of a scripted, one-size-fits-all, curriculum was viewed at being insensitive to culture, context, and individual interests and abilities of students. Although scripted curriculum was viewed as failing to attend to what we understood about learning from the science, there were some who recognized that this model was in some cases justified, or understandable from the perspective of school leadership having to cope with a lack of teacher ability, or the needs of a mobile student population.

> I couldn't believe it, they literally tell the teacher where to stand how to point and what to say…Some of it justified because we started to have some really questionable teachers who didn't know their subject, but it ignored student learning, it ignored individual abilities, and it went on a time schedule so if they didn't get it then it was just too bad. (P9)
>
> There was a guy yesterday who was telling me, he ran the Philadelphia school system which is now gone defunct, you have no idea, I had to go to a structured learning environment I had to go to scripted learning because one quarter of the kids in my school system, he said moved around in the middle of the school year, and when they went to a new school they had to know what page they were on and what they were studying and things had to look the same. These issues need to be part of the discussion to tell us how do we make [a program of neuroeducation] work under such circumstances. (P24)

The use of scripted curriculum was referred to by some as a medical model, and something that was therefore highly prescriptive. This tendency to try to create a systematized model that would be applicable to everyone, everywhere was seen as a poor approach education.

> It sounds a little like an old medical model, if you had a treatment and if people followed the regime exactly you will get the same results across the board. (P13)

> One of the great enemies to good education is this desire to create the model that is going to be applicable everywhere for everybody and I don't think the research supports that concept. (P15)

> On the other hand, when you try to apply the medical model, which is basically there is a problem and we have to fix it, then educators take it into a prescriptive model and that is really not appropriate. What it is appropriate for is what we call special ed kids (P9)

At the same time, certain participants supported the use of some precisely prescribed programs to meet the needs of individuals, in particular for those who were experiencing some learning difficulty. Tightly controlled, scaffolded learning experiences were typically seen as appropriate as interventions to help students who were struggling with reading or other basic skills. This apparent contradiction is one of the critical aspects to consider in what aspects of pedagogy are appropriate to neuroeducation. In general it appears that there are no clear existing models that fit nicely within the framework proposed by all of the participants. It will be important to recognize conflicting views, so that creating a model of neuroeducation does not become just a rehashing of a progressive or free-school model. Neuroeducation appears to support a wide range of activities indicated by the processes of learning based on what we can winnow from the brain and learning sciences. Taking into account this wide range of activities and making sense of how the indicate an effective curriculum is perhaps the greatest challenge facing MBE and educational neuroscience today.

Delivery of Content

One theme that was tightly related to content was that of MBE Classroom Practice. This theme included codes from pedagogical and teaching approaches that were deemed to be aligned with the information from the neuro and cognitive sciences and could potentially inform a program of neuroeducation. Looking at the themes of *content* and *capacity* it was possible to see the means for making the marriage of these two through the generation of a third theme, that of *delivery*. Delivery represents the means of addressing both meeting the demands of the academic content and providing the experiences necessary to build more general capacities. Table 13 shows the relationship between content, capacity and delivery.

Table 13. Themes of Content & Capacity Building Determine Classroom Practices

Content	Capacity	Delivery
Richest Possible	Critical Thinking	PBL
Diverse	Problem Solving	Experiential
Integrated	Creativity	Hand On
Transferable	Communication	Discovery Based
Student Directed	Collaboration	Inquiry Based
Student Selected	Attention	Collaboration
Emotionally Relevant	Mindfulness	Scaffolded
Culturally Responsive	Emotional Presence	Simulations
Differentiated	Expertise	Dialectic
Universal	Moral Reasoning	Play
Meaningful	Memory	Arts

Project based learning. Project based learning (PBL) was brought up by several of the participants as a means of delivering content that would engage and encourage the development of higher order cognitive capacities, and help to meet the goals of neuroeducation. Project based learning was seen as engaging students in a greater degree of active participation, self-organization and self-direction.

> What we discovered is that learning in this natural biologically documentable way is that it is dynamic, and dynamic means that the kids have to be involved in a project of some sort. For example the traditional model is static…well higher order thinking involves planning, organizing, evaluating your own work, metacognition. It involves a way of learning that is evolving and allows for the perception-action cycle, in other words for their own question, their own research, their own analysis. They have to demonstrate what they have done in some new and creative way. (P9)

> We know how children learn and it's not about sitting passively and doing rote memorization and if we know that and have some sense of what engages children how they can make interrelations among the content areas what skill sets they need to have if they are going to be thinkers not just memorizers, then we ought to be using that information. The science it seems to me is fairly clear on these issues but it has not yet jumped into the classroom. (P24)

Play & the arts. The use of play and the integration of the arts were seen as both encouraging creativity and better engaging students in the learning process. Play and the arts were seen as a means of delivering content in a way that would develop cognitive capacities, such as perspective taking, self-regulation and attention, but were also seen as critically important in building social and emotional skills. Play was used as a core construct of how we learn best at any age by one participant who referred to processes of active, engaged learning as "playful learning".

> People have looked at the loss of playground time for kids, the loss of playtime. Not only as a function of schools but as a function of families who over burden their kids with lessons, and one thing or another, that there is not any time for kids to just figure things out for themselves, play games and figure out the rules and learn to interact with others, as not having a good effect on their ability to grow up and to interact with others. (P16)

> I'm writing a book right now with the co-author called ________, that discusses ways in which the arts can enhance the learning of science and math. The thing about the arts, is that the arts are often very emotional and

> require emotional input. So that's one way for kids to learn what they sometimes consider to be the dry information of science and math through using the arts to help them find the meaning of things. (P25)
>
> There's a whole lot of making up plays, or making up stories, where kids act out a particular role, learning that role and getting themselves become engaged in that role. That seems to be one of the best ways, intuitively it seems, that would be a simple way to help kids to take other people's perspectives, which is one of the key issues that comes up in self-regulation. (P21)
>
> What we're trying to get at is the basic science of how children learn …and how they learn best through active engaged and meaningful learning, the word I use for that is playful learning. (P24)

The power of play in learning to engage a student's faculties, and motivate them to the solution of internal questions and expression is one that contradicts our societal view of what makes up school "work". One participant pointed out that it was not just adults who held this view that school was not about having fun, but the children themselves already had adopted the general meme around what it meant to be learning something in school.

> This morning I interviewed some kids and I asked them what is the difference between play and school, and they already know it. They're 7,8,9,10 and they already know that schools is different from what they are doing. They are already on line. One kid was researching pieces of Lego he needed. He contacted different states. Looked them up on the map. Added up how much it would cost him. He was totally engaged in this, but he doesn't see that as learning. (P9)

Direct instruction. Ironically, although scripted curriculum was viewed negatively, there were two different models promoted by three separate consultants that were referred to as "direct instruction" by the literature. Two of the early translators had worked with Madeline Hunter's Seven Step Lesson Plan (SSLP) which created a system of teacher decision making that provided a scaffolded approach for teaching to improve engagement and learning for students (see Hunter, 1994). Both of the consultants claimed that working with Madeline Hunter and her model drew them to the brain sciences as a means of understanding teaching and learning. The explanatory value they found in the brain research inspired them to seek out other information to better clarify for themselves, and for the field of education, how it is that we learn and how we should best teach.

Hunter's SSLP might not be called direct instruction by today's standards, and it is a far cry from scripted curriculum with pacing guides aligned to federally mandated testing. However, Hunter's model does have some aspects of direct instruction within it. First, content is teacher selected. The learning objectives are predetermined at the beginning of the lesson plan. However, part of the object includes building cognitive capacities, in particular meta-cognition. More importantly, activities are assigned to students with the primary mission of engaging them in deep levels of understanding. As part of the seven steps, students are asked to reflect, and to thinking about their thinking on the subject. This engagement in meta-cognition expanded from a code in the first and second block of interviews into a theme in the third block of interviews. Perhaps what resonates with the cognitive neuroscience in Hunter's model was the use of *anticipatory sets* which correspond to psychological research on the effects of *priming* on learning. Priming reflects the impact of exposure to a stimulus on subsequent experience, and occurs at an unconscious level, representing a natural biological process (Graf, Squire & Mandler, 1984). Different from what is meant by direct instruction by today's standards, Hunter's approach can be viewed as a semi-structured framework to guide teachers in how to engage and approach their class. It does not provide content, but requires that content is selected according to the approach taken by the teacher which could range from district selected content to student selected content.

This can be contrasted with the very specific model developed by Zig Engelmann, inconveniently called *Direct Instruction* (DI), which utilizes a strictly scripted curriculum to teach students to read. This approach was paradoxically supported by one participant (P14). Besides the confusion caused by the choice of names, there were several other aspects of the DI approach that appeared to contradict what had been said by nearly all the participants regarding the individual differentiation of instruction. However, for this participant, DI was seen as fulfilling the learning needs of a particular student population, in order to develop the specific skill of reading. There was definite controversy around this approach with respect to the various participants. Scripted curriculum was viewed by most as working at the level of conditioning and failing to engage processes of intrinsic motivation, student individual interests, creativity and deeper levels of comprehension. Engelmann's model of direct instruction was exceptional in that it was deemed necessary to help students step into reading as a skill. Its use of a step-wise approach, based on the science of learning was consistent with building lower level skills. In DI, no more than 10% of new information is generated in each lesson, and hence students are scaffolded up in a step-wise fashion. Perhaps DI was viewed exceptionally because it dealt with the critical content of literacy. To this extent perhaps DI was permissible within a framework of neuroeducation as it dealt with the specific necessary skill building of literacy.

Although *most* participants agreed that literacy and numeracy were critical components of formal education, one that must be brought to the students by the teacher, this belief was not unanimous. The exception to this view came from the school founders, in particular those who worked in free schools where students were completely unconstrained in terms of their choice of learning activities.

Rote memorization of facts, although contrary to neuroeducation as a whole, was seen as useful in the learning of very specific content for some lower order skills providing a foundation for learning higher order skills. Those who supported using rote memorization emphasized that the memorized information should be something that could evolve and be used in creative and meaningful ways. There was not agreement on this point, as some felt that even those basic skill building activities needed to be done in the same full and meaningful way as learning more complex and advanced concepts. For those participants, it was thought that using scripted curriculum in any form was reverting to “conditioning” and that meaningful learning would not have the true associations in relation to intrinsic motivation and personal meaning if it were to be done in a rote emotionless fashion.

More extreme even, there was the belief that not gaining the basic skills were so potentially damaging that it was necessary to provide interventionist strategies that reflected a traditional, direct instruction model. This conflict of opinions surrounding the use of direct instruction evolved into a conversation between camps, asking each of the two participants about this difference in approach.

> Abigail: You talk about attention systems of the brain, do you think that neuroeducation should focus not only on learning reading and math but also cognitive capacities like attention and creativity.
>
> P14: Yes, but, there is an important asterisk before we go on to that, and that is that kids that don’t get through the kind of great barrier reef obstacle-course walls of reading and math are severely harmed.

This statement made by the proponent of DI focuses on need to bring the basic skills of reading and math to students as a primary goal before even building cognitive capacities. The question was then asked to one school founder and promoter of the free-school model in which all activities are self-selected, and all learning is self-directed with support from teachers.

> Abigail: I have had this conversation with others who have differing views, and one of the things that is brought up is that there are certain core skills like reading, arithmetic, these basic skills that are kind of hurdles that need to be addressed directly by teachers. What would you say to that?
>
> P18: And I'm sure that they believe that. That's because they were raised with the old paradigm, and so at a gut level they can't believe. They were able to learn how to walk and talk, an entire language before they went to school, and then as soon as they got to school they were told ‘You can't learn that way anymore,’ and then over many, many years people actually buy that idea that they can't learn on their own. Those are the people who say you need to create those hurdles. Those are the people who are afraid that kids can't learn to read. We know for a fact in all our schools where children are not forced to read that they learn to read, and the reason why kids are not learning to read in regular schools is because they're being forced to learn to read when they are not ready for it. They have to be allowed to read at their own pace, but that is a concept that is totally foreign to them because of their own background and experience.

The two viewpoints bifurcated around the degree of teacher direction. For the free school founder, all curricula should be guided and selected by students, while the reading specialist/consultant believed that there was some content that was critical to insist that a student learn.

> We need to make a distinction between the things that we absolutely insist that children learn and the things that are optional and the things that we are willing to let them differentially find their trail. With respect to the things that we insist that they learn, like reading and math, I think that we need to unfold a stairway up into it that is responding to their learning at a level of granularity and subtlety we haven’t begun to get close to. (P14)

> The old paradigm is that somehow kids need to be forced or manipulated into learning things that other people think are important to them, rather than actually trusting the fact that the kids are natural learners, and building on their interest as they express it. (P18)

Despite the disagreement, there were several participants who supported explicit interventions that followed a highly structured, scaffolded learning experience focused on developing the specific skills. None of the participants suggested scripted learning be applied to all learning activities, and the same participant who advocated the Direct Instruction program (P14), spoke seriously about the need to attend to student emotions and personal interests. This range of suggested programming reflects the expansive nature of what is acceptable to neuroeducation, and emphasizes the required flexibility in creating any program of neuroeducation in the classroom.

This apparent contradiction between all the things previously stated as being supported by neuroeducation, such as student directed curriculum and the respect for individual differences, and use of a scripted curriculum may not be as remarkable as it seems. The basic premise of this approach is able to create harmony between scripted curriculum or conditioning and higher conceptual learning in that learning a skill that provided a foundation onto which the higher order skill would be predicated. The building of the higher skill would benefit from having a bank of hard wired knowledge that could be used for working with abstract concepts. In some instances research indicates that fully teacher directed activities can be less successful than scaffolded approaches, especially when the questions are challenging or highly complex concepts. This is the basis behind the Hunter model utilized by two of our interviewed Consultants who both are considered thought-leaders and founder of the field (Tokuhama-Espinosa, 2008). The difference between a scripted model versus a scaffolded model relates to time allotment, dynamic interaction, and progression of content. A scripted model is rigid on all accounts, while a scaffolded model is flexible and fluid (Krajcik, Soloway, Blumenfeld, & Marx, 1998). Neuroeducation supports a scaffolded model of direct instruction over a scripted model.

Interventionist versus Reformist

The 2002 OECD report on education and the brain asks the question as to how reform based on the learning sciences should move forward in the goal of impact education systems.

> The central question is whether we can create a true learning society by means of the normal processes of gradual reform, so as to adapt our existing models and patterns of provisions to meet the needs of the new century, or whether we need to think rather in terms of replacing them with something distinctly different (OECD, 2002, p.25).

In a similar manner, the interview participants supported a model of neuroeducation for educational reform on a continuum of change. The measure of change ranged from "tweaking" the curriculum to be more aligned with knowledge from the learning sciences, to overhauling a traditional classroom approach in order to create something completely new. A number of comments regarded the creation of interventions that represented small changes for specific groups. It was thought that neuroscience providing important information for creating interventions, in particular for students with special needs. This was also something that was associated with the medical model approach, which had been so derided in relationship to scripted curriculum. Again this points to the range of opinion in how our knowledge from the neuro and cognitive science will find their best application towards building a curriculum.

> One of the things you have to realize is that where the applications are going to be instituted first is probably in the area of special education. Special education is the closest thing that education has to medical problems, so they are kind of the equivalent of the medical problem. (P3)

FastForWord was one such intervention seen by several participants as being the best example that has been developed directly from the neuroscience. On the other hand, not all participants saw FastForWord as being a panacea for dyslexia, and there was a more general distrust by participants towards any programs that claimed to provide a quick fix for educational problems, in particular through the use of interventions, and especially computer based interventions. It was felt that interventions had their place, but that they would be meaningless if we did not change the core views of education.

> There are so many points for intervention. There are so many places where we can change the trajectory. We can't get to there until our orientation as educators is to be stewards as to how well students are participating. When we are not coming from that, when we are not coming from stewarding their participation, then we treat them like an object that we can dunk into certain buckets or we can stick into certain exercise environments. (P14)

Several participants clearly believed that nothing short of a complete overhaul would be sufficient to truly provide an approach that met their vision of what effective education required. These participants criticized the superficial nature of programs claiming to be neuroeducation, stating that the approach of simply adding on programs, or components to the traditional model, i.e. including a socio-emotional program, would do nothing to change the core structures of education that were so misaligned with what is known about the brain and learning.

> My whole sense is sometimes that I think the whole thing needs to collapse before we can ever start over again. (P9)

> I think what we have to do is not just tweak the formal education system but imagine what strong education today would look like if it were truly evidenced-based, that is the way we start our questions now, I think, is that we start by thinking about a classroom with desks in rows and then we move on from that to say how do I tweak what I already have to make it better, and I think that what we may need…a kind of overhaul where we re-think what it could look like…until we can make a really clear model that everybody can understand and that we can teach teachers then I don't think we're going to be able to solve the problem, and that is going to take an interdisciplinary effort of people who don't just try to tweak the horse and buggy, but who honest to God try to re-think what education can be for our time. (P24)

Those participants who worked in free schools felt that the public sector was too rigid at this time to even consider trying to implement effective brain-aligned curriculum in the schools. This was given as the reason that most had chosen to put their efforts into working in the independent sector.

> The problem is that they have so hamstrung their public school system even with the charter schools that it is very, very hard to do this in the public school system and so therefore the best we've been able to do is encourage people to start independent alternative charters that are on a sliding scale for tuition so that they have that cross-cultural interracial makeup, and so most of the schools that we help people start have that approach. (P18)

Other participants took the perspective of creating gradual change, and felt that there were immediate changes that could be made even in the traditional classroom structures that could help teachers adapt their existing lessons to be more brain compatible.

> My direct experience has been in more of a traditional setting. I have been in and out of, and spoken at schools all over the map. I don't have any issue one way or the other I think you can learn in any setting if the teaching-learning intersection is well designed. I don't think It has to be an inductive program or Socratic or out in the woods or anywhere in particular I think you can learn anywhere so long as it's designed well and you're engaged well. (P13)

The secret to success in these cases was that a focus was maintained by the leadership, and that gradual change could occur within the school overtime. This is consistent with the ideas from MBE as a self-learning system that deepens its own theory through documenting outcomes and making adjustments. Practice, and mentored experience were both cited as important means for developing the neuroeducator and effective classroom approaches. This type of reiteration happens at the higher level of the changing science knowledge and interplay between the scientist and the teacher in understanding these things, but also on a smaller scale within the classroom and the school itself. Programs of neuroeducation were seen as needing continued effort across many years to see effective change.

> When I see schools that focus and maintain a focus over multiple years then I see a sustained effort that can be honed adjusted and tweaked where you can see impacts at a much higher level. (P13)

> A lot of the people have the right ideas…so they might give a program for a school to use but they don't understand what level of rigor that it takes for the program to actually make the changes that you want. (P17)

> We started the first training, basically it wasn't training it was just to expose them to the principles and at first we thought, oh well this isn't going anywhere. But we have been back for 10 years every year, and they began to delve into the principles and started to shift their schools. (P9)

> I try to only get involved with schools that are having an ongoing dialogue about the brain science, but too often staff development in schools has been okay, what's the hottest buzzword for this year? They'd do the staff development plate du jour and there's no follow through. (P25)

Summary of Participant Views on Curriculum

Summarizing the views on curriculum is not easy since they represented such a wide range of opinion. Focusing on the commonalities, it is possible to create a general rubric for teachers and educational leaders hoping to advance a more brain friendly curriculum in their schools (Table 14). Six major discernible themes at which teachers can begin to work are presented as at first attempt at organizing ideas around how to better align practice with the goals and indications from MBE and the neuroscience. In addition, guidelines for principals using these same themes are provided as an important reference for moving forward in creating effective schools.

Table 14. Rubric for Teachers and Principals

	Teacher	Principal
Cognitive	Present material in an integrated manner with reference to students' pre-existing knowledge. Build a staircase of learning to build towards mastery, Use large concepts to encourage development of cognitive capacities such as critical thinking, creativity and problem solving	Hire teachers with creativity, mastery in content area, provide continuous teacher professional development in pedagogical and content teaching methods
Emotional/Social	Select content with emotional resonance, expose children to concepts such as virtues and heroes, model respect, work in groups, encourage collaboration not competition	Create a nurturing, supportive environment free from stress and competition for both teachers and students, Loop grades so teachers develop relationships
Physiological	Create a sense of safety and trust, reduce stress and encourage positive emotions, avoid giving chemical laden sugary treats, teach students about the relationship between physical health and brain function, create activities to reinforce positive physical behaviors	Provide healthy nutritious lunches and filtered water in the fountains, use natural lighting and hypoallergenic carpet to lessen harsh light and sound
Temporal	Present most challenging material when students are mentally fresh, alternate between on task and down time, use technology to provide immediate feedback	Flexible scheduling, block scheduling, appropriate teacher to student ratio
Developmental	Introduce material based on developmental research, work in the concrete in early years before moving to abstraction	Reduced academic load in early grades, use physical cues for admission into first grade
Individual	Allow student selected and student directed content, accept differences in strengths and weaknesses and work with them, allow students to follow their own interests in assignments	Loop grades so teachers know students individually, communicate about students' needs with all staff, provide flexible course selection

Neuroeducation was described by participants as more process oriented, focused on developing student cognition, and including processes of self-regulation and meta-cognition in relation to student sense of self. This is where views from neuroscience are confronted by the more esoteric ideas from psychology and the philosophy of education. Thinking of the maximization of the individual not only in terms of cognitive ability, but with respect to their role in advancing the world towards peace and social justice moves the discussion beyond neuroscience and yet may be one of the most critical outcomes of such an endeavor of education reform. Global citizenry was something suggested as a consideration in selection of content as well as development of skills like communication and collaboration, compassion and activism. Problem solving was seen as a skill needed for global citizenry, as were critical thinking and creativity. Ways of developing these skills, and ideas about what should be included in a classroom curriculum were difficult, however to define. Although promoted as the ideal, some believe we were far away from creating such a curriculum.

Axial Coding of Neuroeducation as a Core Phenomenon

One of the critical components of a grounded theory approach is visualizing the findings through the use of axial coding (Strauss & Corbin, 1990). The modeling of neuroeducation in context provides an overview for educational leaders to be able to consider and respond to the major factors important in advancing this agenda. To do this each of the major themes from the interviews is presented in relationship to a single core phenomenon. Using the concept of a curriculum of neuroeducation as the core it is possible to visualize how each of the other components revealed in the interviews influence this central phenomenon. Figure 5 shows a model of four critical factors, influencing neuroeducation including the causal conditions, intervening conditions, and action/interaction, as well as the consequences of enacting neuroeducation. The model represents the exciting new field in the entire context of what is happening in the background, as well as the active efforts of members of relevant communities.

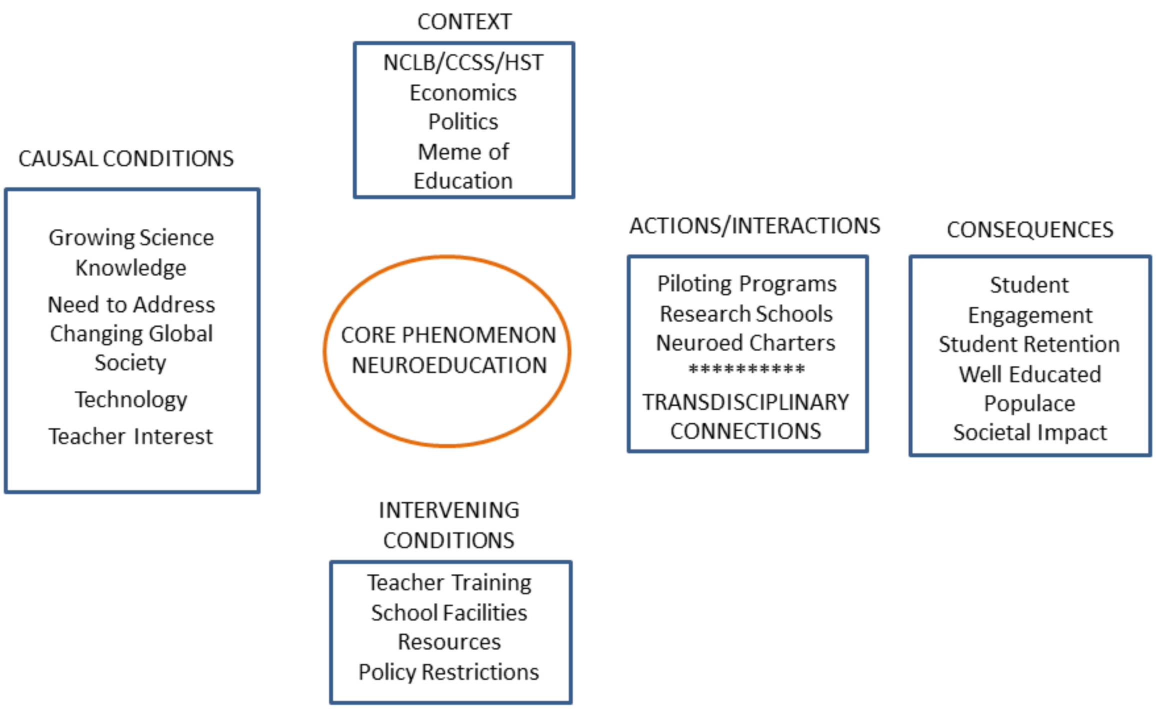

Figure 5. Axial coding of the overall interacting and intervening themes impacting the core phenomenon of neuroeducation. MBE plays the strongest role in the actions and interaction towards creating the core phenomenon, while the growing knowledge in science is one of the underlying causal conditions. Intervening conditions represted areas that need to be further developed before neuroeducation can be successfully enacted.

The causal conditions refer to those influences that are driving us toward manifesting a new curricular model in education. A large component of this causal influence is the growing body of knowledge from the sciences that hold relevance for our understanding of how we should best educate. In addition, the shifting social and political climate, in particular globalization, and the need to prepare for an unknown future, raises the stakes for a model based on developing higher order cognitive capacities. Discontent with the current policies, combined with the growing frustration of teachers, has led to a search on many fronts for alternative models that will better serve the needs of their students. Teachers, in particular, are driving this effort forward as they demonstrate their insatiability for neuroscience based products and pedagogies. Finally, the growing capacity for technology to both provide research scientists tools to address educational questions, and create educational experiences for students that were previously impossible, has contributed to the possibility of an effective program of neuroeducation expanding to a wider-scale.

The context in which this effort is taking place as discussed by the interview participants may represent the greatest challenge for the success of neuroeducation. CCSS has not even been officially enacted, and yet more than 40 states have agreed to adopt this program of reform based not on the brain sciences, but a schedule of standards and testing that will dictate curriculum. Providing opportunities for alternative models will be difficult if they are not aligned with the CCSS. The economics of educations are also tightly connected with these new mandates. The textbook and testing publishing houses have a strong vested interest in continuing on this path. Neuroeducation contests that financial interest. Dwindling budgets and misallocation of funds towards practices that drive us further away from neuroeducation will be a challenge to the field. Finally, changing the cultural views of what is education and learning, including those beliefs held by educators and administrators, is another central challenge. In order to effectively work within this challenging context of education, it will be necessary to work across a number of levels with various stake-holders, and this is happening at the level of actions/interaction in the axial coding.

Looking at the actions/interactions of the development of neuroeducation and the factors influencing its implementation in schools, this is where the majority of the “work” is being done. The piloting of programs, creation of research schools and consortiums, and the use of charters to create new schools of neuroeducation represent the means of validation of effective brain-based curriculum. In addition, the entire axial coding of Transdisciplinary Connections (Figure 4) can be placed within the actions/interactions component of the model. Transdisciplinary Connections, hence, is not just about defining the construct of MBE, but is a key component for the ongoing evolution of a program of neuroeducation. The actions/interactions in the field include within itself the means to continually transform, evaluate its own validity, and incorporate new scientific knowledge. The theme of Transdisciplinary Connections provides a means of continual renewal of knowledge through forums, collaboration and communication.

Neuroeducation is a developing model of curriculum that has the potential to transform the way we think about teaching. The most exciting part of the axial coding presented in Figure 2 is seen in the final frame, the consequences. The result or consequence of following this path represents a new vision of education. Neuroeducation provides a means of transforming students’ experiences, developing cognitive capacities such as problem solving, critical thinking, and creativity and encouraging the full development of neural systems related to emotions. This maximizing of human potential can contribute to the emergence of a generation of leaders capable of addressing problems and engaging in negotiation and collaboration. In this sense, enactment of neuroeducation lends hope not only for the success of our public education system but for the future generations of the planet.

Moving Forward towards a Proof of Concept

Advancing the cause of neuroeducation will be challenging, and one of the key aspects of this challenge will be evaluating classroom practices for their efficacy in building those cognitive capacities that were so highly regarded across interview participants such as creativity, critical thinking and social-emotional skills. This task is particularly difficult, but also critically important in order to move forward and create the necessary empirical evidence strong enough to influence the current structures and policies.

Neuroeducation must be applicable to school system facing real life challenges such as a mobile student body, untrained or poorly skilled teachers, and a vast representation of parent communities. Demonstrating the effectiveness of models across a wide range of cultural groups is what will be necessary for moving the field forward and helping to create what one participant referred to as a *proof of concept*.

> I think our job right now is to create a proof of concept, of what will work, and I think that proof of concept has to have more permeable boundaries between the classroom and informal learning opportunities and once we have what it could look like and then we can begin to ask what are the policy barriers that's would never let us implement that, does that make sense? I think we need a really clear proof of concept, I think there are some things that are demonstrating some benefits, but it's not a proof of concept if you don't know if it will work in a blown out area of South Chicago, do you know what I'm saying? If you don't know that we can really pull this off, and know that it won't work when you're not dealing with upper-middle-class kids, then you don't really have proof of concept. (P24)

CHAPTER 5: Results from Phase 2

The second phase of the dissertation aimed to answer the third research question: *How do we create a proof of concept of neuroeducation?* The approach taken here to broach this challenging question was to evaluate existing models of education for their alignment with MBE themes and impact on student outcomes. Two school models operating in the public sector were examined using both quantitative test-score data and qualitative self-initiated comments on a national parent website. Rather than using an interventionist strategy or traditional experimental design, the use of available data and a quasi-experimental design produced a naturalistic approach to the evaluation of existing models of education. Using available data further allowed for examining pedagogical approaches within the context of our current public schools. Realizing a proof of concept within the public schools, and across a diverse array of cultural backgrounds, will be an important step in validation of practices of neuroeducation. The approach taken here is one that supports the building of an empirical data base broad enough to be generalizable. It is hoped that this research can provide a replicable model for examining existing full-scale teaching models across the country. It is further hoped that the findings presented here can be used to generate relevant questions and directions for those engaged in MBE both at the level of the laboratory sciences and at the level of educational leadership.

The International Baccalaureate (IB) and the Steiner-Waldorf curricula have a number of core concepts that fit with the description of neuroeducation developed in Chapter 4. In this chapter, IB and Waldorf schools are evaluated for their alignment with neuroeducation as well as for their performance on state mandated tests. Data are presented separately as two parallel strands of research. Each strand examined both performance on standardized tests and parent perceptions of the public national Waldorf schools and IB schools in California from state and national websites.

Public Waldorf Schools in the United States

It has been more than two decades since the first public Waldorf methods school opened its doors in the high poverty urban area of Milwaukee, WI. The Milwaukee Urban Waldorf Elementary School created in 1991 was an immediate success, increasing grade level reading scores from 26% to 63% in just three years (McDermott et al., 1996). Since that time, the number of public Waldorf methods schools has continued to grow across the United States, with more than half operating in the state of California. Although Waldorf has predominantly existed in the private sector and has been called a "special philosophy for special children" (see Oberman, 2008, p. 10), on its inception Waldorf was intended to meet the needs of all types of students. In speaking to teachers, Rudolf Steiner described the Waldorf school as, "a school for all classes" with the aim of taking into "account of what is universally human." He went on to say, "In the Waldorf school what is considered is the educational principles and no difference is made in their application between a child of the proletariat and a child of the ex-Kaiser" (Steiner, 1922/1947, *Lecture 4*). Steiner also made specific recommendations as to how the school must adapt to fit sufficiently well within the existing structures of traditional schools. Thus the running of Waldorf schools in parallel with the traditional schools was both strategic and practical as Steiner stated:

> This arrangement to run parallel with the organisation of ordinary schools was an endeavour to accord our own intentions and convictions with things as they are, to make a certain harmony. For there is nothing

> unpractical about the Waldorf School, on the contrary, on every point [Waldorf education] aims at realising things which have a practical application to life. (Steiner, 1922/1947, *Lecture 4*)

Nonetheless, Waldorf schools in the milieu of modern public education face unique challenges when operating within the policy structure of standards and high stakes testing. The difficulty of this endeavor is highlighted by the recent closing of the Milwaukee Urban School. Hence, research on the potential of Waldorf to provide a holistic experience for public school children is critical if we are to protect this approach from the encroachment of rigid policies misaligned with developmental and holistic pedagogies (Nichols & Berliner, 2007; Ravitch, 2010).

Waldorf is not an add-on program to a traditional approach; rather it is structurally and functionally different from conventional public education. It is not a free school where students can decide whether to attend class or not, and it is not a democratic school where students vote on coursework and other aspects of running the school. Waldorf education follows a learner-centered pedagogy within a specific curricular framework including content suffused with texts from mythology and classical literature (Ogletree, 1975). The sequence of the curriculum across grades is set to accord with the developmental and psychological challenges of each specific age range. Teachers are trained to appreciate these specific challenges and utilize meditative practice to fully understand and meet the needs of each student in his/her classroom (Woods, Ashley & Woods, 2005).

Steiner describes his approach as being “based on educational theories founded on a real knowledge of the growing, developing human being” (Steiner, 1971, p. 15). The Waldorf curriculum moves through learning first by engaging students’ motor/action systems, then students' emotions, and finally through engaging students' knowledge and skill base. This is referred popularly to teaching to the *head, heart and hand* (Steiner, 1919/1997). Perhaps the most significant difference between Waldorf and conventional education is the structure of the school day. Rather than switching from class to class in 50 minutes blocks, the students engage in what is called the Main Lesson presented at the beginning of the school day while the afternoon is spent entirely in what some schools might consider electives: second languages, drama, painting, movement, music, and handwork. The Main Lesson contains the core of the academics and is a fully integrated presentation of a given subject. For example, when the students in 7th grade study the Renaissance, the Main Lesson includes content from history, math, science and art that can be combined in a contextual presentation. Discussions of the major figures of the time are presented as historical narratives within which cross discipline content is presented via the major discoveries of those historical figures. So for example learning about Leonardo da Vinci, students might hear how he was commissioned to draw images for the mathematician Luca Pacioli. From there the discussion of the mathematical concepts of the golden ratio could be followed by student created geometrical constructions and perspective drawing. Across the grades, the Main Lesson content follows logically and/or historically so that each year provides the foundation for the following years of schooling. All traditional subject content is addressed through the Main Lesson, and a selected topic is presented for several weeks during which students prepare a high quality artifact of their learning referred to as the Main Lesson Book. General themes and sequencing of content are defined by the Waldorf curriculum, however, the details and specific focus is left to the teacher's discretion, and can be based on the interests of the students. Completely original content is added to meet the specific needs and interests of the community as Steiner was clear that Waldorf education must be responsive to the space and time in which it would be enacted (Steiner, 1919/1966). Other central aspects of traditional Waldorf include: (1) the integration of the arts into all subjects, (2) a slower, more developmental approach to academics, (3) looping of students with a single Main Lesson teacher, (4) block scheduling in which two hours a day are spent on a single subject for several weeks, (5) two second languages starting in first grade, and (6) no text books or standardized testing (Ogletree, 1975). Modern day Waldorf schools also have rules regarding exposure to media. The incorporation of technology is delayed, with some schools not introducing computers until high school. Public Waldorf schools attempt to maintain as much of this framework as possible, but must also follow the requirements of public schools, including the administration of standardized tests.

The empirical research on Waldorf education is surprisingly limited given its nearly 100 year history. However, the available studies suggest a positive impact of Waldorf on a number of cognitive and social outcome measures. These outcomes are aligned with some of the more recent initiatives in education to promote greater creativity and critical thinking in students (*Partnership for 21 Century Skills*, 2008; Bellanca & Brandt, 2010). Waldorf has been shown to be associated with greater creativity (Ogletree, 1971), critical thinking (Gidley, 1998; Mitchell & Gerwin, 2007) and potential for engagement as global citizens (Dahlin, 2010; Oberman, 2008). Research suggests that students attending Waldorf schools show more mature social and moral impulses (Armon, 1997; Dahlin, 2010; Rivers & Soutter, 1996) as well as better social skills

(Payne, River-Bento, & Skillings, 2002) and a reduction in bullying of peers (Rivers & Soutter, 1996). Further, studies indicate that Waldorf students value lasting relationships and helping others (Mitchell & Gerwin, 2007) and have a tendency to have more long term friendships (Oberman, 2007).

Research findings on the academic outcomes of Waldorf students are scarcer. Oppenheimer (1999) reported that Waldorf graduates' SAT scores are well above the national average; however these findings are confounded by the fact that most Waldorf schools are private and parents of Waldorf students tend to be well-educated and financially stable. Studies in public Waldorf schools, although limited, indicate a positive impact of Waldorf on academic achievement (Oberman, 2008; Schieffer & Busse, 2001). Schieffer and Busse (2001) compared achievement scores on national assessments of 4th graders in the Urban Waldorf School to scores in a neighboring school with a similar demographic profile. Overall there were a greater number of students achieving higher levels of performance in the Waldorf school than in the comparison school. Oberman (2007) examined not just over all test scores, but the interaction of performance and grade level. Overall, test scores were significantly lower for Waldorf students; however, this effect was isolated to the early grades. The significantly lower second grade test-scores in her sample were replaced by superior scores by the 8th grade Waldorf students, and these standardized test scores were on par with the top ten peer-alike public schools in the state (Oberman, 2007/2008).

In an article examining parent and teacher's perceptions of the impact of Waldorf on students, Smith (1998) reported that parents felt that Waldorf education developed artistic abilities and appreciation of nature in students, as well as imagination, intuitive abilities, and a strong sense of self. There was also the belief that Waldorf contributed to academic and intellectual skills and, although less frequently cited, a responsibility to the local and global community and spiritual awareness. The study by Smith (1998) was performed in private schools. Parent perceptions of public Waldorf schools have not been formally examined, and hence the research presented here addresses this gap in the literature by examining parent's self-reported perceptions of their experiences with Waldorf using available online data.

In their extensive report on Waldorf schools in the UK, Woods, Ashley and Woods (2005) point to the fact that:

> No research was found on Steiner schools entering the public sector, nor on the process and outcomes of mutual sharing of practices between Steiner and mainstream schools. Both of these topics would benefit from systematic investigation, through action research and other methods. (p. 6)

Although the number of Waldorf schools in the public sector continues to grow, there is minimal growth in literature evaluating these schools. By examining the ways in which Waldorf schools are performing under the constraints and structure of public education, we can begin to identify the issues facing holistic and alternative approaches in general as they are implemented under the current standards driven model of education. In addition, because Waldorf employs many strategies aligned with MBE and developmental neuropsychology, examining the outcomes of this approach can assist in determining effective practice that can be employed in the public sector for a program of neuroeducation.

This strand of research compared standardized test measures of public Waldorf schools using three different data sets. The full explanation of the data sets is presented in the Methods, Chapter 3. Briefly, four data sets, three quantitative and one qualitative, were used to evaluate public Waldorf schools. Data Set A examined national public Waldorf schools against district standardized test scores for the year 2008, Data Set B examined performance on standardized testing and reporting (STAR) for California public Waldorf schools for the year 2009, and Data Set C examined longitudinal performance on the STAR for California public Waldorf schools from the years 2005-2011. Data Set D examined qualitative test scores. This strand of research looked at open-ended school comments posted from the parents, teachers, and students obtained from the third-party resource GreatSchools.org. Content analysis of parent comments from Waldorf and comparison schools were examined for multiple themes including issues surrounding holistic education and Mind, Brain and Education.

Waldorf Test Scores: Data Set A – 2008

There were several significant differences between Waldorf student performance compared to matched district scores in both reading and math. For reading, there was no significant difference for Group, $F_{(1,240)} = 1.13$. However, there was a significant effect of Grade $F_{(6,240)} = 13.93$, $p<0.0001$, as well as a Group X Grade interaction, $F_{(6,240)} = 4.65$, $p<0.001$ (Figure 6). This effect was due to an increase in reading scores progressing from the lowest to the higher grades in Waldorf-based curriculums. Fisher LSD post-hoc analysis revealed significant group differences at second ($p<0.01$) and third grade ($p<0.05$), where Waldorf methods showed significantly poorer test scores than their matched districts. For 7th and 8th grade, however, Waldorf students significantly outperformed district controls ($p<0.05$ and $p<0.01$ respectively). There were no significant Fisher LSD values for 4th, 5th or 6th grades.

For math scores, unlike reading, there was a significant main effect of Group, $F_{(1,240)} = 9.47$, $p<0.01$, but there was no significant main effect of Grade. Similar to reading, there was a significant interaction between Group X Grade, $F_{(6,240)} = 2.53$, $p<0.05$, (see Figure 6). Fisher LSD post-hoc analyses revealed significant differences between Waldorf and district scores at 3rd grade ($p<0.01$). This was due to poorer performance by Waldorf students at this grade level. No significant differences were noted at any other grade level.

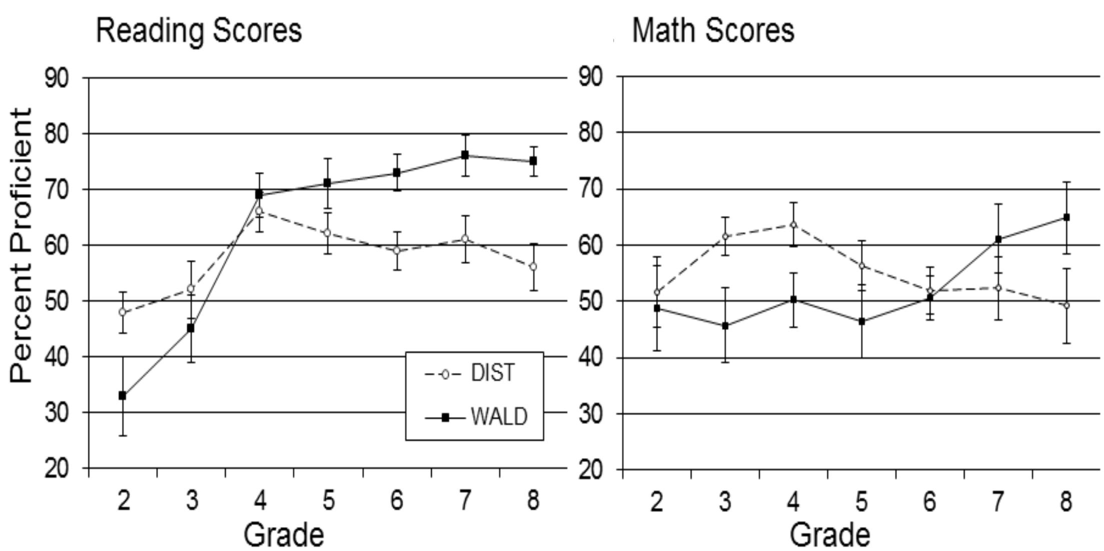

Figure 6. Waldorf curriculum was associated with poor initial performance in the early grades in reading and math this effect was reversed in the higher grades. (Error bars = SEM).

This unique pattern of nationwide public Waldorf schools was intriguing. To further support these findings a second set of data was collected to address these issues that could have potentially confounded the results. This was done by reducing the uncontrolled variables through the selection of comparison schools. The criteria for the second data set are outlined above in the Chapter 3, Methods (see Table 2).

Table 15. Demographic Information from Data Set B

Waldorf n=15 Control n=20	**Class size**	**% SES**	**Parent education**	**% Minority**	**Teacher credentials**
Waldorf	23.4	19.9	3.93	11	89.8*
Control	25.4	20.7	3.76	15.4	98.7

(* = $p<0.05$)(Parent education 1= did not grad HS; 5=completed graduate school; %Minority = %Hispanic+%African American)

Waldorf Test Scores: Data Set B – 2009

Waldorf schools in California were matched for demographic criteria (see Table 15). Five out of the 15 matches were taken from separate elementary and middle schools, the other 10 matches provided K-8th education. Demographic data were submitted to separate individual t-tests. There were no significant differences between Waldorf and matched controls on any of the measures, except teacher credentialing, where Waldorf schools were associated with fewer credentialed teachers $p<0.05$. This may have related to the credentialing requirement of Waldorf not being recognized by the public schools.

The California Department of Education website breaks down performance not only by percent proficient or above, but by far below, below, proficient, and advanced. The performance across schools was examined by comparing percent proficiency and above (proficient + advanced scores) as well as looking at students who were in the advanced range for both math and reading.

There were several significant differences between Waldorf school scores and district scores in both reading and math. For reading, there was a significant difference for Group for both those scoring proficient and above, as well as for percent advanced only, $F_{(1,198)} = 15.4$, $p<0.001$; $F_{(1,198)}$. $=6.7$, $p<0.01$, respectively. There was also a significant effect Group X Grade interaction for both proficient, $F_{(6,198)} = 12.2$, $p<0.001$ and advanced, $F_{(6,198)} = 4.0$, $p<0.001$ (Figure 7). This effect was due to poorer performance in reading and math scores in early grades shifting to better performance higher grades in Waldorf. Fisher LSD post-hoc analysis revealed significant differences between groups at second and third grade ($p<0.01$), for students above proficiency (advanced + proficient) and for second grade and third grade ($p<0.01$, $p<0.05$ respectively) for students in advanced proficiency.

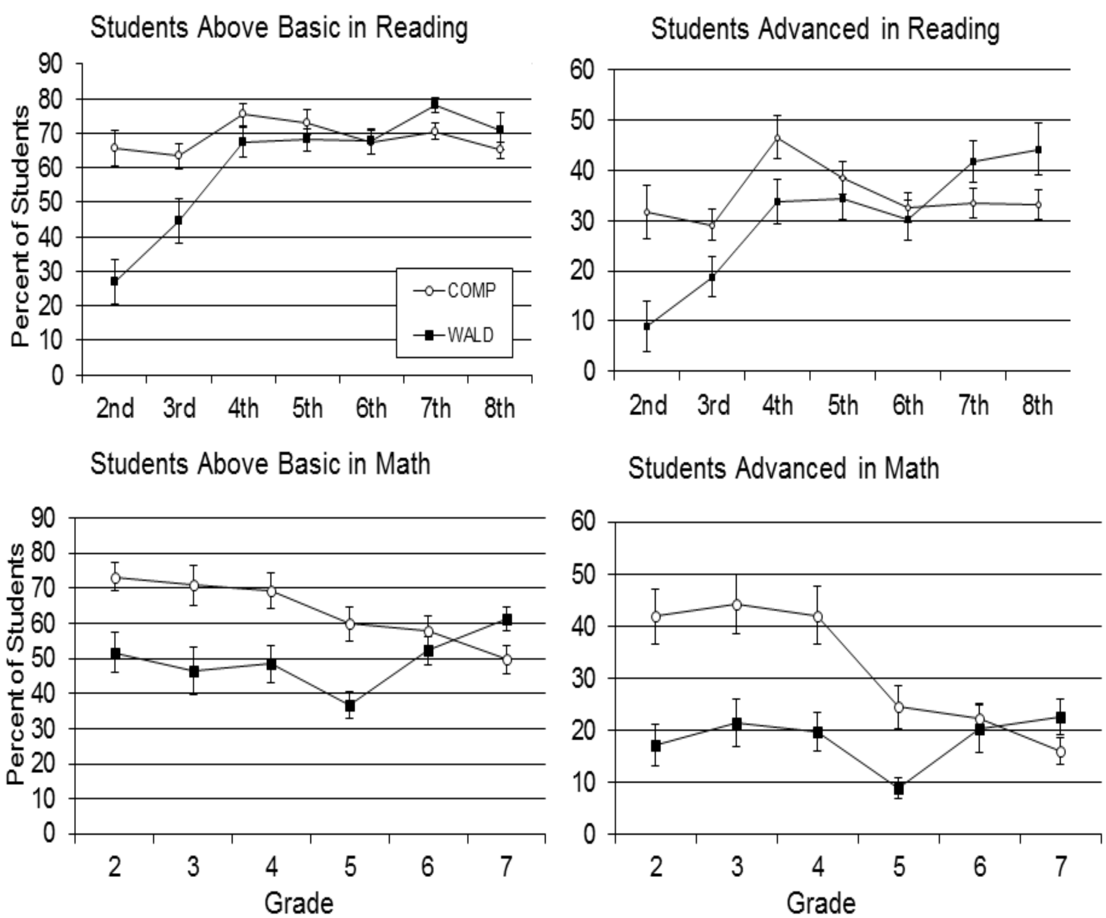

Figure 7. Waldorf public school scores versus comparison schools matched for SES. Scores are presented as those students performing at or above the proficient level and those performing at the advanced level. Waldorf students performed more poorly in early grades, but these effects were no longer present in the upper grades. (Error bars = SEM).

For math scores, for both above proficient and advanced test scores, there was a significant main effect for Group, $F_{(1,187)} = 18.7$, $p<0.001$; $F_{(1,188)}$. $=26.9$, $p<0.001$, and a Group X Grade interaction, $F_{(6,187)} = 5.7$, $p<0.001$, $F_{(6,188)} = 4.7$, $p<0.001$ (Figure 7). Fisher LSD post-hoc analysis revealed significant differences between groups in second through fifth grades for students above basic (advanced + proficient) and for students in advanced proficiency. This effect was no longer significant in 6th through 8th grade, and was reversed for math scores above proficient in Waldorf schools in 8th grade, $p<0.05$.

Waldorf Test Score: Data Set C – 2005 to 2011

Waldorf schools are unique in their continuity of education. More than simply remaining in the same school through the elementary and middle school years, the students and teacher in Waldorf are intentionally kept together through the practice of looping; i.e. instruction by a single main lesson teacher from grade one to grade eight. Data from the previous analyses of test score data indicated improved performance of students in the higher grades. However, examining cross-sectional data from a single testing year limits the assumptions regarding the growth of those same students. In order to address whether individual classes of students would demonstrate these same patterns of performance as the cross-sectional data, test scores of Waldorf school classes from grades two to grade seven corresponding to the academic school years of 2005-2011 were submitted to repeated measures within subject ANOVA. Grade eight data for mathematics were excluded due to a split in the data set for Algebra versus general math in the majority of schools.

Performance by Waldorf students from California schools were compared to schools matched for continuity of grade (i.e. combined elementary and middle school program) and the availability of test scores from 2005-2011. Because of the limited number of schools meeting these criteria, it was not possible to match on all variables known to affect standardized test scores (see Table 16). Comparison schools were chosen based on the nationally recognized GreatSchools.org rating system score. This score is based on a number of performance variables (http://www.greatschools.org/find-a-school/defining-your-ideal/2423-ratings.gs). In addition, the GreatSchools.org site provides the opportunity for parents to rate their own school. Notably, the GreatSchools.org performance measure was significantly higher in the selected comparison schools, suggesting that the schools selected for comparison were “better” schools. However, there was no difference between parent ratings on their satisfaction with the school (Table 16). There was no significant difference in the SES measure between the groups. However, there was a significantly greater number of African American and/or Latino minorities in the comparison schools. Although previous research has shown a relationship between minority students and standardized test performance, correlational analysis between percent minority and students scoring proficient or above in this sample did not indicate a negative impact of percent minority. On the contrary, using a Pearson’s bivariate correlation, California Standards Test (CST) performance measures were *positively* correlated with increasing percent minority, these included Reading scores for 2005, $r(20) = 0.514$, $p<05$; and Math scores for 2007, $r(20) = 0.575$, $p<0.01$. This reflects the nature of the schools that were selected for comparison, of which many utilized unique approaches to teaching, i.e. international schools, open classroom, positive discipline, project based learning (see Appendix F).

Table 16. Demographic Data from Data Set C

Waldorf (N=11) Comparison (N=11)	**Charter School** (y/n)	**Class Size**	**SES**	**Parent Education**	**Minority**	**Teacher Credential**	**Parent Rating**	**Great School Rating**
Waldorf	9/11	22.1	18.8	3.83	13.1	92.9	4.36	5.82
Comparison	8/11	22.2	19.4	3.55	32.9*	95.2	4.09	7.45*

(*p<0.01) (Parent rating, 1=poor, 5=excellent) (GreatSchool rating, 1=low, 10=high)

For the test score longitudinal data analysis was analyzed using separate mixed between and within factor ANOVAs for the following four categories: basic level, above basic (proficient + advanced) , below basic (below basic + far below basic), and advanced.

For reading scores above basic, there was a main effect of Time, $F_{(6,15)}=71.6$, $p<0.0005$, but no main effect of Group. This was also true for those scoring in advanced only $F_{(6,15)}=54.7$, $p<0.0005$. There was also a significant Group X Time interaction for both above basic $F_{(6,15)}=12.7$, $p<0.0005$, and advanced only $F_{(6,15)}=8.59$, $p<0.0005$. This was the result of increasing numbers of students in Waldorf education achieving higher levels of proficiency by later grades compared to no change seen in control students. In math there was no main effect for either Group or Time, for above basic and advanced only. However, there was a significant interaction, between Group X Time for both above basic $F_{(5,16)}=7.89$, $p<0.0005$ and advanced $F_{(5,16)}=7.89$, $p<0.0005$. This was due to increasing scores in later grades for Waldorf students, while matched schools advanced more slowly, or stayed the same (Figure 8). It is interesting to note, however, that these schools, selected from the top schools in the state, showed more evidence of developmental growth than the two earlier data sets (Figures 6 & 7).

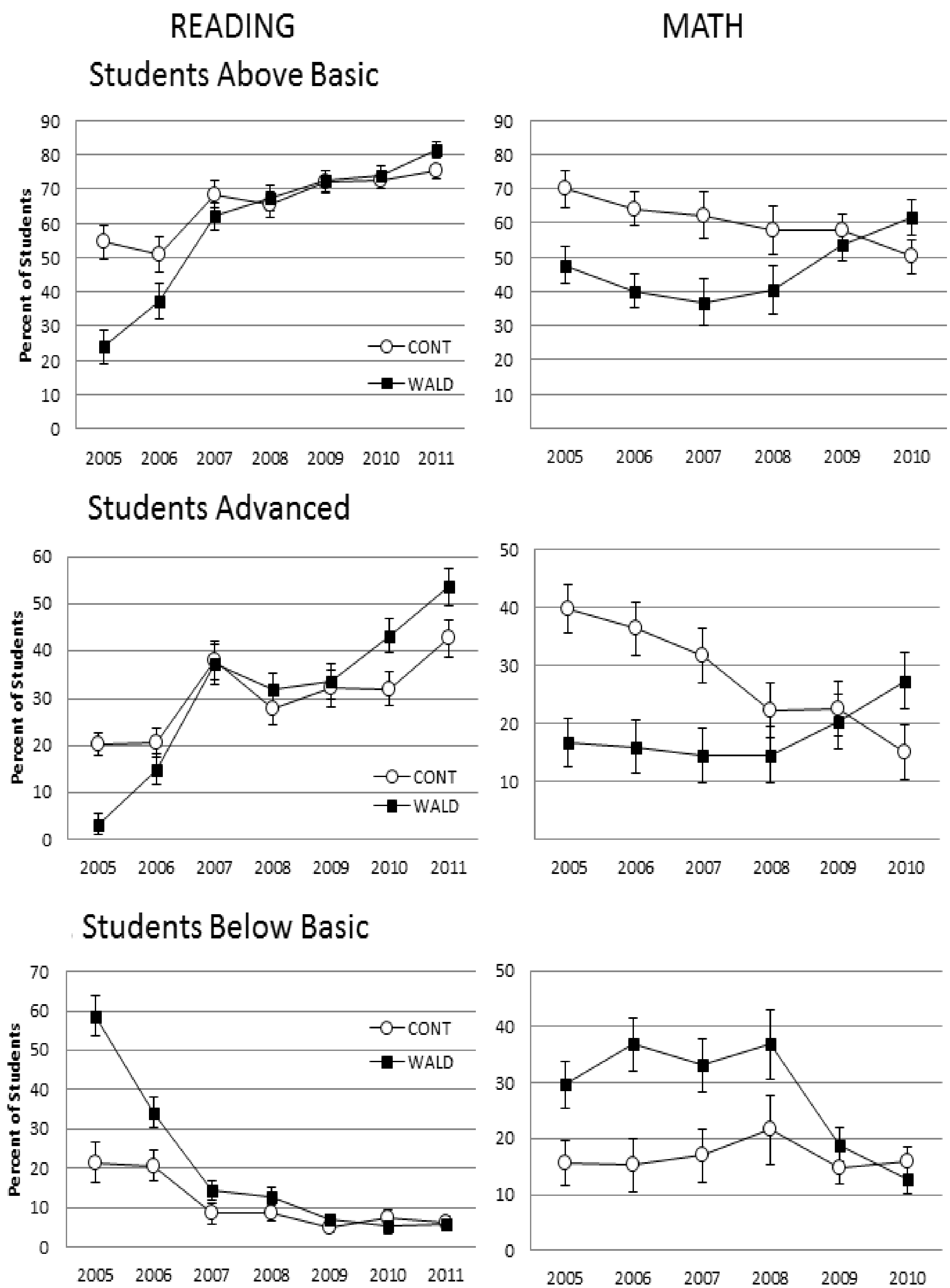

Figure 8. California Waldorf schools compared to high performing California K-8 schools. Waldorf students scored poorer in the early grades, but showed significant improvement in the later grades (Error bars = SEM)

For scores below basic the trend was reversed. Reading and math showed main effects for Group ($p<0.005$; $p<0.05$, respectively) and Time ($ps < 0.0005$). In addition, both reading and math scores below and far below basic resulted in significant interactions for Group X Time $F_{(6,15)}=14.8$, $p<0.0005$; $F_{(5,16)}=4.04$, $p<0.01$ (Figure 8). The initial repeated measures ANOVA was significant for Group X Time for above basic, advanced and for below basic. In order to examine which of the grade levels differed between the groups post-hoc analyses using independent sample t-tests were applied (Table 17).

Table 17. t-test Post-hoc Analyses of Waldorf & High Performing Schools

	READING – t-tests & p values						
t-test P-values	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade	8th Grade
ABOVE BASIC	-4.53 .00	-1.82 .08	-1.16 .26	.38 .71	.06 .95	.42 .68	2.02 .06
ADVANCED	-5.23 .00	-1.27 .22	-.14 .89	.84 .41	.27 .79	2.22 .04	1.99 .06
BELOW BASIC	5.25 .00	2.38 .03	1.75 .10	1.29 .21	1.19 .25	-.70 .49	-.33 .74

	MATH – t-tests & p values					
	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade
ABOVE BASIC	-2.94 .01	-3.42 .00	-2.86 .01	-1.77 .09	-.69 .50	1.58 .13
ADVANCED	-4.24 .00	-3.21 .00	-2.70 .01	-1.16 .26	-.32 .75	1.75 .10
BELOW BASIC	2.78 .01	3.37 .00	2.81 .01	2.14 .05	1.52 .14	-.63 .53

Note: Blue indicates poorer performance by Waldorf students, while orange indicates better performance. (Above Basic = Proficient + Advanced; Below Basic = Below + Far Below Basic)

There were several significant differences between the two groups in the early grades. All of the performance levels for reading and math show significantly poorer performance by Waldorf students in 2nd grade ($ps < 0.01$). By the 6th grade Waldorf students were no longer performing more poorly than matched schools, and for advanced students by 7th grade there was a significant difference in performance in reading, and a trend towards better performance in math ($p<0.05$, $p<0.10$, respectively). In 8th grade, both those scoring above basic and in advanced range in reading showed a trend towards better performance than non-Waldorf students ($p<0.10$).

Waldorf Parent Comments: Qualitative Data Set D

The use of qualitative data in the form of parent comments further contributed to understanding the dynamics of Waldorf in the public sector as it was perceived by parents of children attending the school. Data was coded using descriptive and *in vivo* coding. The second coding phase examined patterns of codes of Waldorf parent comments relative to parent comments generated from the comparison schools that had been utilized in the quantitative test score data. A final examination of codes and comments in relation to principles of neuroeducation is provided at the end of this section.

Results from First Coding: Hand Coding

The first coding of the parent comments utilized Waldorf school data only. This first coding sequence segregated positive and negative comments, an approach supported by quantitative content analysis when using frequency coding (Saldana, 2009; Weber, 1990). By far the majority of the comments were positive, with the emotional tones of enthusiasm, gratitude, appreciation, ownership, and pride. Approximately 10% of the codes were negative, and these had the tones of warning, insulting, sarcasm, disappointment and anger. Once positive and negative comments were separated, differences in code frequencies between the positive and negative codes provided a look at tendencies within the data. The frequency of the more common hand-codes are presented in order in Table 18.

Many of the codes corresponded to the central elements of Waldorf education. Parents appreciated the arts integration, music and handwork along with second language starting in the early grades and continuing throughout the child's education. In reference to the Waldorf approach, parents particularly liked the holistic model, and cited frequently the attention to head, heart and hand (Steiner in *Discussions with Teachers*, 1919/1971). Positive comments included an appreciation for the slow build-up to academics and the use of play in the early childhood without formally teaching reading until later. In fact there were positive comments for almost all of the aspects central to Waldorf (see Ogletree, 1975 above).

Frequency Based Content Analysis

Following analysis of hand coding, a frequency report was generated on the codes (Table 18). Looking at the pattern of codes it was possible to see the frequency of concerns as well as general attitude towards those concerns. There were distinct differences in the balance of that positive negative frequency across the codes. Looking at the percent of codes that were positive, there was a wide range of the degree of appreciation, from 100% positive (love of learning and second language) down to 14% positive (special needs). Positive themes of more than 90% were community, music and holistic education (97%), and art (91%). Four comments only, had greater numbers of negative than positive codes: leadership (45% positive), discipline (28%), slow paced (27%) and special needs (14%). Responses were examined for patterns of parent concerns and these patterns were used as a means of validating the second coding process using an autocoding proceedure. A description of the coding process is provided in the Methods, Chapter 3.

Table 18. Waldorf Hand-Coding Counts

HANDCODING WALDORF		Frequency Counts	
	% Positive	Positive	Negative
Teacher	80%	208	52
Arts	91%	171	16
Community	97%	168	6
Waldorf Curriculum	87%	78	12
Love of Learning	100%	84	0
Academics	69%	53	24
Music	97%	73	2
Parent Involvement	86%	64	10
Holistic Ed	97%	56	2
Leadership	45%	25	32
Social Development	89%	47	6
Second Language	100%	35	0
Discipline	28%	7	18
Testing	63%	10	6
Slow Pace	27%	4	11
Media	50%	4	4
Special Needs	14%	1	6
TOTAL	84%	1088	207

Teachers. The most common code for the first descriptive coding was *teachers*. Parent comments referred to teachers as caring, committed, dedicated, aware, knowledgeable, and doubly-credentialed. Teachers were seen as being sensitive and responsive to their child and respecting individual differences. Twenty percent of teacher comments were negative. Negative posts commented on poor communication, flakiness, cold, cliquish attitudes, aggressive behavior towards their child, and being brushed off. One aspect of the teacher-student relationship that was specific to Waldorf spoke to the difficulty of successfully “looping” with the child given factors such as teacher attrition and inconsistent teacher quality. Getting a good teacher was considered the luck of the draw and was deemed critically important in the quality of the education.

Art & music. The second most frequent code was *art*, and frequently cited with art was *music*. The comments about art and music were highly positive, 91% and 97% respectively. Enthusiasm for the integrated arts program was reflected in responses from every school, and could be considered evidence that public Waldorf schools have followed the integrity of the arts focus of the private Waldorf schools. Comments spoke to the importance of the arts to the students' experience, the way arts were interwoven with academic content, the benefit of art in creating enjoyment in the learning process, and most frequently, parents left general statements about how much they loved and appreciated the arts programs during this era of education when neighboring schools were cutting the arts to make time for more academics. The few negative comments revolved around the lack of quality or disorganization of the arts programs, programs being run by unqualified volunteers, the prescribed nature of the activities that did not encourage free expression, or that the schools were providing arts and crafts in lieu of real academic coursework.

Community & parent involvement. The third most common positive code was *community*. Besides having a high number of posts overall, it was also ranked as one of the highest percentages of positive responses, 97%. Waldorf parents described the community as warm, welcoming, loving, nurturing, supportive, diverse, open-minded, dynamic, active, magic, and rare in comparison to traditional public education. The community was compared to a family and thought to foster sensitivity and respect for others. Community was at times associated with the code parent involvement which was less frequently cited and percentage wise less positive, 86%. There was mention of the participation in festivals and school performances as volunteerism overlapped with community.

Although parent involvement (PI) was a decidedly positive code (86% positive), there were some negative comments associated with PI. These related to parents feeling used both financially and for services in the classroom. Parents described feeling like piggy banks, and the negative consequences for serving mandatory volunteer hours, especially for single, working parents. Parents reported feeling unappreciated and that their voice was not heard or that they were not even allowed in the classroom. On the other-hand, PI was also seen as negative when it seemed overly pervasive. Several comments mentioned parents dictating classroom activities and teachers not being in control. One comment suggested that certain parents, referred to "Waldorfites" controlled the school. Along those lines there were a very few (2 comments) extreme comments of Waldorf as being a cult, having a secretive feel, or that there was a spiritual undercurrent to the school seen as negative. Although this was an infrequent theme, it is not a trivial issue as Waldorf schools in the public sector have faced lawsuits falsely accusing the schools of being religious or engaging in occult practices (PLANS, Inc. v. Sacramento City Unified School District, Twin Ridges Elementary School District, 1998). Because of this, parent involvement and awareness of the neurobiological basis for many of the Waldorf practices should be addressed carefully though parent education. We as a society may not be ready to accept spirituality in education, even if it was non-sectarian. This was brought up by one Waldorf proponent as a potential problem for implementing Waldorf in the public sector (Ruenzel, 2001). Only time and comparison studies will give us the answers to these challenging questions.

Waldorf curriculum & holistic education. Many of the quotes surrounding the Waldorf curriculum focused on the developmental approach of teaching to the head, heart and hand. As previously mentioned in Chapter 2, the head, heart and hand sequence is aligned with some of the sequential developmental profiles from systems level neuroscience. Head, heart and hand corresponded with parental comments indicating that Waldorf curriculum represented a holistic and well-rounded approach to teaching. The Waldorf curriculum was described as being hands-on, and “enriched” including programs in handwork, gardening, word-working, music and art. Several parents contrasted Waldorf to traditional schools which were seen as “dumbing-down” their curriculum in order to focus on testing, and cutting many of the arts and enrichment. Several of the parents who were unhappy with the curriculum believed that Waldorf did not provide enough of the basic academics. And a few emphasized that Waldorf focused too much on students’ happiness and enjoyment.

> [Waldorf School] has many pros and cons. If your main interest is knowing that school will be fun place for your kids. This is a good school. There does seem to be a lot of emphasis on extracurricular activities such as knitting, gardening, field trips, painting and drawing, mixed with a bit of music. However, it is lacking in the basic curriculum in regards to reading, writing, and math. There are no text books for each child and most of the work that is handed out is hand-printed. In two years, my child has not had one spelling test nor has spelling been taught as a class in and of itself. There also seems to be a lack of clear organization and direction. I would have to honestly say that if one's priority is in learning the basic educational curriculum, then this will not be the school for you. However, if one's priority is that your child thinks that school is fun and that people are nice and, if that is good enough for you, you will more than likely like this school very much.

Examining the above comment it is clear that this parent sees little benefits to providing experiences outside of traditional academics. The belief that fun and school do not go together, and that activities such as gardening or the arts are secondary, or taking away from education, is consistent with what was discussed by interview participants as the cultural meme of education. The final sentence of the comment stating that if a "priority is that your child thinks that school is fun and that people are nice" was made in such a derisive and sarcastic manner. This comment exemplifies the distorted cultural beliefs about learning and demonstrates how our scientific knowledge surrounding positive mood, motivation, love of learning and engagement have not yet reached the parent body.

Love of learning. Many of the parents reported with enthusiasm how much their children loved the Waldorf school and felt this was the beginning of life-long learning. In fact this comment was so frequent that it ranked 5th on the list, even above academics (Table 18). Love of learning was only associated with positive comments. In particular there was the belief that through instilling a love of learning, the child would be successful in pursuing their own achievement throughout his/her life. And given that life-long learning was reported as one of the central goals of educational neuroscience based on the OECD report (OECD, 2002), it is important to recognize ways in which schools effectively connect with this goal. Sample quotes from the code love of learning are provided in the discussion of the alignment of parent comments with MBE themes.

Academics, testing & slow pace. In terms of academics 69% of codes were positive and a similar profile was seen for testing (63%). Many parents appreciated the slow build-up to academics, positive comments revolved as much around the lessened focus on academics as the quality of academics themselves.

> I choose this school after my child attended Kindergarten at a public school. I was not happy that after only one year my child hated to read. [Waldorf School] takes a much slower approach at academics and I am happy with that.
>
> It is true that [Waldorf School] takes the hard-core academic stuff more slowly (reading, writing, math) in the earlier grades, but if you look at the test scores, the [Waldorf School] kids 'catch up' to the higher rated schools by the older grades. And in the meantime, they have learned German, Suzuki violin, they've had art and music every day, Spanish twice a week, and the older kids I've met are well-rounded, delightful human beings who have developed a life-long love of learning. Class sizes are smaller, aides are in abundance, and kids are given the individual attention they need.

Negative comments around academics frequently referenced poor test scores. Although test scores also came up in positive comments, with parent praising the fact that their schools were not just about test scores, or that they did not ‘teach to the test’ as other public schools did, a number of parents were decidedly unhappy with the low test scores. With respect to the reduced academic load and holistic focus, one parent commented that Waldorf was teaching laziness and mediocrity, another that students were being taught arts-and-crafts at the expense of real learning or factual knowledge. Parents also feared that the reduced academic load would leave their child unprepared for high school or life. Parents voiced concerns that the Waldorf approach was not preparing their children for the future. In some cases the same parents who were concerned with the lack of academics stated that they appreciated the arts, and others appreciated the slow pace for the younger grades although many were decidedly unhappy with the pace in the later grades. A number of these comments were associated with decisions to take a child out for middle school due to ‘lack of rigor’ in the upper grades.

> If you want even a moderate amount of focus on academic learning and aquisition of basic language and math skills, look elsewhere, anywhere else will be better. There is absolutely no desire to teach the students anything remotely close to basic academics. To have a school in the

> middle of ___________ ranked 375 out of 381 elementary schools in [X] County is criminal. How parents can want their children to be so disadvantaged is hard to understand. And yet [X] renewed their charter. Go to the [Waldorf school] website and look for anything that relates to academic achievement. There is nothing. They do learn how to knit and compost, however.

Although the school referenced above also showed the same growth in test scores across the grades, with 8th graders performing alongside those top performing schools in California, it is clear from this parent's comment that he/she was unable to imagine that the low test scores were not a serious academic problem. Negative comments around academics and testing often reflected the testing culture of the mainstream, or the meme of education.

Leadership. Leadership was the most frequently cited code with greater negative than positive comments (45% positive). Many of these comments referred to the principal as the problem. Negative descriptions of the leadership included terms like: absent, awful, rigid, unresponsive, lack of control, dysfunctional, unqualified and unprofessional. The problems of sweeping issues under the carpet and being brushed off, or a lack follow-through on problems pointed to the failure of leadership to effectively meet parents' concerns. On the other hand, positive comments around leadership often gave considerable credit to the success of the school based on the commitment and hard work of the principal or director. Positive comments were associated with principals who were approachable, friendly and responsive.

Social development. The code of *social development* was highly positive (89%) and revolved mostly around students relationships with teachers and peers. Parents loved that students made close, often described as life-long, friends and were being given the social tools needed for their success in life. They appreciated that teachers were concerned about their children's social development as well as academic growth. Mentions of developing compassion and character development, caring and respect were terms used around social development. The negative codes focused on poor relationships between teachers or poor peer-interactions.

Second language. Second language was one of the two codes scoring with only positive comments. Codes were almost entirely enthusiastic praise for the early introduction of second languages with the presentation of two second languages as early as 1st grade. Rudolf Steiner emphasized the early introduction of languages stating, "The earlier you begin, the more easily children learn foreign languages and the better their pronunciation. Beginning at seven, the ability to learn languages decreases with age. Thus, we must begin early." (Steiner, 1966, p 79). The fact that this aspect of Waldorf continues to be enacted in the public sector is reflected in the parent comments. From the literature on the brain and second languages, we now know that bilingualism, and early second language exposure has powerful benefits on brain development. Patricia Kuhl, co-director of the Institute for Brain and Learning Sciences at the University of Washington, has shown that language learning alters the brain, and that bilingual education should be provided during critical and sensitive periods of brain development so that these cellular networks are available for the life of the individual (Kuhl, 2011).

Discipline & special needs. Discipline and special needs were decidedly negative with only 28% and 14% positive comments respectively. Parents reported bullying, poor classroom management and disruption in the classroom from behavioral issues. This was related by some as a result of the fact that their school had become a magnet for children who were misfits and had problems. At the same time, several parents felt that their Waldorf school was not equipped to work with students with special needs. More than one parent reported that the school failed to accept that their child had a learning disability, and in one case this resulted in calling in the state to intervene. On the other hand, as mentioned above, special needs were seen as prevalent, and that they drew attention away from effective programming. Positive comments related to children who had received successful interventions, or who had, through the change to Waldorf seen great strides.

> My son entered [Waldorf School] after struggling at the local middle school. Feeling as though I was constantly struggling to keep his self-esteem together, I pulled him out of the system in frustration. As parents, we KNOW what our children's potential and talents are. And I felt [the previous school] had labeled my child has a failure, and tracked him as such. A friend told me about [Waldorf School] and immediately we scheduled an interview. He started two days later, and went from an F student to an A student in two weeks. His talents, ambitions and self-esteem thrived and he made lasting friendships with his peers… At the end of the term, the resource teacher assisted my child's IEP for high school.

Media. Although media was not one of the most common codes, it deserves mention in today’s technophile society and because it is one of the pivotal points of the 21st Century Schools agenda (Partnership for 21st Century Skills, 2008). Waldorf schools take a stance that is contrary to this trend and not only delay the use of media in the classroom, also create media restrictions for home life. Parents who opposed the media policy required by most public Waldorf schools believed that the atmosphere was of a fear of technology. This was thought of as failing to prepare students for the future. Parents who appreciated the policy believed that the limiting of media encouraged students’ inner imagination and involvement in activities other than videogames or TV.

Second Coding: Auto-coding

The second coding consisted of analyzing the frequency of words using auto-codes (see Appendix H). Unlike the hand-coding where some subjective assessment of the comment will be used to assign a code, the use of auto-codes provides an unbiased analysis of word frequency. Auto-codes were selected based on the three themes that emerged through evaluation of the hand-codes, (1) *Parent-Student Relationships,* (2) *Whole Child Learning* and (3) *Academic Core* (see Chapter 3 for a list of related codes). Because both hand-codes and auto-codes were performed on the Waldorf schools, comparisons between the two allowed for internal validation of the accuracy of the chosen auto-codes. Comparing the responses in Table 18 and Table 19 one can see the similar pattern of positive and negative responses between the two methods of coding. This is true even though the hand-codes used actual counts, and the auto-codes used percent or proportional responses, something more appropriate when applying parametric statistical measures (Weber, 1990). Furthermore, the high level of concordance between the hand and auto-codes supported the validity of the selected key-words as representing the hand-coded categories (Appendix H).

Responses from Waldorf and the comparison schools indicated several similarities between the two data sets (Table 18 & 19). For example, both Waldorf and comparison schools showed the greatest overall number of responses to the codes of teachers and leadership. In addition, both had similar patterns of positive versus negative comments surrounding the themes. For leadership, there was a greater percentages of negative responding compared to positive responses for both Waldorf and comparison schools.

Factor Analysis & t-tests

The data were analyzed for alignment with the intended three themes (see above). The rotated varimax output from the fourteen variables produced a five factor model explaining 71.25% of the variance. In this model none of the variable loadings were less than 0.5, and three were greater than 0.80. The use of a factor analysis with such high explanatory value, and high factor loadings further supported this approach (Costello & Osborne, 2005). Therefore the five factor model was used to organize the table as well as to guide the interpretation of the data (see Table 19).

Table 19. Waldorf Qualitative Data Percent Positive and Negative Responses

POS (Ns= 23, 27)	Factor	Waldorf		Comparison		POSITIVE		NEGATIVE	
NEG (Ns=12, 14)	Loading	POS	NEG	POS	NEG	t-test	*P-value*	t-test	*P-value*
Factor A									
Parent Involv.	.61	6%	3%	12%	8%	-1.57	*p=0.11*	-0.72	*p=0.48*
Leadership	.68	7%	30%	17%	56%	-2.75	*p<0.01*	-1.88	*p=0.07*
Teachers	.72	43%	47%	59%	69%	-2.77	*p<0.01*	-1.55	*p=0.14*
Factor B									
Academics	.82	9%	16%	16%	24%	-1.99	*p=0.05*	-0.47	*p=0.64*
Testing	.68	4%	10%	6%	12%	-0.97	*p=0.34*	-0.11	*p=0.92*
Factor C									
Curriculum	.66	17%	21%	9%	11%	1.95	*P=0.06*	0.77	*p=0.45*
Holistic Ed	.61	10%	3%	2%	0%	3.79	*p<0.001*	1.01	*p=0.34*
Second Language	.69	7%	0%	2%	0%	2.29	*p<0.05*	NA	*NA*
Factor D									
Arts & Music	.87	29%	1%	12%	7%	3.35	*p<0.005*	1.01	*p=0.39*
Love of Learning	.83	10%	0%	3%	0%	1.63	*p=0.11*	NA	*NA*
Factor E									
Community	.51	24%	4%	14%	0%	1.85	*p=0.07*	1.00	*p=0.34*
21C Skills	.65	4%	0%	1%	2%	2.13	*p<0.05*	-0.92	*p=0.34*
DAP	.65	6%	17%	1%	0%	2.78	*p<0.01*	1.48	*p=0.17*
World Citizen	.79	6%	<1%	4%	<1%	0.98	*p=0.33*	0.40	*p=0.69*

**(light blue = significantly less frequent; light orange = significantly more frequent from Waldorf)

There were distinct differences between the Waldorf and comparison school comments with regards to the five factors. Factor A and Factor B both showed higher rates of responding by non-Waldorf schools, whereas for Factors C-E, Waldorf schools had greater rates of responding. Interestingly, these higher rates of responding were seen in both negative and positive comments, indicating the greater presence of these themes overall, and that not all members of the community were in agreement on the value of each.

Using independent t-tests, looking at differences between the frequency of responses across the 12 themes for positive and negative comments, there were several distinct significant effects that produced a clear pattern of response differences between the Waldorf and comparison schools. Table 15 shows significant differences between Waldorf and comparison schools for both significantly higher rates of responses (light orange shading), and significantly lower rates of responses (light blue shading). However, there were no significant differences for any negative comments. This might reflect the fewer number of negative comments contributing to the data set.

Unexpected Factor Loadings

There were several response patterns between Waldorf and comparison schools that were unexpected and did not fit within the initial categories of related codes. It was initially assumed that parent involvement would be related to community in *Parent-School Relationships*, however, these did not load together in the factor analysis, and community versus parent involvement showed distinct differences between Waldorf and comparison school comments with regards to factor loadings and t-test outcomes. Specifically, Waldorf schools show lower rates of responding around issues related to parent involvement, and higher rates of responding for community. In reflecting on the significant of the difference between community and parent-involvement in relation to MBE and holistic education there are some potential points of connection. Parent involvement may reflect a more structured and specific activity than community. Community invokes the feeling of family, and hence is supported by MBE through theories of evolutionary neurobiology (Geake, 2008). This difference should be further investigated with regards to effective parent engagement.

It was also initially assumed curriculum and academics would be related under the theme of *Academic Core*, however, the factor analysis grouped these separately and again, there was a distinct difference between Waldorf and compariaon schools. Waldorf school comments were higher for the term curriculum, while the term academics was more often seen in non-Waldorf school comments. The difference between what is signified by a curriculum versus academics can be interpreted through the lens of MBE as having a more content directed focus versus a more global framework and should be investigated further for this reason.

Waldorf School Comments & the Major Themes of Neuroeducation

In order to further examine the relationship between Waldorf and the principles of neuroeducation, comments made by parents were examined for themes and codes that corresponded to what had been generated in the interviews with academics and educational leaders. There were a number of codes and themes already mentioned, such as the arts and twenty-first century skills. This section provides quotes from parents to demonstrate the rich data set provided from the use of data mined in this manner.

Comments were selected as typical and best examples, and to show how often the concepts from neuroeducation appeared together in single comments.

Brain-based education. Although brain-based education was a term to be avoided according to academics, there was not this same level of aversion to the term from some of those in administration, and it still has a strong foothold in the lay community. There were several comments that addressed the fact that parents felt the Waldorf approach benefited brain development, and in fact several pointed to aspects of teaching to both sides of the brain, something that has been called a neuromyth by the academic community.

> The school helps kids to balance their right and left sides of their brains, using creative arts to enhance the teaching of academics.
>
> Education that uses BOTH right and left sides of the brain. What more could you ask for!
>
> [Waldorf School] does indeed offer a rich curriculum that is based upon the developmental needs of the child. They do indeed learn handwork, which has a specific role in brain development.
>
> While we know this education is great for enhancing neural connections in the brain, we love that our kids receive the ingredients of a meaningful human experience.
>
> Small supportive community. Whole brain, body approach to teaching.
>
> Well rounded in regards to arts and holistic learning, which is best for a child's brain chemistry and development of neurological pathways."
>
> Being a student of cognitive science, I'm continually amazed by how well the faculty know how to use the best research about how young people learn. Did you know that vestibular development and proprioception are essential to developing spatial-temporal reasoning needed for higher level math (think Trig here)? My son's teacher does. Art is emphasized, since it's a form of higher level thinking, Knitting helps to develop neural pathways across the corpus callosum. To understand what makes this school amazing, you need to be willing to look a little deeper. [Waldorf School] favors the long term payoff over the quick fix.

There were also examples of parents discussing teaching to different learning styles, and multiple intelligences. Both theories that were part of the brain-based research movement.

> They use multiple teaching views in order to tap into everyone's ability to learn.
>
> All of the children are reached by the use of the multiple inteligences in the classroom.

The fact that so many parents referred to the brain sciences, specifically mentioning building of neural connections supports the notion that parents of Waldorf students are aware of the value of an approach aligned with brain development. Whether this awareness led parents to this approach is an area worth investigating as a means of helping to shift the meme of education and advance the cause of neuroeducation.

Social-emotional development. Parents of Waldorf student spoke frequently about the fact that their student’s school provided an environment that nurtured their social and emotional development and wellbeing.

> [Waldorf School] takes a developmentally appropriate approach to its curriculum. The teachers, staff and parents are there to guide the development of the child in a healthy and supportive way. By first nurturing a child's social and emotional being, the child will be more ready to grasp and integrate the academics as they grow.
>
> The teachers and the school philosophy look at how a child develops, physically, emotionally, mentally and bases the teaching curriculum and style on that, so that a child's success is maximized.
>
> If you want your child to be cared for and loved then this is the school for you. School cares equally that children develop physically, emotionally, and academically.
>
> Great perspective on the balance of academic and emotional intelligence.
>
> This is a wonderful, nurturing school. They are as concerned with the personal and emotional development of the child as they are with the educational development. A very full, well rounded approach to education.

There were many other comments that suggested the way social and emotional development were encouraged, for example through nurturing, and respecting and honoring students. Perhaps even more interesting than social emotional development as a component of the Waldorf approach, was the fact that parents spoke to an effect of this experience with respect to student outcomes.

> I find Waldorf children to be confident, outspoken and very fluent. They never move their eyes down when you speak to them. They are treated with respect by their teachers and that shows in the way the children respond. They beam with the confidence that they can and will make the world a beautiful place.

> I look to the small, but impressive group of [Waldorf School] grads who have gone on to various high schools and rigorous universities with much success. In these children and my own, I see the unbridaled creativity, optimism and concern for others that this world needs most.

The emotional development of the child is a core component of both neuroeducation and the Waldorf curriculum. These parent comments support the notion that public Waldorf schools are engaging in this aspect of the Waldorf pedagogy.

21st century skills. Codes for critical thinking and creativity were given the title 21st Century Skills. Many parents felt the Waldorf curriculum was effective in developing these skills, a necessary component for student in this rapidly changing world. Furthermore, there was the repeated mention that this focus on 21st Century Skills was unique, and that the traditional school models were not engaging students in building these capacities of critical thinking, problem solving and creativity.

> Most schools teach a child WHAT to think, [Waldorf School] teaches a child how to think. These are skill sets that help a child thrive in a changing world.

> This school is one of the few in __________ County that actually prepares students with the 21st Century learning skills that other schools can't cram into their day because parents are screaming for sky-high test scores in

> 2nd grade. My children attended [Waldorf School] and are now well-rounded high school honor students.
>
> [Waldorf School] provides an amazing education to children, fostering their independence and critical thinking, in an alternative and nurturing environment. Kids who graduate from this school excel at an unusually high rate.
>
> [Waldorf School] provides my son with an environment that provides all the ingredients necessary to nurture his love of learning and inspire his creativity and development of character every day.
>
> [Waldorf School] teaches students to think critically, express themselves articulately, and consider complex issues with compassion and sensitivity. What School X does best is what our world needs most.
>
> Compared to the public school district schools, [Waldorf School] and its emphasis on Waldorf methods is the choice between a McDonald's hamburger and a creative five course organic meal! This school has retained an innovative staff, backed by outgoing and caring parents, within a academic Waldorf framework that focuses on creativity rather than only memorizing information.

Development & individual differences. Development and Individual Differences was one of the top themes on the subject of students and curriculum, and had the greatest number of count of any other student issue for both Block 1 and Block 3 (see Table 9). It is therefore not surprising that parents of Waldorf student highly appreciated the respect and attention given to the developmental and individual needs of their children.

> Even though class sizes are in the low 30's, my child has been taught individually to meet his needs. The teacher takes just a few moments to meet his specific needs and he functions highly. In the public school system I was demanding my child be tested because he was always behind and kept in at every recess and would cry that he didn't want to go to school anymore.
>
> [Waldorf School] emphasis on the needs of the individual that provides a non-threatening, non-stressful environment for the children
>
> Curriculum is shaped by the teachers themselves according to the developmental needs of the children at each particular age.”

> [Waldorf School]'s emphasis on the needs of the individual that provides a non-threatening, non-stressful environment for the children"
>
> The teachers and staff offer a truly caring and supportive environment that is developmentally appropriate and appreciates the individual child.
>
> Academically both challenging and encouraging, as a community we work together to educate our children in a format that is more well-rounded than what is available in public schools and in a system that is open-minded to the natural differences between individuals.

There were so many quotes that could be applied from Development and Individual Differences that is was necessary to be selective here. The ones presented above are typical. In some cases, individual quotes seemed to encompass all of the major themes from the neuroeducation model. Below are two examples, note that there are alignments with neuroeducation in nearly every sentence.

> I have seen my two nieces thrive under a program that encourages individuality and creative growth as well as academic fundamentals. The school appears to take pride in cultivating a child's natural abilities, strengths and interests. At the same time [Waldorf School] teaches its pupils well balanced social interaction while integrating such important qualities as courtesy, respect and discipline. This school exemplifies a wonderful mix of life skills.
>
> [Waldorf School] provides a beautiful environment for learning while fostering your child's imagination and natural potential. Emphasis on nature, rhythm, creativity, character and kindness are all part of the daily routine. Your child is revered as an individual and not seen as a "kid" that needs to be controlled which allows your child's spirit to soar!"

Arts. Art, mentioned previously as one of the most frequent codes, also represents one of the themes that emerged from the conversation with academics in MBE and educational neuroscience. Parents reported that the use of an integrated arts curriculum acted to enhance learning of core curriculum and increase the enjoyment of learning, something that had been promoted in the interviews with academics as an important value of applying the arts in education.

> All the learning is done through art and songs and stories.

> [Waldorf School] honors the children, art, music, teaching the children that learning is fun, and they can learn anything they put their minds to.

> I think every child can benefit from the 'love of learning' being taught here. Each child is given the opportunity to explore so many different aspects of art that they are bound to find something that moves their spirit and speaks to their hearts.

> This curriculum integrates body mind and soul thru a dynamic interplay of arts, music and didactic learning.

> Music and art are woven throughout every day's lessons, which is rare in public schools these days.

Play. The importance of play in learning has been a professional scientific study for more than 3 decades. Animal research points to the benefits of play in social behaviors, and even supports the role of play in increasing activity and connectivity in those regions of the social-emotional brain systems that are indicated is cooperative and possibly moral behaviors (Churchland, 2011). Parents of Waldorf students loved the play program, and several of them equated play with learning. There was the belief that resonated with what had been stated in the academic interviews that through play we could make learning fun and create a life-long love of learning.

> I love that in Kindergarten they PLAY! For young children the best way to learn is through play.

> My son is in his second year of kindergarten at ocean charter and we are very happy with the play-based, developmental curriculum. It allows young children to be children for a little bit longer, in this hurried, goal oriented world!

> After 2 years of imaginative play, students are ready to sit at desks and the rigors of academic learning begin with reading and math- all introduced through the arts. In first grade they start Spanish and Japanese as well as handwork- which starts with knitting. The development of fine motor skills helps with their handwriting and drawing.

> I love that my daughter has such a warm, loving, and playful environment for kindergarten, with no homework! She comes home singing every day.

The extension of this concept, brought up by one of the expert interview participants, was that "playful learning" should be a central approach to teaching at all levels and ages. Waldorf parents indicated that the play and the concept of playful learning extended beyond just kindergarten in the Waldorf schools where their children attended.

> This school was very different from our local public school. It is personal, not institutional. It takes into account the child's point of view and needs. My first grader is learning Japanese, Spanish, knitting, flute, games and gets recess and free play. All the learning is done through art and songs and stories.

> I love that the school stresses the importance of play and homework is not assigned until 2nd or 3rd grade, yet test scores are among the highest of all comparative schools.

> I love how this school allows and supports children to be children - even 8th graders play.

The few negative comments about play, just as with the arts, indicated that parents felt play was somehow taking the place of academics. Parents associated play with laziness, slacking off, and lacking in work ethic.

> I like the playful, cheerful environment, but it is a lot of play and not a lot of work. If the purpose of school is to prepare our children for the future and to build the foundation for a strong work ethic and a successful career, then [Waldorf School] falls dreadfully short. The influence I see being indirectly taught to the children is that of mediocrity and laziness, which is such a shame.

This comment indicates the general beliefs of our current culture surrounding the difference between learning and play. It is suggested that to address this cultural belief (educational meme) parent outreach by both academic members of MBE community need to find outlets for publications that will better reach a broad audience. In addition, schools themselves can work to educate parents. As teachers develop greater science literacy, they will be able to find and interpret research providing parents with ample resources to increase their understanding of the benefits of play and other aspects of neuroeducation.

Public International Baccalaureate Schools in the United States

International Baccalaureate has been recognized by members of the MBE community for its alignment with the principle goals of a program of neuroeducation. As case in point, Tracey Tokuhama-Espinosa gave the opening speech at the 2011 IB conference in Geneva and.Howard Gardner is featured on the IB website (www.ibo.org/announcements/howardgardner.cfm). Created as a program of international education in 1968, IB has been particularly successful in the public sector in the past 10 years. Perhaps this relates to the way in which IB, unlike Waldorf, has been designed to follow local standards and benchmarks providing for attention to national requirements. Also unlike Waldorf schools, IB schools are not necessarily K-8 schools, although there are some that are K-8 or even K-12 IB schools in the public sector. The IB curriculum has three separate programs, the Primary Years Programme (PYP) typically serving K-5 in the U.S., the Middle Years Programme (MYP), serving 6-8, and the Diploma Programme (DP) equivalent to a U.S. high school program.

The evaluation of IB schools presented here was designed to parallel the analysis of Waldorf education; however, several modifications seemed appropriate given the unique differences between the school structures and programs. Like the analysis of Waldorf schools, IB schools were evaluated for both quantitative test score data, and parent comments. However, because IB is rarely K-8, test score data were analyzed for the PYP schools only. This was done in order to have better control in determining the school's impact on student performance. Using PYP programs for the quantitative portion of the data analysis allowed the researcher the chance to examine how students progressed in their performance from 2nd to 5th grade. Mean scale CST data were further examined for the relationship between academic performance and the length of time the school had been accredited by IB, and for growth of performance based on difference scores (see Methods, Chapter 3).

Quantitative Analysis of IB Schools in California

Within subject ANOVAs. For all categories there was a significant main effect for Subject (Reading, Math) and this was due to higher performance scores in Math than Reading across the board, all p levels <0.001 (Figure 9, 2010; Figure 10, 2011). For scores above basic, there was no main effect of year of accreditation; however, there was a trend towards significance, $F_{(1,24)}=3.0$, $p=0.09$, and there was a significant interaction between Year X Grade, $F_{(3,22)}=4.0$, $p<0.05$. This was due to overall better performance in 2011 than 2010, and this being more prominent in the upper grades. There was also a main effect of Grade, $F_{(1,24)} = 25.1$, $p<0.001$, and a significant Subject X Grade interaction $F_{(3,22)} = 39.8$, $p<0.001$. Examining these effects there are clear differences between grades in terms of performance and these tended to be specific to the subject matter. State comparison data show that these tendencies followed state averages, suggesting that it may be related to the particular content required in the separate grades producing the effects more than to the impact of IB itself (Figure 9 & Figure 10).

For scores in the advanced range there was a slightly different profile. Once again, there was a trend towards significance for Year, $F_{(1,24)}= 3.69$, $p=0.06$, however, this failed to reach significance for Year X Grade, but remained a trend, $F_{(3,22)}=2.42$, p=0.09. Unlike for above basic scores, advance scores showed a significant interaction between Year X Subject, $F_{(3,22)} = 14.2$, $p<0.005$. This was due to growth in scores in Reading in the advanced level, but no corresponding growth in Math. There was also a highest level interaction for Year X Subject X Grade, $F_{(3,22)} = 3.1$, $p<0.05$. This was due primarily to the poorer performance in 2nd graders in Math from year 2010 to 2011, while all other grades improved across both the subjects, again, with greater increases seen in Reading scores. As for the above basic scores, there was a main effect for Grade, $F_{(1,24)} = 37.1$, $p<0.001$ and a significant interaction between Grade X Subject, $F_{(3,22)} = 42.8$, $p<0.001$. Once again, IB effects for grade and subject mirrored the state data.

For data examining students scoring below basic, there was no main effect of year of accreditation and no significant interaction between Year X Subject. However, there was an effect of Year X Grade, $F_{(3,22)} = 4.2$, $p<0.05$, and this was due to decreases in students scoring in the below basic range in the 4th grade in particular in both Reading and Math. Other grade levels increased slightly, or did not change, i.e. < 1% change. For below basic scores, there was a main effect of Grade, $F_{(1,24)} = 17.8$, $p<0.001$, and a significant interaction between Grade X Subject, $F_{(3,22)} = 20.5$, $p<0.001$. Again these differences reflected the patterns of performance across the state.

Understanding these results as they related specifically to IB status was challenging. Unlike Waldorf schools, there was no obvious growth across the grades. Part of this may relate to the way in which IB is implemented within the schools, or possibly as it relates to the time that the school had been accredited in IB. In order to examine more closely possible impacts of IB on test scores, schools with IB status were divided based on the length of their IB accreditation.

Between subject ANOVAs. The majority of IB schools (60%) had been in IB status for one year or less. Whereas only 20% had IB status for 2-3 years, and the final 20% had IB status for 4-6 years. No PYP accredited schools extended beyond 6 years of IB status. IB schools were divided into four groups for the between factor ANOVA. Schools with less than 1year of IB accreditation by 2010, Schools with 1 year IB status, schools with 2-3 years IB, and schools with 4-6 years IB.

For the Mean Scale Score for the CST, there was no main effect for year of accreditation nor were there any significant interactions. There was a main effect of Subject, $F_{(1,21)}$=147.7, $p<0.001$, and also a main effect of Grade, $F_{(3,19)} = 8.9$, $p<0.005$. Furthermore, there was a significant interaction between Subject X Grade, $F_{(3,19)}$=53.1, $p<0.001$. There were no significant main effects or interactions for the between subject measure corresponding to years of IB status (Figure 8). Looking at the data, despite the lack of statistical significance, the overall means for schools having the greatest length of accreditation were higher in nearly all grades and across both subjects.

Although there were no significant effects for the between subject factor, the mean scores appeared to change in a greater positive direction for schools that had most recently entered IB (i.e. New, or 1 Year IB). In order to look more closely at this change in performance over time, data were transformed into difference scores created through subtracting the score for each cell from year 2011 minus year 2010. These transformed data were submitted to separate between subject ANOVAs using the four categories of length of IB accreditation as the between factor.

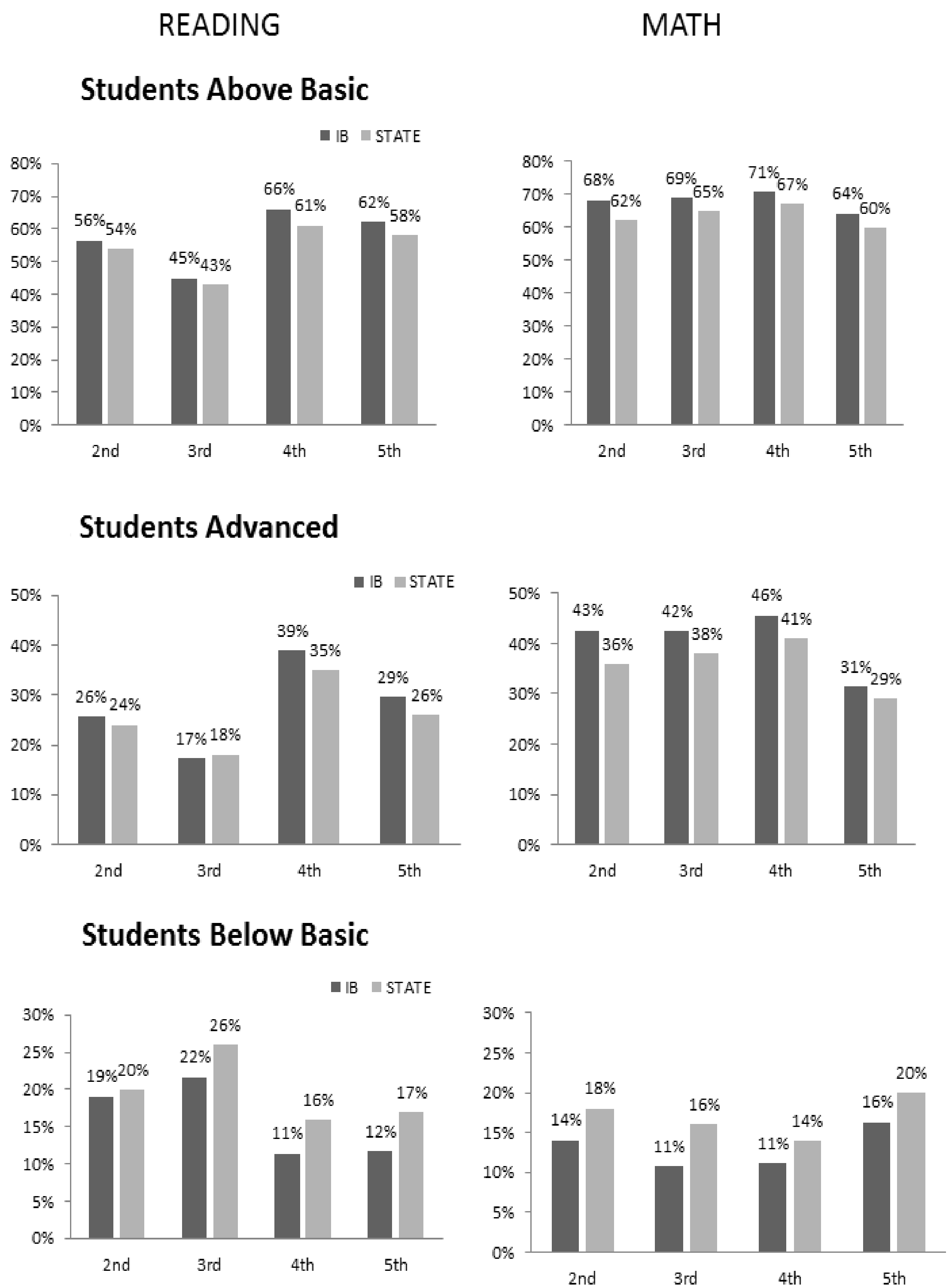

Figure 9. Performance of California public IB PYP schools for the 2009-2010 school year. State scores are presented for comparison.

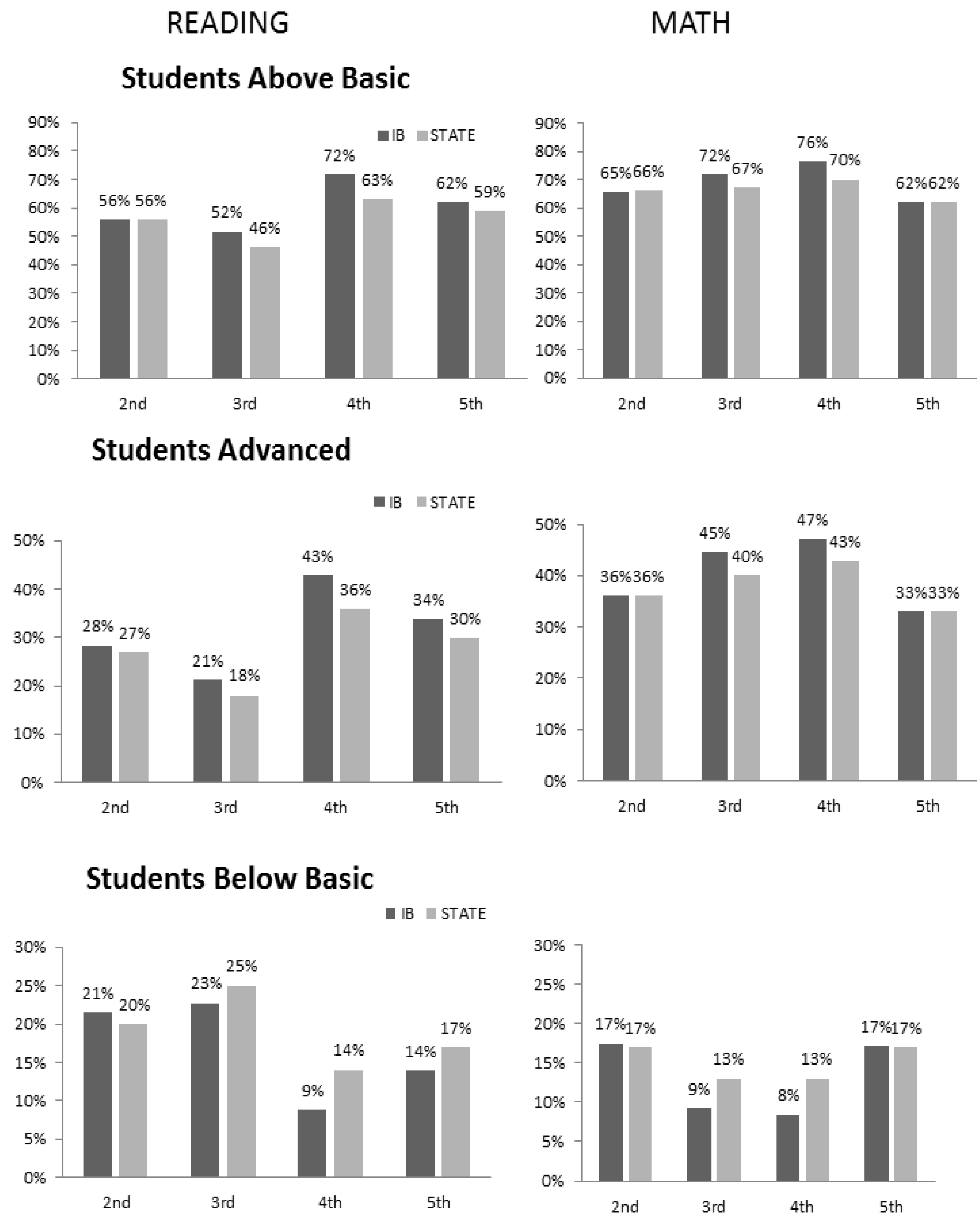

Figure 10. Performance of California Public IB PYP schools on CSTs for the 2010-2011 school year broken down into each performance range. State scores are presented for comparison.

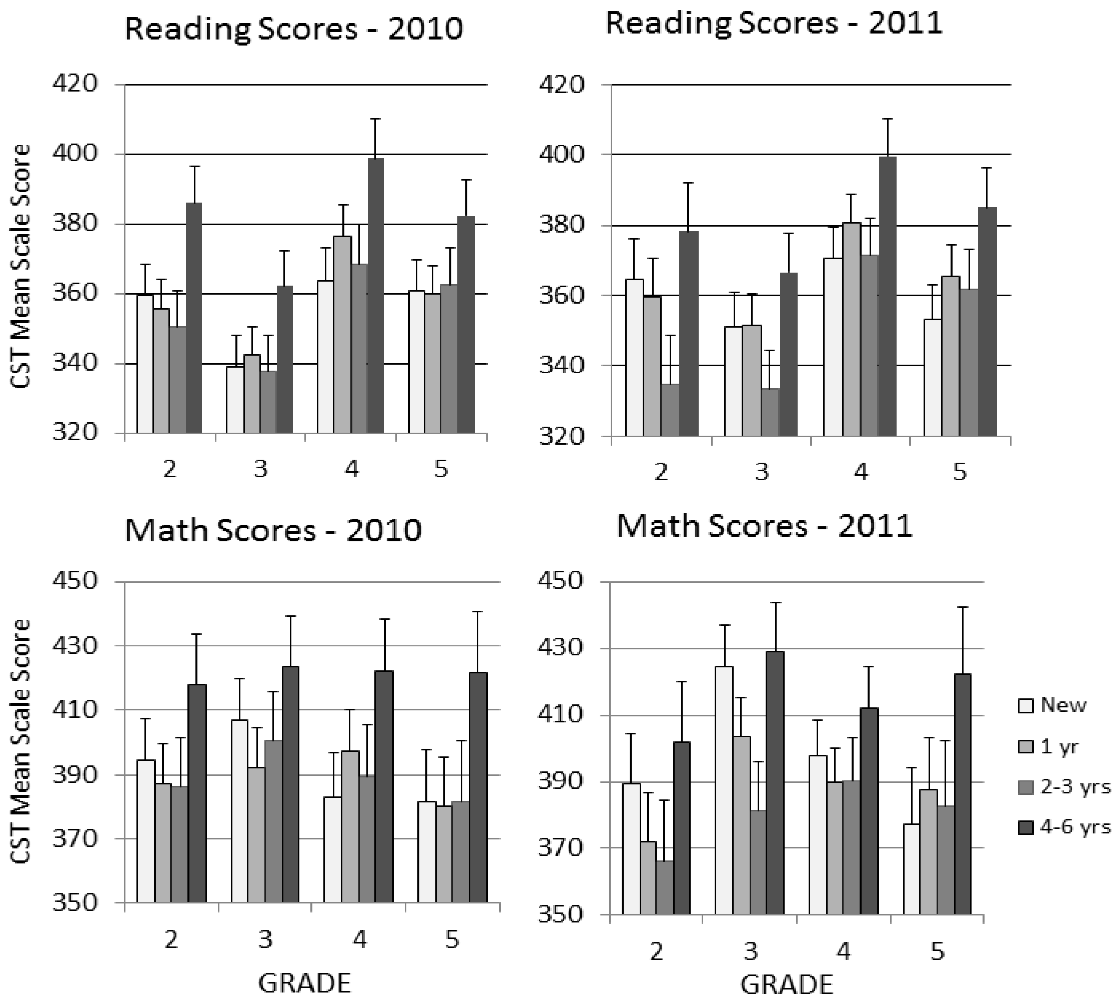

Figure 11. Cross-sectional data showing CST mean scores across 2^{nd} to 5^{th} grade. Data indicated an overall higher level of performance with the greatest number of years of certification. Interestingly, new schools showed the greatest level of growth from 2010 to 2011.

There were no main effects or interactions for subject or for grade when examining difference scores, nor were there any significant between subject effects for the four groups based on years of IB status. A planned contrast did show significant differences for Reading scores between those schools that were either new to IB or had one year of IB accreditation versus schools in their 2^{nd} and 3^{rd} year of IB accreditation (Mean Difference New = 8.9, 1 year =10.5, $p<0.05$, $p<0.01$ respectively). However, this type of contrast should be regarded with caution as the overall ANOVA did reach significance (Figure 9).

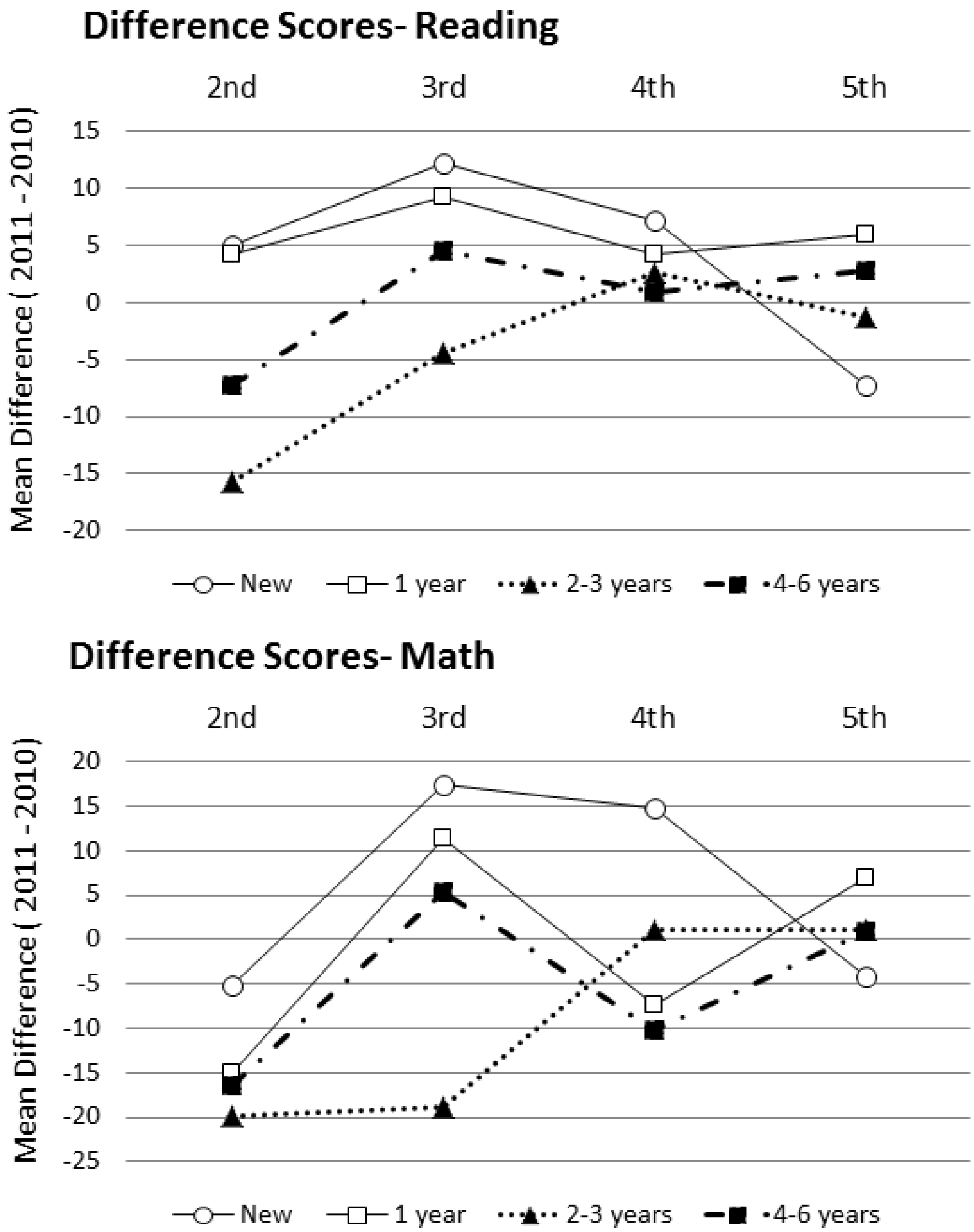

Figure 12. Difference scores for IB PYP schools CST mean scale scores based on years of accreditation. Planned Contrasts showed significantly greater improvements in reading for New schools or schools with 1 year of IB status compared to schools with 2-3 years IB status.

Qualitative Analysis of IB Schools in California

Schools with PYP and/or MYP certification before September 2011 were used for the qualitative data analysis. The qualitative data on California IB schools with PYP and/or MYP certification were obtained from the GreatSchools.org website in September, 2011. Parent comments were examined for themes as they related to parent perceptions and satisfaction with the school. All comments were hand coded by the researcher. Comments from teachers and students were not coded and hence not analyzed as part of this data set. The initial coding used *in vivo* and descriptive coding (Saldana, 2009), and themes were allowed to emerge throughout the coding process. The analysis focused primarily on pattern extraction and hypothesis building. During the coding, patterns were noted by the research and these notes were used to build a hypothesis for the analysis phase. The primary hypothesis related to the frequency of codes related to IB and MBE themes in relation to positive versus negative experiences with the school.

The coding procedure produced 829 codes that were grouped into 28 themes. The general themes were separated into positive and negative comments for the analysis. These included: academics, administration, community, communication, extracurricular/special programs, learning environment, parent involvement, students, teachers and pleased/disappointed (Table 20). Themes relating to MBE or IB were not separated based on the theoretical framing of the analysis (see Methods, Chapter 3). Overall, there were greater numbers of responses for the positive codes for each of the separate themes, with the highest percent positive occurring for comments under the theme of Community (88%). The only theme that was populated with higher counts of negative comments was Discipline with only 35% positive comments.

Table 20. IB General Themes Separated by Positive & Negative

HANDCODING	Frequency Counts		
IB	%Positive	Positive	Negative
Academics	68%	39	18
Administration	66%	102	52
Communication	52%	12	11
Community	88%	99	13
Discipline	35%	29	53
Extracurricular	78%	124	36
Environment	71%	186	75
Parent Involvement	79%	143	39
Students	85%	213	38
Teachers	81%	278	65
Pleased/Disappointed	53%	73	64
TOTAL	74%	1298	464

From these general themes a total positive score and a total negative score was generated for each school Individual schools were then examined for the extent to which the responses were positive or negative. The range of percent positive comments to negative comments extended from 12.5% positive comments in the lowest school to 100% positive comments in the highest school. These differences in the percent positive responses were used for ranking schools with respect to the degree of parent satisfaction.

Correlations. Based on observations during the coding process, a hypothesis was generated that schools with a high ranking of positive experiences would positively correlate with the frequency with which parents mentioned IB and also with emergent themes integral to implementation of IB and neuroeducation, here referred to as MBE themes. MBE themes included: 21st Century Skills, PBL, Philosophy, Curriculum, Arts Culture & Language, Holistic/DAP, Character Education, and Technology. It was further hypothesized that negative themes would negatively correlate with IB and MBE variables. In order to validate this hypothesis bivariate Pearson's correlations were used to examine these relationships.

There were no significant correlations for 21st Century Skills, Project Based Learning, Philosophy, or Technology for any of the general school themes, and therefore these data were excluded from the table for the sake of concision. Those data that did show significant correlations between the IB and MBE variables and positive and negative themes in general tended to fit the hypothesis (Table 21 & 22, positive and negative respectively). This was particularly obvious when looking at Total Positive and Total Negative comments, but was also true for the theme of Parent Involvement (both positive and negative), Student (both positive and negative), Community (positive only) and Discipline and Teachers (negative only). However, there were also several unexpected correlations, for Community, Administration, Discipline and Extracurricular. For Community, there was a positive correlation of MBE theme even when comments around Community were negative. For Administration, Discipline and Extracurricular activities, there were negative correlations with IB themes even when comments around the general themes were positive. These issues deserve greater attention, and were further investigated here through the use of factor analyses.

In addition to examining the correlations between IB and MBE themes compared to positive and negative school themes, it was deemed important to examine how the internal constructs of IB and MBE themes were related to one another. An additional correlation matrix was generated comparing the internal themes (Table 23).

Table 21. Correlations of IB & MBE Themes with Positive Codes

N=37	IB	Arts, Culture, Language	Curriculum	Holistic/DAP	Character Education
TotalPOS	.343*	.318*	.176	.356*	.374*
ACAD+	-.073	.003	-.004	-.235	-.019
ADMIN+	-.111	.074	-.126	-.085	-.284#
Community+	.049	.405*	.035	.288#	.284#
Discipline+	-.218	-.220	-.090	.042	-.279#
Extracur+	-.379*	-.031	-.170	-.361*	-.299#
Environ+	.031	.019	-.058	.134	.080
PI+	.149	.349*	-.057	.283#	.278#
Student+	.294#	.056	.294#	.207	.287#
Teach+	.058	-.004	-.101	.108	-.088

**p<0.05, **p<0.01, #p<0.10*

Table 22. Correlations of IB & MBE Themes with Negative Codes

N=37	IB	Arts, Culture, Language	Holistic/DAP	Character Education
TotalNEG	-.343*	-.318*	-.356*	-.374*
ACAD -	-.260	-.122	-.257	-.265
ADMIN -	-.230	-.169	-.165	-.236
Community -	-.145	.542**	-.235	.332*
Discipline -	-.151	-.300#	-.402*	-.426**
Extracur -	-.111	-.128	-.050	-.160
Environ -	-.280#	-.271	-.285#	-.293#
PI -	-.244	-.334*	-.253	-.318#
Student -	-.281#	-.225	-.212	-.288#
Teach -	-.297#	-.210	-.282#	-.276#

**p<0.05, **p<0.01, #p<0.10*

Table 23. Inter-correlations of IB & MBE Themes

Variables	1	2	3	4	5	6	7	8	9
(1) 21C skills	–	.243	.604**	.347*	.207	.460**	.198	.557**	.390*
(2) IB		–	.133	-.019	-.075	-.018	.274	.309	.128
(3) PBL			–	-.032	.015	.278	.168	.396*	.402*
(4) Philosophy				–	.416*	.720**	.269	.338*	.000
(5) Arts & Culture					–	.240	-.006	.450**	.108
(6) Curriculum						–	.229	.409*	.155
(7) Holistic DAP							–	.446**	-.037
(8) Character Ed								–	.411*
(9) Technology									–

Table 23 shows a number of significant correlations across the IB and MBE themes. Character education showed the most positive correlations with the other themes, and was significant at the 0.05 level or less for all 7 of the other MBE themes. The only theme that did not significantly correlate was that of IB itself. In fact there were no significant correlations of IB with any of the other MBE themes. Perhaps this relates to the fact that IB was a title and that although a school could obtain IB accreditation, it did not mean with certainty the schoos engaged practices encouraged by MBE. This helped to support the hypothesis that the quality of the IB program would be related not just to IB status, but to the way in which it was implemented, especially with regards to the MBE themes of PBL, arts and culture, and holistic practices. The evaluation of a program of IB can be done based not only on IB accreditation, but more importantly thought evaluating the extent to which the program implements those core aspects of the philosophy and curriculum, including inquiry based instruction, PBL and character education.

Factor analysis. An exploratory factor analysis was performed to examine the relationship between MBE themes of PBL, 21st century learning, arts and culture, and IB with the positive and negative constructs (see Table 20 for the list of positive and negative constructs). In order to reduce the number of variables and increase the power of the analysis, factors were selected only if they correlated, either positively or negatively, with overall percentages of positive responses. Two primary factor analyses were conducted, one for positive comments, and another for negative comments. Each factor analysis also included MBE themes. Both the positive and negative factor analyses resulted in 7 component factors when using an eigenvalue cutoff of 1.1. Using positive comments the FA resulted in 7 components accounting for 67% of the variability. Negative comments also resulted in 7 components, accounting for slightly more of the variance (73%). MBE themes that were not divided into positive and negative comments behaved similarly in both models. Factor 1 through Factor 4 show the similar groupings for the two models (Table 24, 25). Factor 1 included Project Based Learning (PBL), Technology, 21 Century Skills, and Character Education in both models. In Factor 2, IB paired up with Holistic/Developmentally Appropriate Practice (DAP) and Character Education in both models. For Factor 3, Philosophy and Curriculum had the highest loadings in both models, and were accompanied by 21 Century Skills and Arts. For the fourth factor, Arts and Character Education were consistent across the two models, and oddly enough, Community, although it reflected positive comments in the first model and negative comments in the second model, it loaded positively for Factor 4 in both. For Factor 5 and Factor 6, there was less correspondence between the two models.

Table 24. Factor Analysis of Positive Codes for IB Schools

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
PBL .753	IB .801	Philosophy .930	PI+ .745	Testing .722	Teach+ .820	Pleased .843
Technology .731	Student+ .459	Curriculum .833	Community+ .732	DAP .491	Discipline+ .763	Academic+ .575
21C Skill .645	DAP .417	21C Skills .478	Arts .727	Environ+ .332	Environ+ .445	Admin+ .481
Character .497	Communicat+ .373	Arts .448	Character .418	PI+ .310		
Student+ .415	Character .301	Character .422				

Table 25. Factor Analysis of Negative Codes for IB Schools

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
PBL .774	DAP .653	Philosophy .899	Community- .861	Communicat- .841	Admin- .865	Academics- .881
Technology .756	IB .442	Curriculum .870	Arts .817	Student- .452	Disappoint .863	Discipline- .775
21C Skill .737	Character .412	21C Skills .387	Character .370	Teach- .300	Student- .751	Teach- .760
Character .508	Extracurricu- .336	Arts .328			Environ- .693	Environ- .492
						Extracurricu- .397

Comparing Highest & Lowest Ranking IB Schools

It was clear there was a great deal of variability in the schools with regards to the extent they were successful based on parent perceptions of their school experiences. Taking the highest and lowest ranking schools, it was then possible to examine the extent to which IB and MBE themes were related to overall positive or negative experiences as expressed by the percentage of positive to negative comments in each school. Because IB and MBE themes were not separated into positive or negative variable, it was possible to say that within a given comment on IB, or PBL, or character education, an individual comment might be either positive or negative. Independent sample t-tests showed that of the ten IB and MBE themes, eight of these did not have a single comment from the schools with the overall most negative comments (Figure 13).

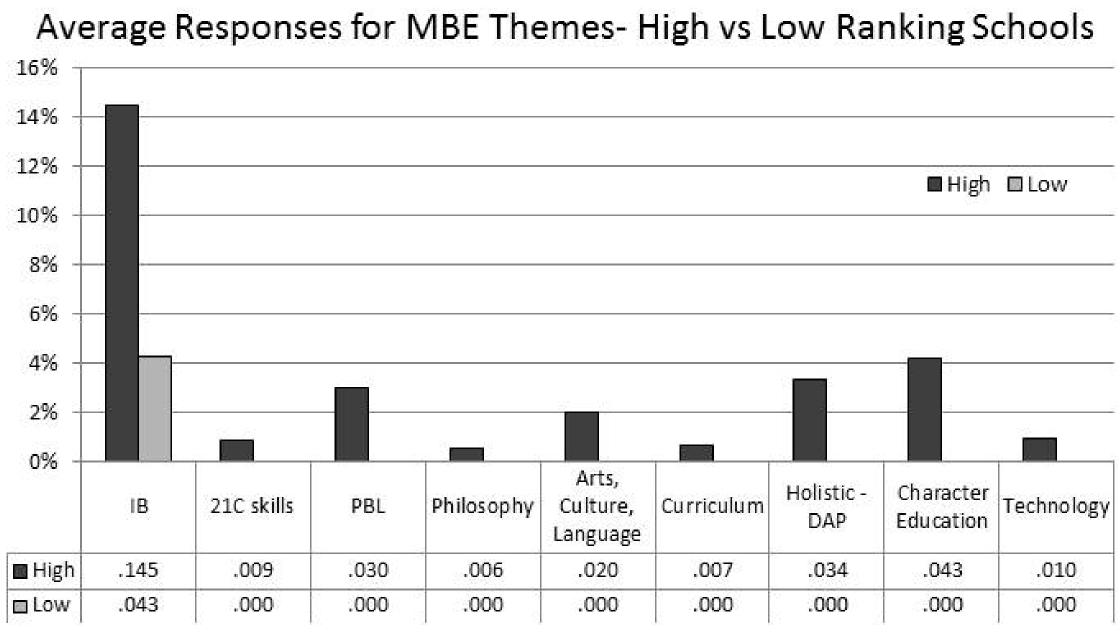

Figure 13. IB and MBE themes in the high ranking and low ranking schools. Overall schools with high rankings scored higher on IB and MBE themes. In 8 of the nine themes, low ranking schools did not have a single comment on MBE related themes.

Table 26. Demographic Data for High & Low Ranking IB Schools

IB Schools N=12	Years IB	PYP/MYP	Class size	% SES	% Minority	Parent rating	GreatSchools rating
Highest Ranking	2.3	4/2	23.7	33**	27.5**	4.5*	7.5*
Lowest Ranking	2.7	1/5	24.0	82	81.3	3.5	3.7

*p<0.05, **p<0.01

Only two of the non-segregated themes showed any comments for low ranking schools, those were IB and test scores. The t-test analysis showed that high ranking schools made significantly more comments about IB than low ranking schools t=2.72

(df= 10), p<0.05. Values from t-tests were also significant for the codes Holistic-DAP t=2.87, p<0.05, and Character Education t=2.90, p<0.05. None of the other MBE themes reached significance. Interestingly, Holistic-DAP and Character Education were the same two themes that corresponded with the IB variable in the factor analysis. Table 27 shows more closely the codes that made up the two themes.

Looking at the codes that make up these two themes, Holistic Education-DAP and Character Education it is possible to see that these are consistent theme recognized by neuroeducation. In fact, Holistic-DAP as a theme was the overarching element for the component of individual differences. This coincides with the emphasis of neuroeducation on attending to individual differences, one of the most common codes in each of the neuroeducator interview blocks, supporting the idea that IB increases the association of teaching to individual differences. The majority of comments surrounding individual differences spoke to the idea of working with the individual at multiple levels, something consistent with the early research from members of the MBE community.

Table 27. Codes for Themes Linked with IB

Holistic DAP	Character Education
Balanced approach, challenged not stressed, develops whole child, differentiated instruction, educating all students, effect of looping on relationships, holistic approach, individualized learning, lacks differentiated instruction, lacks personal attention, meet individual needs of students, multiple ways of learning, non-competitive, not about worksheets, not busy work, Not just about test scores, not just academics, not just textbooks, not like public school drones, nurturing, personal attention, slow rate of learning, teach whole child, too much pressure at young age, well rounded, well-balanced education, work with child multiple levels	Character development, character education, community service, family values, friendships, inclusiveness, making friends, personal growth, relationships, service & activism, socially accepted, socially conscious, socially responsible, students know each other, students_respect each other

For the theme Character Education, issues surrounding social-emotional development, including relationship building and social skills were a large component of this theme. Socio-emotional development was also one of the top six repeating codes across the separate blocks of interviews. The fact that IB was connected with two of the top six repeating codes generated in the interviews with academics and educational leaders is suggestive of the hypothesis that as an educational approach IB utilizes some of the most recognized principles of neuroeducation.

MBE themes were not separated out for positive versus negative responses. Indeed, there were negative comments in nearly all of the IB/MBE variables. The purpose of this line of analysis was to show that schools that were paying attention to these themes, whether they were appreciated by parents or not, were more likely to be successful in general, and that those schools that were implementing IB successfully would necessarily have some degree of responsiveness around those pedagogical aspects of the program, be they good or bad. In response to the IB curriculum and PBL even the top schools showed some negative responses as demonstrated by the examples provided below taken from the top six highest ranking schools.

> The IB cirriculum [SIC] requires a foreign language, art/drama/video prod/Int. music. all very intersting [SIC] but often a lot of extra work on top of the core classes (8 classes instead of the usual 6). Also more projects then I remember as a middle schooler.
>
> Sometimes we felt too much emphasis was placed on the fluff, and not enough on the nuts & bolts.

The point is that these comments reflect the fact that even if parents did not agree with the approach, the frequency with which parents commented on IB principles suggests that top schools are engaging in the IB curriculum. Again we are left with the situation of parent education as an important step in helping the issue of combatting the meme of education. Negative comments outline the importance of helping parents understand alternative approaches to education that may not fit within the traditional standards or traditional understanding that most have come to believe, however misguided, is the only effective way of educating.

IB in Correspondence to Neuroeducation Themes

Some of the IB themes directly corresponded to the themes generated from the interviews with academics and educational leaders. For example, 21st century skills, PBL, arts, and character education all correspond to codes and themes from the emergent curricular model based on interviews with academics and educational leaders. Quotes from various IB schools are presented here to demonstrate alignment with neuroeducation. As with the previous quotes the names of the IB school data will be eliminated and the generic [IB School] will be put in its place.

Individual differences & learning styles. Individual differences are central to a good program of neuroeducation. Several comments indicated that the public IB programs were responsive to individual ways of learning. Less was spoken of regarding differences in rates of learning as was reported in Waldorf schools, however, there was an apparent respect for students who may learn differently.

> [IB School] encourages creativity and takes into account 'all' methods of learning.
>
> They mentor each child according to his/her strengths and struggles, and help provide an excellent social atmosphere that nurtures both the kids' brains and their sensibilities.

> The teachers are amazing and offer extremely personalized attention to your student. They really take the time to know your student and challenge them.
>
> This is a large school but my daughter has received all the attention she needs from several sources. As she moved ahead of her class in math, she was given individualized work to challenge her.
>
> We had a special needs child attend this school when [Previous School] elementary refused to include him fully in a kindergarten classroom. He did need some special attention, and [IB School] provided this and more.
>
> They go out of their way to make sure that each individual student's needs are met. We couldn't be more pleased!

Universal concepts. The theme based educational approach with a focus on internationalism is a core component of the IB curriculum. In talking about theme based learning, neuroeducators discussed the importance of using large universal concepts as the framework. It was thought that through engaging in higher order thinking students could see patterns of event on a global scale.

> An [IB School] student is well rounded and is trained to think and always look 'towards the bigger picture.'
>
> Not only do my children learn about weather, they learn that it is something that is common all over the world and they study what weather does in other parts of the world. They learn not only about the American Revolution but about other country's fight against tyranny.

Project based learning. Not all comments surrounding PBL were positive, but in general, PBL was seen as a strong teaching tool that increased the ability for students to learn in a meaningful manner. This form of learning was seen as a means of increasing student self-regulation of their own learning as well as providing experiences that went beyond the traditional “sit and get” lecture to include multiple sensory modalities.

> We love that the International Baccalaureate program teaches the kids to learn through inquiry and hands-on experience.

> Beyond state scores, the project based learning has developed his ability to self- teach. This will become important as he goes into high school and beyond.

Critical thinking & inquiry based learning. Inquiry based learning was associated with a shift away from rote memorization again towards more meaningful learning experiences. In addition, the focus on global citizenship, one of the goals of IB was associated with the inquiry based teaching platform.

> [IB School] is teaching our children to be inquirers- not memorizers.

> [IB School] promotes learning and thinking. If you want Rote learning for your child this is not the school for you.

> The students are learning to be global thinkers and their critical and analytical skills are being developed through the methods of inquiry

Social-emotional development. Character education was one of the themes that corresponded significantly with a strong IB program. IB has an integrated program of character development, and this aspect of the IB program was praised by parents as increasing student wellbeing, as well as building their emotional intelligence. The building of strong personal relationships and friendships was seen as a means of increasing the students' self-esteem which in turn helped student with their academic success as is indicated by the principles of neuroeducation.

> The project-based learning in the environment of the character principles, which teach emotional intelligence, combine to create a space where my son has developed close, meaningful friendships in addition to achieving academically. From my observation, this confidence has served his growth as much as the process of finding his own questions and finding their answers has served his curiosity.

Love of learning. The love of learning is an integral aspect of what neuroeducators might call natural learning. Activating these systems of curiosity, wonder and motivation to learn through engaging students in the joyful experience of learning something new was recognized as a product of the IB schools approach to teaching.

> The International Baccalaureate program has done wonders for increasing the love of learning in our children.
>
> I have found that this school takes teaching to the level that encourages the students to want to learn.
>
> Kids leave here loving learning, loving their world -- not just churned out as achievement clones with good test scores.

Summary of Findings from Phase 2

The approach taken here in evaluating two school models using extant data is one that lends insight into the impact and experiences of various pedagogical practices. With the passing of the Charter School referendum, Initiative 1240, Washington State has become the 42nd state to embrace the charter school movement. As this movement continues to grow across the United States, the opportunity to experiment with alternative educational approaches will grow along with it. After 20 year of charter school laws, it is now time to evaluate how various models have fared across the nation. The use of extant data provides an avenue to begin this evaluation requiring little more than a computer with internet access.

Federal Title I mandates of No Child Left Behind (NCLB, 2002) have created an accountability program that relies heavily on standardized test scores. This emphasis on academic fact-based content knowledge presents challenges to alternative education, including neuroeducation. The difficulty of undertaking a program that may intentionally delay academics, or follow a different sequence and scope of curriculum than is outlined by the standards and testing involves a great deal of risk for administrators. Evaluating school outcomes in this naturalistic manner can help to support approaches that push the limits of the testing and standards frameworks through, for example, intentionally engaging students in a slower developmental approach or greater variation in content based on student interest or community cultural values.

Research indicates that parents generally base their perceptions of school quality almost entirely on student test scores (Chingos, Henderson & West, 2010; Gibbons & Silva, 2011). If we are to implement programs that focus on the arts, culture, and playful learning schools must work against the culture of competition for the highest test scores and educate parents to the purposes of a more balanced developmental approach. Parent comments provided a number of examples of the cultural misbeliefs about learning. Engaging students through alternative approaches to education and not simply providing teacher directed academics will benefit from empirical evidence support the long-term benefits of more holistic approaches.

The unique pattern of performance by students in Waldorf education on standardized tests presented here suggested a trajectory of continued improvement in both cross-sectional as well as longitudinal data. This developmental profile was not noted for IB schools. This is most likely based on the alignment of IB with state standards and testing requirements. Research on the early introduction of academics in the classroom indicates that the small initial benefits seen in the early grades are followed by long term worsening of life outcomes (Nel, 2000; Schweinhart & Weikart, 1997). It would be interesting to note whether particular IB schools may focus more heavily on development in the early grades, and whether these differences could be examined with respect to student performance in later grades. The question as to whether the delay in academics is in fact a determining factor for the positive outcome of Waldorf students is one that deserves investigation. Presently, the pressures on students and teachers to reach reading milestones early is if anything increasing. Research on demanding a student read at an early age, may in fact, have a causal relationship to acquired learning disabilities. David Boulton calls the emotional damage caused by attempting to force a child to read before they are developmentally ready, *Mind-shame* (Boulton, 2005). This is why members of the MBE community support developmentally appropriate education in numerous forms.

Moving beyond standardized test performance in assessing the quality of education this phase of the dissertation examined qualitative self-report data by parents. Themes related to neuroeducation occurred in both Waldorf and IB schools, and were associated with these approaches by parents. By comparing code frequencies in Waldorf versus non-Waldorf comparison schools patterns in responses support the idea that Waldorf schools are more holistic and that a more holistic approach is possible in a public setting in the era of accountability. For IB schools with higher frequency of parent positive comments, there was also a greater numbers of comments relating to MBE and the principles of neuroeducation. Schools with poor approval according to parents had almost no comments reflecting the use of the principles of neuroeducation. These data support the idea that qualitative data mined from publically available sources can potentially inform our understanding of the dynamic functioning of curriculum enacted within the school. Parent comments spoke of both Waldorf and IB schools as producing socially well-adjusted students able to think and solve problems of their own design. The third and final phase of the study was designed to more closely examine the social-emotional development and critical thinking in middle school students from one public Waldorf school, one IB school and one Traditional school.

Limitations of the Findings from Phase 2

There were several limitations regarding the generalizability of the findings presented here. In particular, the use of the quasi-experimental design and the source of the data make this approach somewhat unconventional, and potentially less reliable. Nonetheless, these findings can be used as a foundation for later studies using more controlled designs and are intended to be a first step in moving forward in the difficult task of evaluating pedagogical practices aligned with MBE. The major limitations to the approach taken here are discussed below.

Extant data. These studies were drawn from extant data, primarily from schools in California, and were therefore limited the generalizability of the data. True experimental designs with control groups where individual schools participate in random double blind protocols utilizing interventions are challenging, but also could be considered unethical in educational research. Attempts to control for variables, while respecting the naturalistic setting of a school is an approach that holds great promise in understanding programs aligned with neuroeducation. Laboratory schools, which are promoted by MBE (Hinton & Fischer, 2008; 2010) are another option but do not allow for examining full school models, and are limited in their ability to address culture and community due to the few available examples. The results from this phase of research show patterns of responses that are organic and part of the existing school culture. Looking at correlates in these data sets is one way to address the complexity of schools and to assist in developing experimental questions.

Parental bias. There is a need to recognize that the qualitative data collected for phase two of this research represent a unique population of participants. These represent only a few voices from the many members of the school community. Nonetheless, it is safe to say that although this group is not random, the perspectives may be more meaningful in that it required a certain degree of motivation to engage in the comment writing process. This motivation could reflect a bad experience, or it could reflect school pride and enthusiasm. There is no system of by which the leadership of the school is able to delete comments, although there is a way for abusive comments, or those not meeting the guidelines for commenting can be challenged, and removed by a greatschools.org administrator if they are deemed to not follow those guidelines (www.greatschools.org/about/guidelines.page). Another, perhaps more difficult potential bias was based on cultural differences of parents of the selected schools in their patterns of responses. Most of these schools are schools of choice, and so, for example, Waldorf parents may have shared philosophies, and a shared vocabulary that reflects less on the school itself than on the unique population of parents selecting this school for their children. QCA is not about making causal determinations; it is an approach that is able to highlight trends and tendencies within written text. The tendencies reported here lead to some interesting hypotheses that suggest possible directions for further investigation of these schools in relation to principles of neuroeducation.

QCA. An additional limitation to the approach taken here relates to the use of Quantitative Content Analysis (QCA) to determine the unique nature of parent perceptions of their schools. Traditionally QCA has been used for documents. The use of QCA in unsolicited comments from a national website represents a rather novel use of this technique. However, although this approach is still uncommon, there is a growing trend to mine data from blogs and internet sources and to use it with QCA (Berendt, 2010). As this is an unusual approach, caution should be taken in interpretation of the QCA data presented here. It should be noted that these data represent a select portion of the population of the attendees at the schools and as such should be considered supportive, but in no way conclusive. QCA is not about making causal determinations; it is rather intended to look for trends and tendencies within written text. QCA was used here to examine tendencies in responses that can be used to generate hypotheses that frame questions and may suggest possible directions for further investigation of these schools using more direct methods.

Acknowledgement of Published Material

Chapter 5 contains portions of published material appearing in *Current Issues in Education*, 2012 Larrison, A. L, Daly, A. J & VanVooren, C. The dissertation author was the primary investigator and author of this paper.

CHAPTER 6: Results from Phase 3

The final phase of research focused on three schools in the public sector and the impact of the various teaching models on measures of critical thinking and social-emotional development. The schools were selected as best examples of Waldorf and IB and the traditional model was selected as a convenience sample. The goal of this phase was to begin to look at student outcomes on measures important to neuroeducation. This is a critical piece in the puzzle for understanding whether practices of neuroeducation in fact are able to achieve their goals of developing cognitive capacities beyond just academics.

Overall the three schools represented unique student bodies. All three schools were suburban, with relative proximities to major cities. The two experimental schools (Waldorf, IB) were north of Sacramento while the comparison, Traditional school was south of Los Angeles. The experimental schools were both serving K-8 populations, while the Traditional school served grades 6 through 8. Interestingly, both the experimental schools had experienced several location changes, for the IB school the most recent move had occurred within the past year before participating in this study. On the other hand, the Traditional school had undergone a number of changes in leadership, including the hiring of a new principal who participated in this project.

Description of the Three Schools

The schools used in the case study phase are referred to throughout by their pedagogical approaches, i.e. Waldorf, IB and Traditional. Information on the schools' student body, philosophies and history were obtained from the schools websites, as well as the California Department of Education website and Greatschools.org. Further details on the philosophies of the schools were obtained through interviews with the principals/directors, and for the Waldorf and IB schools additional interviews were conducted to clarify the origins and development of the schools' pedagogies. For the Waldorf school, this consisted of two interviews, one with the principal, and one with the curriculum director. For the IB school, three interviews were conducted, one with the director of the school and two with founding parent members who were present during the adoption of IB. For the Traditional school, a single interview with the principal was given to outline the curricular models used at the school.

Waldorf school. The Waldorf school was selected based on several aspects of its formation and long presence in the public domain. The principal of the school had been a part of the program from the beginning, with a short hiatus. This principal had a deep understanding of the Waldorf curriculum, based on more than 12 years of continuous training, but also respected the structure and rules of the public schools system. He/she had taught solely in the public sector, and as a teacher had applied Waldorf the curriculum as much as possible in his/her non-Waldorf classroom prior to taking the position at the Waldorf school. The principal reported that in these previous positions there were no serious difficulties implementing Waldorf, and this was attributed in part to the fact that he/she was self-proclaimed rule-follower.

During the first year as the principal of the Waldorf school he/she acted as both teacher and administrator, but by the second year the school had added enough students to be able to employ a full-time administrator. The principal stated that the decision to work in Waldorf was based on the fact that his/her own children had been unable to attend the private Waldorf school due to cost, and that the idea of a public forum for this education was so critical to create the impetus to forego a higher salary for the sake of promoting the opportunity for a Waldorf education for all students. In his/her own words, “I had felt something…that is what it feels like to want the best thing for your child and not to be able to afford it.”

The first six years of the program were described as “pioneering” with the philosophy of “let’s just make it work”. Building the school was described as a team effort involving teachers, parents, and administration. At first, perhaps because of the hard work, teacher attrition was very high. This high-rate of teacher turnover changed when the school examined the hiring of teachers. Rather than focusing on credentialing, either in Waldorf or public education, the process of hiring became more focused on the teacher as in individual person. The goal became to find people who were creative, or open to creative work. This was done by examining whether they were a creative person in their own life in some way, while also looking for whether they were willing to work hard. Since the implementation of NCLB, hiring teachers required full certification at the state level for all teachers. Given that the majority of Waldorf certified teachers are not certified in the public sector it became ever more important that Waldorf teacher training occur once teachers were hired.

Although currently nearly all teachers were fully credentialed in Waldorf, Waldorf teacher training was not presently available through the state funding. Teacher professional development in Waldorf was paid for primarily through parent and outside contributions. Although the principal stated that the student body consisted of fifty percent students qualifying for free/reduced lunch, it was stated that 78% of parents gave to the teacher development program demonstrating a high level of parent appreciation and receptivity for this approach to education.

In terms of testing, the Waldorf school had managed to stay “above the line”, but there was some concern that this could change due to the growth of the lower grades. Given that the lower grades tended to show poorer performance on the standardized tests, it was certain that this would affect the school’s API. The coming charter renewal was greatly concerning, but there was a belief that the school would be “okay” since the school had a good relationship with the district officials. The principal emphasized that the relationship component between the school and the district was “what makes it possible in this day and age” to be able to have a program of holistic education.

The principal had found ways, working with her teaching staff, to integrate the state standards with Waldorf curriculum through finding connections between what was already being taught and what was required in the standards. The approach to meeting standards was somewhat unconventional in that the curriculum was not aligned with the standards but the standards were aligned with the curriculum. This meant that each standard was met on a different schedule and sometimes during different academic years than was indicated by the state. This resulted in difficulties when it came to performance on standardized testing, but was something that was seen as critical for maintaining the Waldorf philosophy. With regards to the common core standards, the principal felt them to be more Waldorf friendly and just as the staff at the Waldorf school studied here had worked together to find the points of connection between Waldorf and a state directed curriculum, there was a beginning effort at one of the neighboring public Waldorf schools to provide the same guide that could be shared by all Waldorf public schools. The principal described this distribution of material as typical and reflecting of the "atmosphere of sharing" in the public Waldorf school community. The sharing of resources between schools was seen as important for the success of Waldorf in the public sector.

Parent education was important to the principal both during the initial meeting to determine if the parent would select the school and throughout the length of the child's education. Parent meetings were held regularly, and parent understanding of the program was seen important to the child's success. The biggest difficulty encountered, "the sticking point" as the principal put it, was the media policy. The Waldorf school asked that children are media free up to 3rd grade and that in the upper grades students have no media during the week unless they are doing a research project. Surprisingly, few parents took issue with the slower build up to academic learning, and the principal stated that many parents had chosen the Waldorf approach because of the slow beginning. The principal did express that parents tended to get nervous around the third grade, especially if the child was still not reading fluently. The principal pointed out that they did provide additional support in the form of interventions for students who were struggling. These interventions could occur for any struggling student, they did not need to be specified through an IEP. Nonetheless, the intervention process involved the generation of a specialized and individualized plan for the student.

School environment. The Waldorf school was visited by the researcher in mid-April 2012 on a Thursday, the day of the teacher meetings. The students in the third grade handwork class were working outdoors, and both girls and boys were knitting and talking amongst one another while sitting on a bench or on the circular walkway. The building was a mid 1950's ranch style design, with two long buildings containing the majority of classrooms, and a green space between with two with awning covered walkways that stretched the length of each building. There was a separate building which housed the business offices and the nurse's station. Across from this space was the cafeteria that had been set up for the monthly teacher's luncheon. This space appeared to serve a number of purposes, and had a full kitchen as well as a stage area. At the end of the building area there was green space that could be used for recreation. There was also a small vegetable garden around the side of business office building that looked healthy and had both flowers and vegetables growing in it. The principal suggested observing the 8th grade class. The classroom was rather full although the class had been separated for Algebra as the students of different levels were sent to different classes for math. As the Algebra lesson progressed, student worked together on problems, and the teacher moved from desk to desk checking student progress and answering questions. A few students in the back were talking and playing with what looked like objects for the circus arts, including a jester's hat. The teacher redirected the students when the conversation became loud, and the students quieted down. At the end of the math lesson, additional students entered the room and there were seat changes made by others. At this time, several students introduced themselves, and I told them I was a graduate student studying Waldorf education. Two students gave me their recently completed research papers to read. Both were high in quality, and one was exceptional and included qualitative data analysis. The teacher explained that he was going to narrate a story for a unit on the Great Depression. At some point students took out a title page for the lesson on FDR, and the teacher began to talk. As the teacher told the story, students were sketching, and working on their title page. Some of the students were focused on their drawing, while others seemed to scribble on the page, and some did not draw at all but simply listened. At the end of the story, some students continued to draw, and one crumpled up his paper and threw it in the trash. What was most interesting about this approach to teaching was that I felt the mood of the classroom change the minute the story started, and indeed, the story itself was filled with the emotional turmoil experienced by FDR as he faced a troubled nation.

Social-emotional curriculum. The Waldorf school had two programs that addressed student emotional development and self-awareness that were an addition to the traditional Waldorf curriculum. The first, the Virtues Project, was developed by members of the Bah'ai faith , Linda Kavelin Popov, Dan Popov and John Kavelin. This educational program was based on the desire to awaken those universal principles of what it meant to be the best of ourselves. The virtues were applied as a character building tool throughout the school, and had been in operation about five years. Much of the program focused on learning what each of the virtues meant and these were worked into activities which were integrated throughout the day and during assemblies or family gatherings. Ina conversation with the curriculum coordinator she described it as follows:

> The main premises of the virtues is that if you use this language, you get what you focus on, so if you talk explicitly about the virtues, specifically with children, it helps them to wake up to what is already there within them.

The second program, implemented only in the last year focused on acknowledging in students those things that were special and positive in them. The Nurtured Heart program focused on noticing and giving a lot of energy to what the students did right, and not attending or giving special attention to what the student might have done wrong.

> The teacher is really giving them what they need for their success, which is recognition. That is what they need to be successful.

Integrating the Nurtured Heart (NH) program with the Virtues Project, students might use the acknowledgment aspect of NH to describe a virtue they saw in someone else. This program not only allowed for deeper understanding of the virtue, but also for a type of objective perspective taking that has been shown to be critically important in types of critical thinking and cognitive development. Prior to implementing the NH, the principal and curriculum director had noticed some behavioral issues that they did not know how to deal with. The principal in particular believed that NH had reduced the disciplinary problems in the school, and had improved teacher-student interactions. This did not mean the teacher did not correct the student, but it would be done in a discrete manner with respect and without emotional energy.

The NH program was integrated into the Virtues Project which had been in place for several years prior. The two programs were stated to work well together,

> With the Nurtured Heart we are acknowledging children for what we see in them and we can use the language of the virtues to do that.

The curriculum coordinator believed the Nurtured Heart helped with student self-esteem and interactions with peers and had positively impacted the atmosphere of the classrooms while the principal noted that the numbers of disciplinary actions or suspensions each of which are part of his/her responsibility, had decreased significantly.

The Waldorf school was continually evolving and looking for ways to best meet the needs of its students. It respected the Waldorf curriculum, but had not become dogmatic in its approach. Interestingly, when speaking of student behavior, the principal brought up the need to allow student choice, especially in the upper grades. She described Waldorf as being highly prescribed, that is, all students get the same electives in each of the grades. Their school saw the need to allow the students in the upper grades a chance to choose their elective. They added a single choice elective once a week, and this was seen as something that greatly improved student behavioral issues. The belief was that meeting the needs of the students was the best way to deal with discipline. This ability to reflect and continually evolve should be carefully examined within the alternative school frameworks if we are to understand effective schooling.

IB school. The IB school was selected based on its history of practice, the fact that it served a population of K-8th graders, and that it had been one of the first schools in California to obtain IB status reflecting a strong history of use of critical inquiry and project based learning. The school engaged in multi-age teaching and looped teachers with student in K-1, 2-3, and 4-5 and then providing separate teachers for the middle school years. This multi-age classroom model emerged out of the initial small class size but continued as a basis of relationship building, and as a means of providing the opportunity for the older student to be the experts and assist with teaching their peers, both aspects of socio-emotional skill building.

This school started uniquely as a project based learning program that utilized “centers” rather than whole group instruction from its inception. The school emerged out of a cooperative pre-school started in the 1950s, and through parent initiative expanded gradually to become K-8. The parent body responsible for this initiative were from various career paths, but none had a primary background in education, hence the pedagogical and curricular model developed in the first years in the program were based on their experiences with the centers model of the preschool program. Seeking an effective curriculum that would work with PBL and the centers based approach, the decision was made to become an IB school. IB was brought in by the previous director of the program and was embraced by sections of the parent body. The process of obtaining IB status was described as easy. In fact, in some ways the school was recruited to IB as it was already incorporating the inquiry based approach and PBL as its central modes of instructional delivery. The director, who had been with the school during the process, described IB accreditation and then the subsequent decision to forego accreditation as follows:

> We did get IB, I think that was in 2000, and we did IB extremely fast. I think about half the time that it actually happens, because from the beginning we were very much in alignment with the IB philosophy. So when we had a director come to us and say, "look at your inquiry, look at your character ed, -what we called life skills, IB called student outcomes at the time, "they are very much in alignment, we could get you IB accreditation very quickly." So we did, and it was fantastic. We just ran through it, got our accreditation and had the accreditation for a few years, and then of course, California tanked, and there is no money, and we had to essentially ask, do we continually pay for the accreditation, or do we take the money and put it into student services.

IB was seen as adding a needed structure for the curriculum that was based in PBL and inquiry but did not provide a content structure. According to the director, what IB added was the theme based content selection and the vertical integration through structured teacher collaboration. The decision to forego further IB accreditation was not taken lightly, and in an interview with one of the founding parents, and participating board member for the school, there was some fear that by dropping IB status they would see a decline in the teaching. Both the director and the school founders believed that the

IB approach was still being utilized even without the continued oversight by the IB accreditation program.

During the development of the school, the curriculum was continually adapted and teachers and parent participants were constantly looking to improve and expand their understanding of how to teach best. One of the programs that was adopted initially was David Lazear's *Seven Ways of Knowing* (1991) which is based on Howard Gardner's theory of multiple intelligences (Gardner, 1983). The director spoke to the current search for another framework since they no longer had the IB accreditation. One possibility proposed by the director was to implement Susan Kovalik's program of Highly Effective Teaching, one of the premier programs in brain-compatible instruction, and a program that was highly regarded in the interviews with academics and educational leaders (Appendix B). Again, as with the Waldorf school, the IB school was continually evolving, an aspect of school curriculum and pedagogy that deserves further investigation with regards to understanding effective school models.

Concept based learning was seen as responsible for the success of the IB school in testing. But it was thought that other districts were afraid to copy them since they were scared to adopt a program that was seemingly so "soft", as opposed to a program that was designed to create fidelity as with scripted curriculum. With regards to scripted curriculum, the director spoke about having had a person from Saxon publishing into their school to describe such a program. The director described the disbelief of the cooperative school founders and long-time teachers as they watched the representative explain a program that, according her own admission, "could be taught by the janitor".

The director described the joint feeling of the staff in response to this program as, "How about getting professionals in the classroom and let them do their jobs?"

> I go for my program eval they will ask me the same question. "But how do you get such good scores?" And we just say, "Well, we teach them to think" If you teach them the concept of the Industrial Revolution and you ask them when did Eli Whitney develop the cotton gin, they will have a broad information base to draw on to be able to answer that question, they do not need to memorize that date. But the district I think is really scared because that's really a leap of faith, that if you don't have those text books in front of you with accommodations for English language learners, they are not going to be successful. Fear.

Teacher hiring was done in a cooperative style allowing parents of the school to participate in the decision making. It was stated that it was very infrequently that teachers left the school and the longevity of teachers contributed to the ability to build on their pedagogical program. The director described some of the teachers as being "renegades" from the public school sector, those who were seeking to do more than follow the scripted curriculum which had been adopted across the district.

Not integral to IB, but supported by IB philosophy, is the use of project based learning. Because the school used centers and PBL, IB was an appealing choice, especially when the director spoke about working with students with ADHD. His/Her belief was that the traditional school approach did not meet the needs of students with ADHD, and he/she mentioned that they often received ADHD students from other schools because the parents understood that the IB school could better meet their child's needs. On reflecting on how their program met the needs of students with ADHD, the director stated:

> I definitely think that the expectations on the ADHD kids is unrealistic in the traditional system, that they are not engaged, because we know that ADHD kids can be engaged for a long time if they are interested in the

> subject, and you can't keep their eyes on the paper if they are not. But it is also about *movement* and so we tried to have their education set up in centers, so that you have various different things to do. You're probably only spending about 20 min. on a task before you're moving to a next task, and you get some choice as to which task you want to attend to first. You get a week's worth of work. So you've got some choice as to when you are going to get this accomplished.

The centers based approach, which allowed for movement and increased student choice is consistent with themes from the model of neuroeducation. The curricular model applied by the IB school was in fact meeting a number of the goals of neuroeducation even above and beyond that which was designated by IB.

School environment. The researcher visited the IB school in April of 2012. Unfortunately, the students were on their spring break, and so it was not possible to observe a class. The director was engaged in planning, and agreed to give a tour of the facilities. The school had recently changed sites, and was attached to the back of a larger, traditional middle school program. There was a maze of doors and classroom, but in the center, there was a beautiful green space that had been created by the students. Although small, about 10' X 20', it housed a bench, and a bubbling pond around which red slider turtles sunned themselves on the rocks. In the classrooms were the IB themes with the current unit of study highlighted. In the Kindergarten/First grade, there was a large open space with a circular rug, and off to the side, several tables and child sized chairs. As an example of student directed lessons, the sharing of a story about hibernating animals had so interested the class that the teacher and students had created an area of hibernating stuffed animals, with signs saying "Shhhhh, we are hibernating". In the second/third grade there were a number of indications of engaging students emotionally. There was a "calming area" that was sectioned off. The director explained that students who had trouble controlling their behaviors could be asked, or could choose to sit in the calming area until they felt ready to rejoin the group. On a sign next to the area were several notes, “Mistakes are opportunities to learn” and “What do I need to do to calm my body down”. There was also a pie chart with a spinning arrow that had several emotions on it where the student could use to indicate how they felt. Next to the space was a Peace Table, with paper and pencils, designed to mediate student conflicts. There was a problem solving wheel with ten options on how to solve problems including, “wait and cool off”, “apologize” “talk and work it out” and “make a deal”. This was to be done by students themselves, as instructions next to the wheel stated students get an adult only if it was an *emergency*. It is interesting to note that there was also a rather large open space with a circular rug. The use of a morning circle time was part of even the higher grades, and was posted as morning meeting, and the opening activity of the 4th grade. It appeared some kind of group morning activity was applied in every grade, and in 5th grade they started each morning with 20 minutes of yoga. Because the entire school used centers, there were no rows of desks, but rather tables throughout the grades. The 8th grade the homeroom class had been converted from the science lab, so students shared, and had access to, a fully equipped lab bench. In several classrooms, there were student cubbies to keep their work, and the written work for any week was kept in binders shelved against the wall. The school shared a music room that was part of a separate building, and students had music in all grades. In the back of the building was an open green space with a large vegetable garden. This was maintained by several different grades. The ability to embrace and care for the school environment was apparent by the extent to which they had effectively built up their garden, pond, and classrooms in a single year.

Social-emotional curriculum. Although IB focuses on character development, there was an additional social-emotional component of the school curriculum that did not come from IB, Positive Discipline. Positive Discipline, developed from theories of Alfred Adler (1930), had been part of the early childhood program preceding the charter and had been the mainstay of the school philosophy since it opened as a cooperative preschool back in the 1950s. Both teachers and parents were trained in the techniques and communication tools from Positive Discipline and this training and engagement in Positive Discipline continued throughout the entire K-8 program. The IB School had a good reputation as an exemplar of Positive Discipline, and had recently considered becoming a demonstration school for the program. Positive Discipline uses the theories of learning from operant conditioning of rewarding positive behaviors. It is not, however, considered behaviorism since it utilizes an internal locus of control, and includes exercises in self-reflection and metacognition. It is focused on nurturing respect between the student and the teacher, and considers respect as originating from the appreciation for the emotional needs of the other.

Interestingly, the Nurtured Hearts program recently added to the Waldorf school participating in this case study used a similar approach by focusing on or acknowledging the good or positive points of behavior and ability, and ignoring or “not giving energy to” negative behaviors. However, NH had only just been implemented at the Waldorf School, compared to decades of experience with Positive Discipline at the IB school. The multiple programs focused on building emotional skills exemplify the strength of the school as a program that implements components of neuroeducation and worthy of investigating as a case study.

Traditional school. The Traditional school was selected based on convenience, and because it reflected the conventional model of education. This school is provided as a reference more than as an experimental control. The Traditional school, having been in program improvement (PI) for five years, was heavily focused on test scores. It served a population of 6-8th graders with a high English language learner (ELL) population. The school used several very structured/scripted curriculum programs. For the ELL students they had recently switched to using a Scholastic English/Language-Arts curriculum called *English 3-D.* It was described as providing little flexibility, and that if it were to be implemented with “fidelity” it was necessary to adhere to the curriculum guide. Teachers were trained on how to implement this program, and it was deemed to be highly effective for long term ELLs in their district. In addition to adopting scripted curriculum, the school had also moved to a small group instruction model for some of its classes, with students rotating through groups where teachers could work more closely with individual students. The mainstream core curriculum for English/LA and literature classes was provided by Holt. The pacing guide for the Holt meant that all teachers should be within one to two pages from each other. According to the principal this was seen as a solid curriculum but required fidelity to the pacing guide.

> When you have a solid curriculum, the only way to tell if that curriculum is really effective across a number of teachers is that if all of those teachers are implementing that curriculum with fidelity, you can use that as an accurate measure of not only instruction, but if the curriculum is providing the right tools for the teacher. So if it is not implemented with fidelity you can’t really measure that accurately.

The principal stated that teachers had overall been happy with the curriculum, but that in the past, when they had used a different scripted curriculum, the teachers had complained that it did not meet the needs of the students.

Asked about 21st century skills, the principal reported that the school was mostly focused on academics at this point, but mentioned that they had purchased 95 iPads to be used in the classrooms with the hopes of becoming more technologically advanced and to "move into the 21st century". Costs of both technology and the training of teachers were seen as a barrier to fully implementing 21st century skills. As for the arts, they were seen as secondary to the corrective action mandate that had been part of the schools PI requirements. Because of this mandate, most of the students received additional English/LA instruction, and/or additional mathematics instruction. What that meant for the students was double periods of English or math resulting in elimination of electives, such as art or music or second language courses. In response to this, the school supported afterschool activities, such as band and athletics.

The principal explained that he/she would love for all students to have access to electives, and that it was used as an incentive for students who did well on benchmark assessments. NCLB was seen as taking away from the "well-rounded" student model of the middle-school to create a literacy and mathematics heavy model. The Principal pointed out that in some schools they had gone so far as to eliminate not only the arts, but science and social studies, something he/she described as a crime against students and taking away the activities that kept students interested in school. He/she felt strong about protecting their school program from losing the balance of curriculum subjects by working hard with the master schedule to both provide the necessary interventions as well as engage students in a wider range of subject matter.

School environment. The Traditional school was visited in June 2012 when the surveys were given to participating teachers. Arriving before school started, the gates at the front entrance were locked, and several student stood amongst their friends talking, texting and listening to iPods. The school was a ranch style building, with several separate buildings housing classrooms spread around the school yard. There was also a separate office building, but no obvious green space, although the Principal stated that there were numerous fields for soccer, football, and baseball as well as a number of outdoor tennis courts. The participating teachers met to discuss the surveys in the 6^{th} grade classroom. The room was large with a wall of windows that provided ample natural light. Rather than rows of desks, the room was set up with tables. On the tables were student research projects that integrated both math and science though the mapping of the depth of the ocean floor. There were a myriad of art supplies, books and materials that were accessible to students. Based on this, and the displays of student artwork, it was clear that although it was a traditional classroom, the teacher enjoyed providing students with opportunities for artistic work.

Social-emotional curriculum. The Traditional school had a number of character development programs either in use or that were in the process of being established. The first program, designed as a “microcurriculum” focused on student issues of sexual harassment and bullying, or cyber bullying. This program consisted of schoolwide assemblies on the subjects that were further elaborated in the students’ classrooms. The issue of sexual harassment was discussed in the science classes, and bullying and cyber bullying were expounded on during social studies. There was a formal curriculum booklet and quizzes that all students were required to complete. At completion, parent and student signed completion form that was kept on file. Every student participated, and new students entering in the middle of the year received their booklet in their enrollment packet. If a student had an issue during the school year with any of the components of the course, they might be required to repeat the course as part of a natural consequences.

In addition, the school utilized a PASS AmeriCorps program which focused on youth at risk. Approximately fifty students at the school participated in an Aggression Replacement Program (ARP), designed to help student better self-regulate their behaviors and emotions. This aspect of the character development at the school was meant to target a specific challenging population. In addition, the Principal was looking to incorporate peer mediators across the entire school through the use of the Community Alliance for Youth Success (CAYS) program with its eight keys of quantum learning. This program was seen as a means of expanding character development into the entire school.

The demographics of the schools were not identical, and therefore these should not be viewed as direct controls, but rather as individual cases. In particular the Traditional school differed both for SES and percent minority. This indicates the need to look at much within the school populations as across them when evaluating findings.

Table 28. Demographic Data for Participating Cases

Mean	**Grade Level**	**School Size**	**Participating Class Size**	**SES**	**% Minority**	**GS Rate**	**Parent Rate**	**API**
Traditional	6-8	720	31.8	87%	93%	3	3	705
IB	K-8	199	20.6	17%	19%	8	4	884
Waldorf	K-8	303	25.3	50%	12%	5	4	764

Materials & Procedures

Review of the survey instruments. A full description of the survey instruments and administration procedure is available in the Methods, Chapter 3. A brief narrative review is provided here for convenience. The first page of the survey consisted of demographic questions as well as questions designed to allow the student to share his/her personal likes and feelings. For the demographic questions students were asked their age, gender, years they had attended their current school, the first language of their parents/guardians and the language spoken in their home. The next three open-ended questions intended to allow the student to open up and feel comfortable in the process of taking the surveys which addressed emotions as well as cognition. Students were asked to share their favorite book, their favorite subject in school, and what career they might imagine for themselves if they had all options available to them. This was followed by the first survey instrument also chosen to allow students to share about themselves, as well as to indirectly measure creativity and cognitive development. The Goodenough-Harris Draw-A-Person Task has been utilized in psychological circles as a measure of development, intelligence, and psychological wellbeing. The task involves drawing three images of people, first a man, then a woman, then a self-portrait. For this study, the final task requiring students to "draw a picture of yourself", was used as a non-verbal measure to examine the many factors assessed by the Goodenough-Harris task. The next survey was developed by the researcher herself and was used as a measure of school enjoyment. In addition, to the 10 questions on student enjoyment of school, students were asked 10 questions in the same survey on aspects concerning attention and ADHD, these were developed based on the researchers own knowledge of attention systems as well as on global criteria for defining ADHD by various professional sources (Appendix J). The fourth page consisted of a standardized survey of adolescent emotional development, the Adolescent Short Form version of the Trait Emotional Intelligence Questionnaire (TEIQ-ASF). The final page of the survey consisted of a shortened version of the Cornell Conditional Reasoning Task (CCRT) used here to assess one aspect of critical thinking.

Data Analysis & Results

Qualitative questions & analysis. Students were asked about their favorite school subject, and what they would like to do as a career if they could do anything they wished. The data were examined for the frequency of each subject by school and for grade differences in subject preference. The most common selections are presented in Table 29 and 30. Chi-square analyses were used to examine differences in favorite subject across the school types and for grade level. There was a significant grade level difference for students choosing PE/Recess as their favorite school subject. This was due to higher numbers of students from the lower grades preferring PE. Mean percentages for each grade were: 6th = 38.3%, 7th = 22.9%, 8th = 9.7%, χ^2.(2, N=325) = 25.08, p<0.001. There was also a significant grade difference for the academic subjects of English and Math, χ^2.(2, N=325) = 10.8, p<0.005, and χ^2.(2, N=325) = 9.29, p<0.01, respectively. Both academic subjects saw progressively greater percent of students preference in the higher grade—English: 6th = 2%, 7th = 11% , 8th = 14%; Math: 6th = 29%, 7th = 36% , 8th = 49%. Subject preference was also examined for differences between the school models (Table 29). There was a difference between expected and observed values between schools for Math, χ^2.(2, N=325) = 22.8, p<0.001; Science,

χ^2.(2, N=325) = 7.38, $p<0.05$, and Art/Music χ^2.(2, N=325) = 15.26, $p<0.001$. Traditional schools had the highest percent of students preferring math, while IB showed the highest preference for science amongst the three school models. Waldorf students rarely mentioned science as a favorite subject. For art and music, IB students showed the greatest preference followed by Waldorf students, while only 3% of students in the Traditional school chose art/music as their favorite subject. There were a few school subjects categorized under other, and these included leadership, yearbook and lunch for the Traditional school, resource classes, and Spanish for the IB school, and Main Lesson and computer class for the Waldorf school.

Students were also asked about their ideal career choice. Responses were categorized into 14 categories and descriptive results are presented in order from highest to lowest based on averaging across all schools in Table 30. Student career choices resulting less than 1% of responses (cooking and business) were not included in the table. Averaging across schools, a career in the arts was the most frequently cited choice. The category of arts included fine arts, musician, novelist/writer, actor/actress, and other careers in entertainment. Dancer was not included in the arts, but was categorized as athlete. Also categorized in athlete were all the major sports, with soccer being the most common choice, but also martial arts, horseback riding, and coaching. Healthcare included doctor and dentist, but also nurse, travelling nurse, pharmacist, herbologist, pediatrician, ophthalmologist, psychiatrist and therapist. Military and police included all areas of the military including air force, marines, navy, but also border patrol, California game warden, and CIA. Architect/Engineer was a rather broad category and included architect, engineer, construction and mechanic. Veterinarian was straight-forward and had only one exception, a student who wanted to run an animal shelter. Technology included any job involving or related to computers or specifically stating wanting to work with technology. Teaching included early childhood, high school teacher, Waldorf teacher, singing teacher, etc. Lawyer was singular in its category. Several students, particularly in IB stated they wanted to be scientists, others specified careers such as marine biologist, or astronomer, in addition two students from the traditional school wanted to be inventors as a career and these were included under science. Finally, the careers indicated under Design included graphic design, interior design, fashion design, designing custom cars and any specifically visual design and not related to engineering a product.

Students were also asked why they chose the career choice and to this the most frequent response was to help others. Also having a skill in a particular area or being told they had a particular skill was common, especially for those who chose engineering where there was an association made with being good in math. Enjoying or liking a subject area or activity, the ability to express oneself, and even the description of experiencing ‘flow’ while doing those activities were additional reasons given by students for their job choice. These reasons were more frequent even than money or fame, and reflected a certain degree of thoughtfulness and maturity on the part of the students. Finally, there were also a number of students who said they did not know what they wanted to do yet, some pointing out the fact that they were only just barely a teenager. To some extent job choices for each school corresponded to the profile produced for favorite subject. For example, higher percentages of both IB and Waldorf students selected Art or Music as a favorite class, and this corresponded to higher percentages of responses for career choices in these same areas. This was also reflected in the selection of science as a favorite subject. Of the three schools, IB students showed the highest percentage of students selecting science as the favorite subject, and again, when comparing that to career choice, IB had more student choosing science as a career.

Table 29. Student Preference for School Subjects

SUBJECT	TRAD	IB	WALD
Math	49%	18%	29%
PE/Recess	22%	23%	29%
English/Language Arts	7%	15%	11%
Art/Music	3%	18%	11%
Science	13%	16%	3%
History	2%	5%	5%
Other	3%	3%	7%

Table 30.Student Selected Career Choice

	TRAD	IB	WALD
Arts	12%	35%	28%
Athlete	12%	10%	18%
Healthcare	14%	4%	13%
Military/Police	16%	8%	5%
Architect/Engineer	9%	12%	3%
Vet	9%	4%	5%
Technology	5%	6%	5%
Teaching	5%	2%	8%
Lawyer	6%	2%	7%
Science	1%	8%	2%
Design	2%	4%	3%

Quantitative scale validation. A description of the selected quantitative scales is provided in the Method section of this dissertation. All quantitative scales were submitted to factor analyses to determine their construct validity. For the School Enjoyment scale, the principle component factor analysis and an eigenvalues cutoff of 1.1

indicated a single component factor for the scale. Factor loadings ranged from 0.35 for question three: “When I graduate I am going to college to continue my learning”, to 0.76 for question five: “I enjoy school” (see Appendix J for a full version of the survey). For the Attention scale applying the same eigenvalue cut-off resulted in two principle components. These roughly separated around the themes of (1) distractibility or absent-mindedness, and (2) memory or willfulness. Questions 11, 15, 16, 18-20 corresponded to the first factor with loadings ranging from 0.42 – 0.69, and questions 12-14, 17 corresponded to the second factor with loading ranging from 0.47 – 0.72. These first two scales were developed by the researcher. The fact that the scale on school enjoyment produced a single construct reflects the intentions towards simplicity of the scale questions. It is hoped that through this small initiative future scales may be developed to look at similar issues, including student love of learning and creating life-long learners as a component of school enjoyment.

The TEIQ-ASF was the least consistent with its purported constructs. Using the same rotated factor analysis and eigenvalues as for the School Enjoyment and Attention scales, produced more than 11 factors. Creating a forced five factor model consistent with the constructs proposed by the authors, only one of the five constructs loaded together as a single factor. That was Wellbeing, while the other factors were evenly distributed among the other four factors with counts ranging from 4 to 6 questions per factor, and loadings from 3.6 to 6.7. The shared loadings were most prominent between social and emotional questions, social and motivational questions, and self-control and emotional questions. A more formal investigation into the construct variability reported here should be investigated in the future to determine the reliability of the scale.

The construct validity of the CCRT was far better than for the TEIQ-ASF. The expected three factors (Verbal, Algebraic, Prior) actually produced four factors when eigenvalues were set at 1.1. This appeared primarily due to verbal questions generating two instead of a single construct. For Verbal questions of conditional reasoning, 7 questions loaded in Factor 1 and 5 loaded in Factor 2. For the algebraic questions, 4 of the 5 questions loaded in Factor 3 and one loaded in Factor 4. For the two questions requiring students to ignore prior knowledge, one questions loaded in Factor 2, and one loaded in Factor 4. Although there was a rough distribution of the questions according to their category (i.e. Verbal, Algebraic, Prior), it may be that there was a greater effect of the difficulty of the question regardless of category.

Remedial classes in the traditional school. For each of the experimental schools, there was only one class per grade. The larger size of the traditional school provided multiple classes per grade across the school. For the Traditional school two classes per grade were selected by participating teachers. Of the selected classes in the Traditional school, one in 6th and one in 7th were considered by their teachers as strategic or remedial. The remaining non-remedial classes were considered proficient, or advanced/proficient based on the teacher's self-reports. The two remedial/strategic classes were analyzed for differences from their same grade level peers across each of the survey measures using individual t-tests. Significant differences between the remedial and proficient/advanced classes resulted in those classes being removed from the group analyses for those survey measures. Significant differences between the remedial and proficient students for the most part fit with the idea that students in remedial classes were also impaired in non-academic areas. However, the findings were not as robust as one might have expected, and for every one of the significant effects in one class, the alternate class did not show the effect. Nonetheless, any significant difference in a subtest resulted in the elimination of the remedial group from both grades from the statistical analysis not only for the subtest, but for the scale as a whole.

Table 31. Significant t-tests for Remedial versus Proficient/Advanced Students

Significantly Different	Variables	t	df	p	Mean difference
6th	TEIQ_total	-1.99	57	0.05	-0.298
	Wellbeing	-2.11	57	0.04	-0.650
	CT_verbal	-5.11	56	0.001	-0.268
	CT_prior	2.81	56	0.01	0.259
	GH_rate	-3.99	57	0.001	-1.174
7th	ADHD	3.71	56	0.001	0.538
	Self-control	-2.45	56	0.02	-0.722
	CT_algebra	-2.06	56	0.04	-0.145

df = degree of freedom, *p* = *p value.*

Table 31 shows the significant t-tests for the two remedial classes compared to their same school and same grade level. Nearly all of the significant findings indicated poorer performance or greater attention deficits by the remedial group. There was one exception to this pattern of poorer performance by remedial students, and that was for the critical thinking measure of prior knowledge (CT_prior). In this case, students in the remedial class scored higher than the proficient/advanced group. This may have been due, not to the greater number of correct responses in the remedial group, but the fewer number of responses overall, or the fact that guessing on the Prior knowledge questions may have resulted in a greater likelihood of getting the correct answer. For the CCRT incorrect responses were counted as - 0.5, whereas non-responses were counted as 0 and correct answers were recorded as 1 point. The CT_prior knowledge task was particularly difficult for the students across all grades, with less than 25% of students answering correctly on each of the two questions.   In support for this hypothesis, the finding of better performance by the remedial students was found for the 6^{th} grade students only. The younger grades tended to perform more poorly on the tasks of critical thinking, and so by 7^{th} grade, remedial students no longer showed better performance than their peers, and in fact the overall effect was reversed, although not significantly. When there were significant effects for the remedial group, they were excluded from any of the ANOVA analyses for all grades.

Goodenough-Harris Draw a Person. The Draw a Person task was limited to the last page of the original assessment, and that was for the participants to draw a picture of themselves. The drawings were evaluated according to the GH rating scale general analysis (Harris, 1963). Ratings ranged from 3 to 9.5 with a mean rating of 5.52, standard deviation of 1.46. A 3 X 3 X 2 Group (Trad, IB, Wald) X Grade (6^{th}, 7^{th}, 8^{th}) X Gender (M, F) factor ANOVA was applied to the GH rating. There was a significant main effect of Group, $F_{(2,265)}=13.2$, $p<0.001$ and a significant main effect of Gender, $F_{(1, 265)}=26.4$, $p<0.001$. There was no main effect of Grade, nor were there any significant interactions for Grade. However, there was a significant Gender X Group effect, $F_{(2,265)}=4.4$, $p<0.05$ (Figure 11). This was due to a greater discrepancy for gender in the IB and Waldorf schools than in the Traditional school. Fischer LSD post-hoc analyses indicated that all three groups significantly differed from each other on the GH rating.   In this case, Waldorf showed the highest GH ratings, followed by IB, and then Traditional.

It is clear to seen in Figure 14, that Waldorf and IB, females in particular, outperform traditional schools on the Goodenough Harris rating. IB males were lower than traditional students, although not significantly so, where as Waldorf males students were significantly higher than both IB and traditional school ratings. Traditional schools were significantly lower than both IB and Waldorf (p<0.001), and IB just met significance for lower scores than Waldorf (p=0.05).

There were a number of interesting findings from the drawings, and these data hold some interesting appeal when seeking non-verbal creative measures. Samples of drawings are provided to demonstrate the general quality of drawings at the upper and lower ends of the scoring scale. Figures 15 to 18 show the highest rated drawings from the traditional school, IB school, and Waldorf school for each grade, and figures 19 to 21 show the lowest rated drawings for each school and grade.

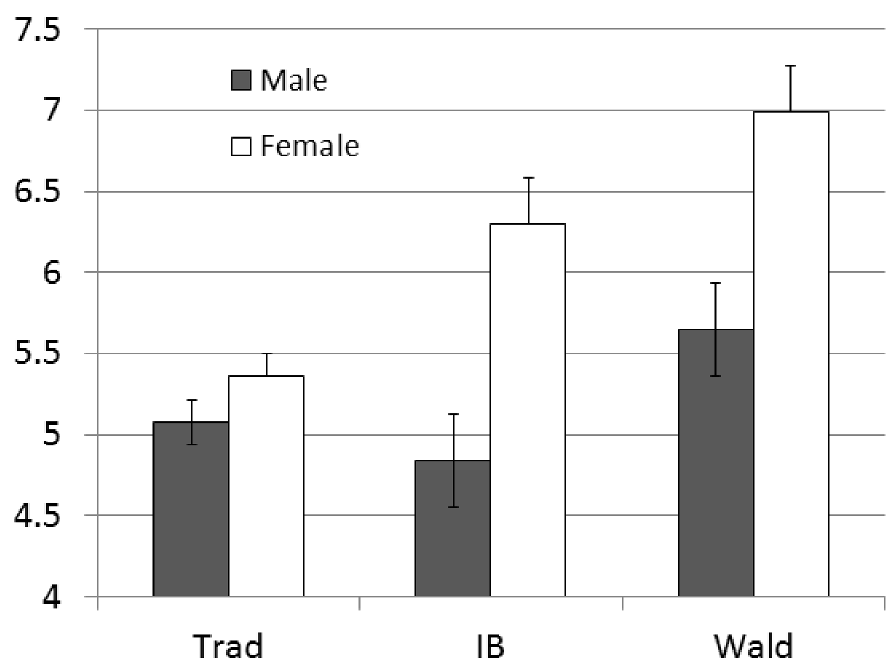

Figure 14. Gender differences on the Goodenough-Harris Draw a Person task. Females consistently scored higher than their male peers on aspects of body proportions, facial detail. This was significant across each participating school type.

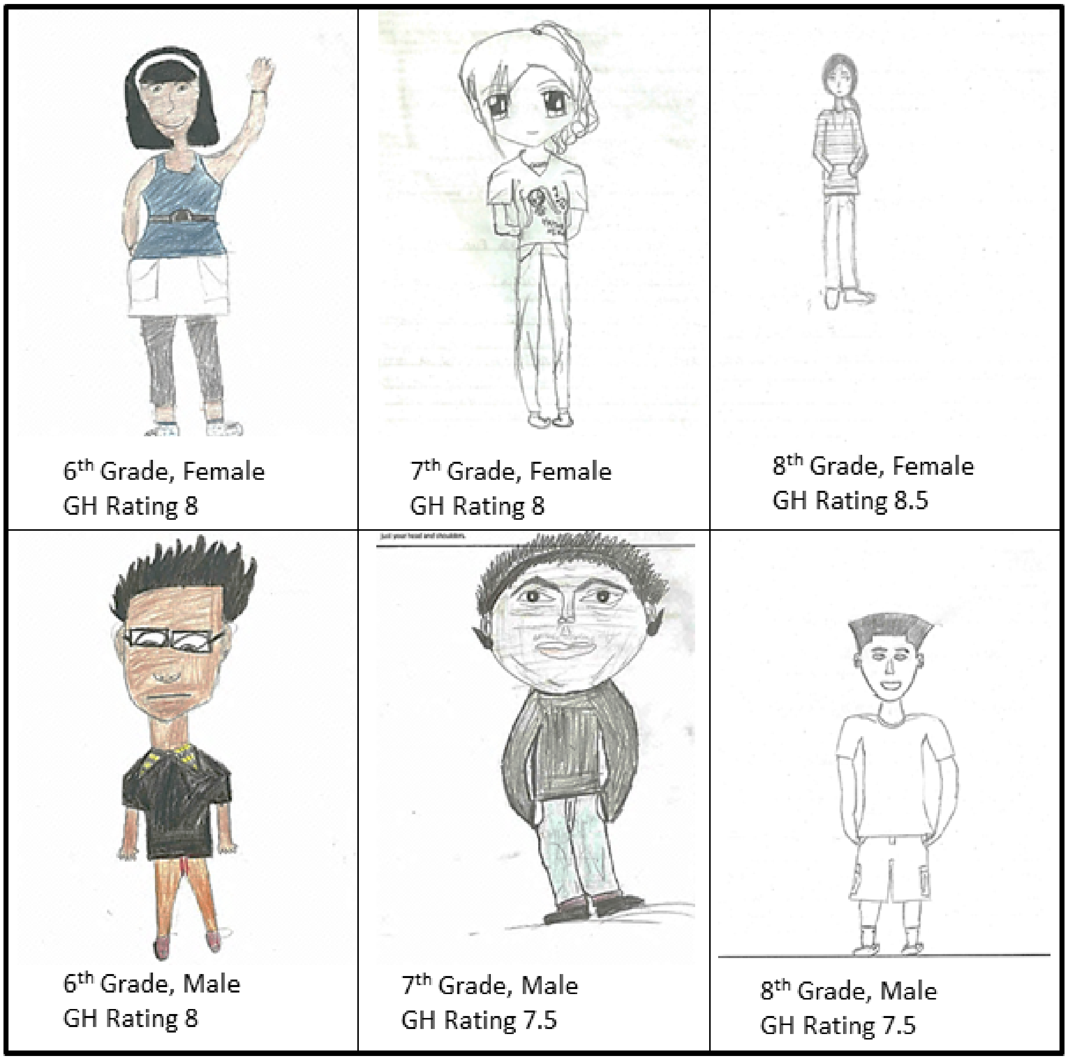

Figure 15. Highest scoring Traditional student drawings for female and male students, Grade 6-Grade 8.

The highest ratings for the Traditional school ranged from 7.5 to 8.5. The absolute highest rating of 8.5 reflects both the bodily proportions as well as the quality of the lines. Ratings for males were relatively lower, and t is possible to see problems in proportion for male students (i.e.length of arms, 6th grade, shortened legs, 7th & 8th grade; oblong head and no neck, 7th grade, diminished body size 6th grade). The highest rated drawing for the IB school ranged from 6.0 to 8.5 For the IB school, the highest rating of 8.5 reflects the superior proportions and detail for the 7th grade female. The lower scores for the IB males reflected the lack of facial detail, as the proportions were overall quite good. For the Waldorf students the highest rated drawings ranged from 7.5 to 9.5. The drawing from the 8th grade female ranked the highest of 9.5 due to the excellent proportions and the additional use of shading to provide dimension. This is the highest rated drawing from all the samples.

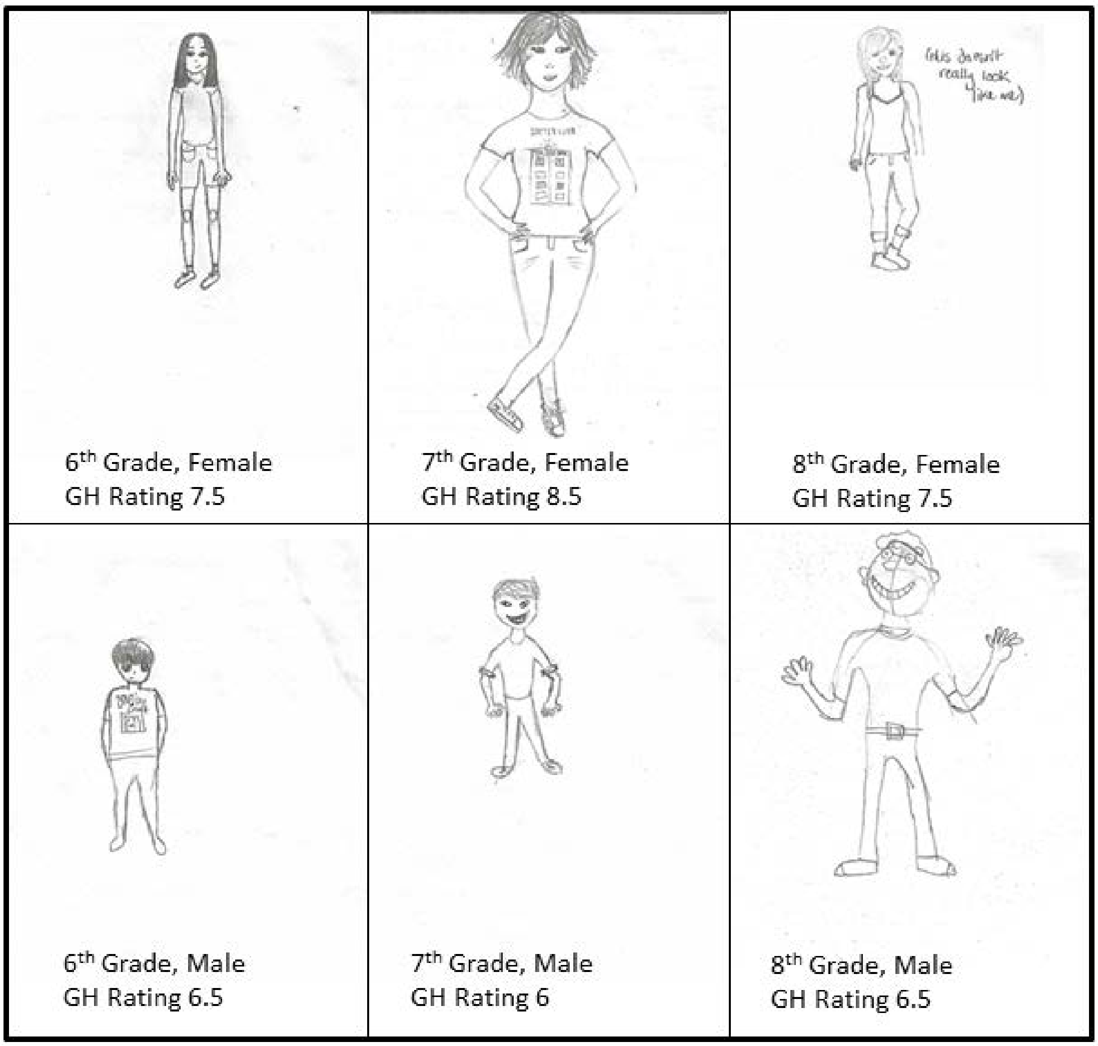

Figure 16. Highest scoring IB student drawings for female and male students, Grade 6-Grade 8. Comment: 8th grade female (this doesn't really look like me)

Figure 17. Highest scoring Waldorf student drawings for female and male students, Grade 6-Grade 8. Waldorf students Comment 8th grade male (*super tall*) Comment: 8th grade female (I refuse feet FOOT STRIKE).

Figure 18. 8th Grade GH drawing add-on. This addition was drawn at the bottom of the TEIQ-ASF questionnaire page.

The highest rated drawing of all classes was submitted by the Waldorf 8th grade female who included highly creative component. In her original drawing she did not draw feet, but made a comment “I refuse feet, FOOT STRIKE” however, on the following page, at the bottom of the questionnaire, she drew feet that aligned quite well with her original drawing, and wrote the comment “my feet came back to the union”.

In evaluating highly rated drawings, it was interesting that the facial expressions were less often “happy” than for those which rated more poorly. This could have been related to the use of the “smiley face” which was common in simpler drawings, whereas for those drawings using facial detail including lips, the facial expression was more often neutral. In addition, highly rated drawings more often included clothing detail, as well as greater use of color. Finally, looking at the IB student, male drawings in particular, it is possible that these students were scored more poorly due to the methods of drawing analysis. The internal reference system used for each school may have resulted in a reduced range applied to the IB students. Future analyses of these and similar data should employ more standardized techniques, including using the full analysis as provided by the GH manual (Harris, 1963).

Figure 19-21 show the lowest rated drawings from each of the three grade levels and each school. Drawings receiving the lowest scores on the GH rating scale were most frequently stick figures. This was particularly true for the Traditional school (Figure 19). While Waldorf and IB showed better overall drawings even at the lowest level. Notice the large number of erasures and negative expression in several of the drawings.

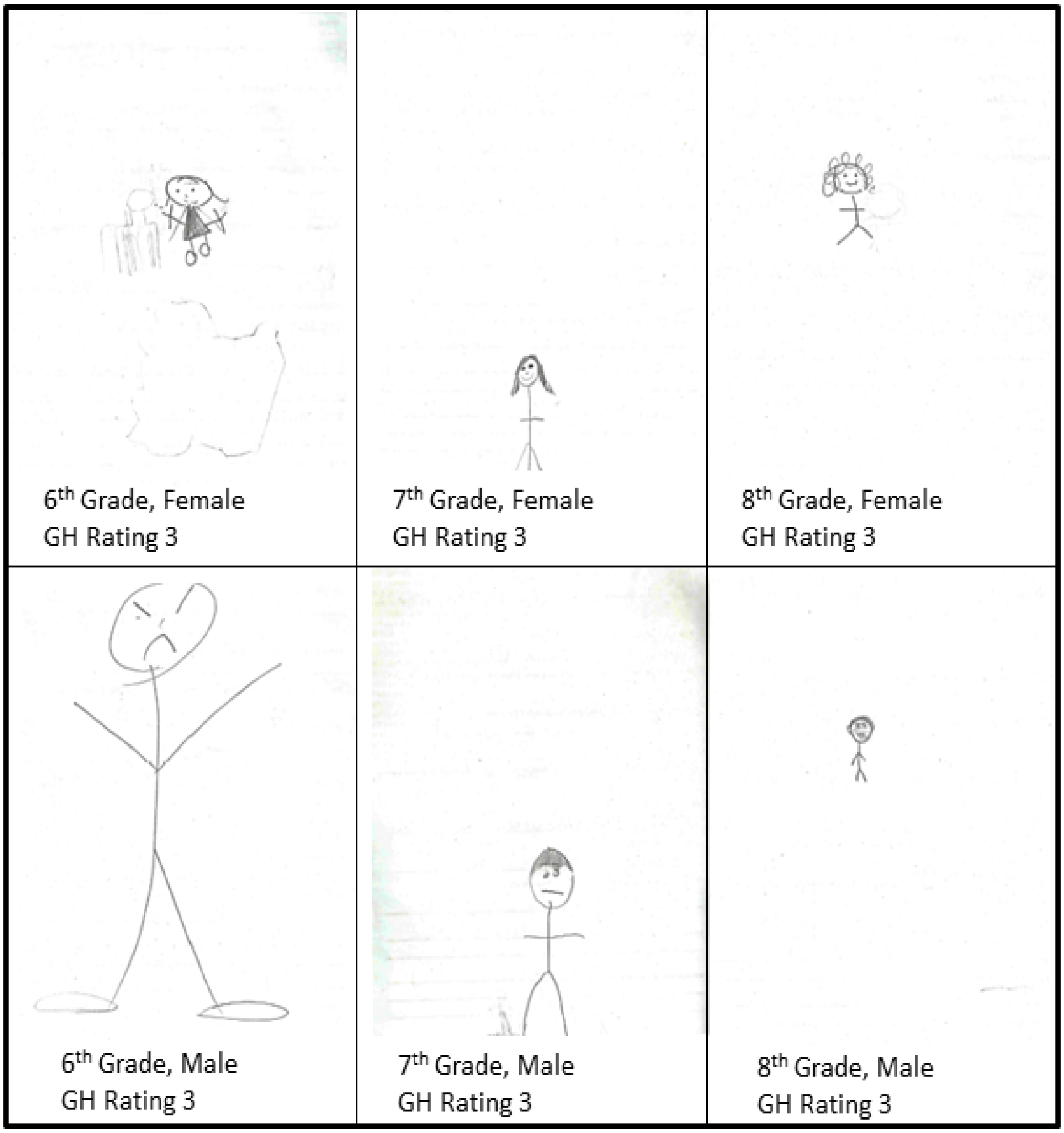

Figure 19. Lowest scoring Traditionl school student drawings for female and male students grade 6 to grade 8. Notice the number of erasures, and the use of stick figures.

For the IB lowest ratings, it can be noted that none of the IB female students drew stick figures, and for the 6^{th} grade, the lowest rating was a 5.5 indicating a relatively good sense of proportion. Notice the shortened arms on the 6^{th} grade male drawing and the odd construction of the sholders for the 8^{th} grade female with poor line quality.

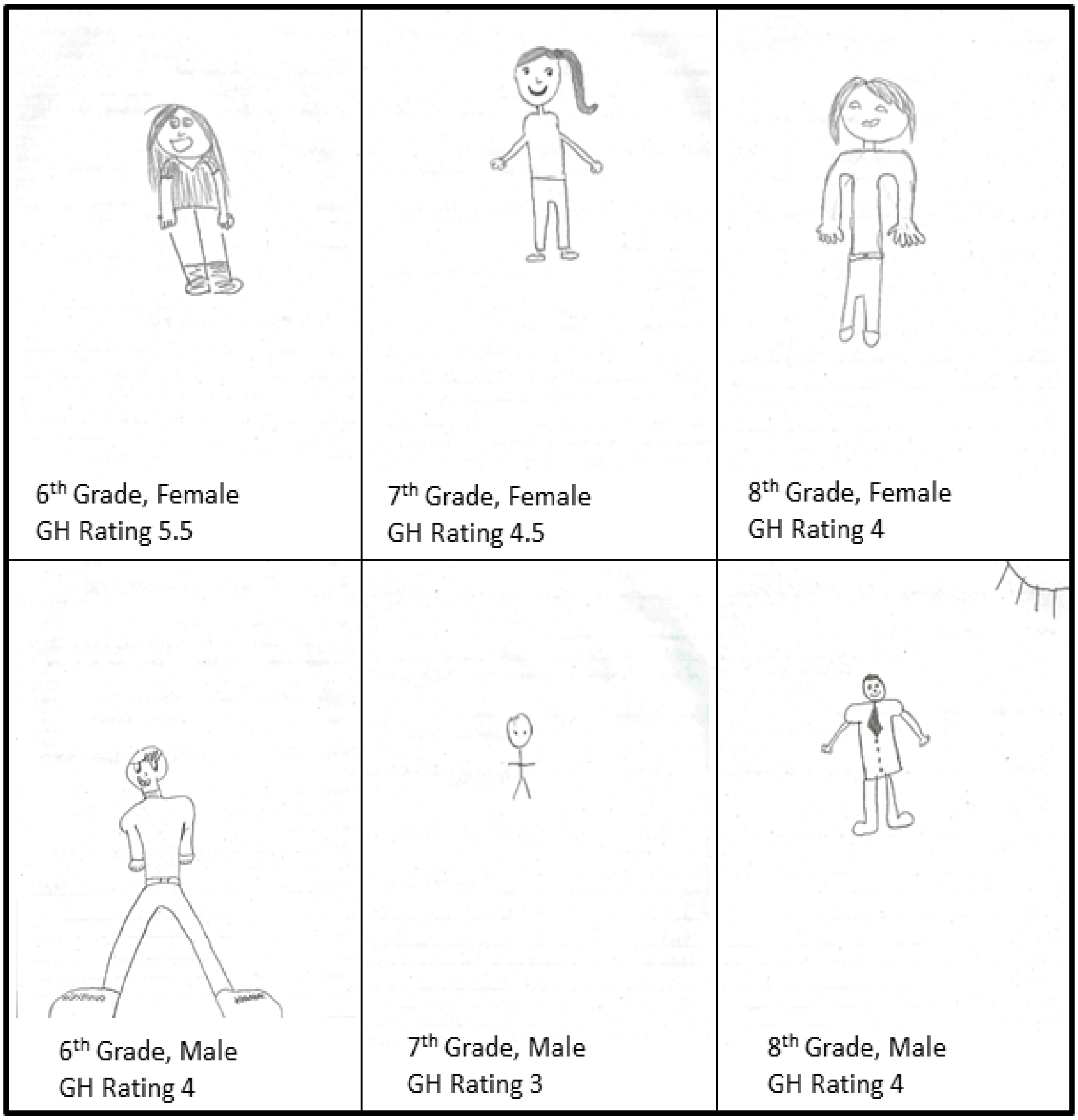

Figure 20. Lowest scoring IB student drawings for female and male students grade 6 to grade 8**.**

For GH ratings of Waldorf students, again there was a notable difference between male and female students, where males drawings were considerably more poor than female drawings. None of the female drawings were less than a 5.5 rating, while all three male students scored the lowest score of 3. This is consistent with poorer overall male performance across each of the three cases (see Figure 14).

Figure 21. Lowest scoring Waldorf student drawings for female and male students grade 6 to grade 8. Comment 8th grade male (Hoodie).

An odd phenomenon in Waldorf schools was the high number of students drawing animals instead of humans (Figure 22). There was a highly significant difference between the expected value and the actual value for the drawing of animals in place of a person for Waldorf students, χ^2=32.8, (2, N=299), p<0.001.

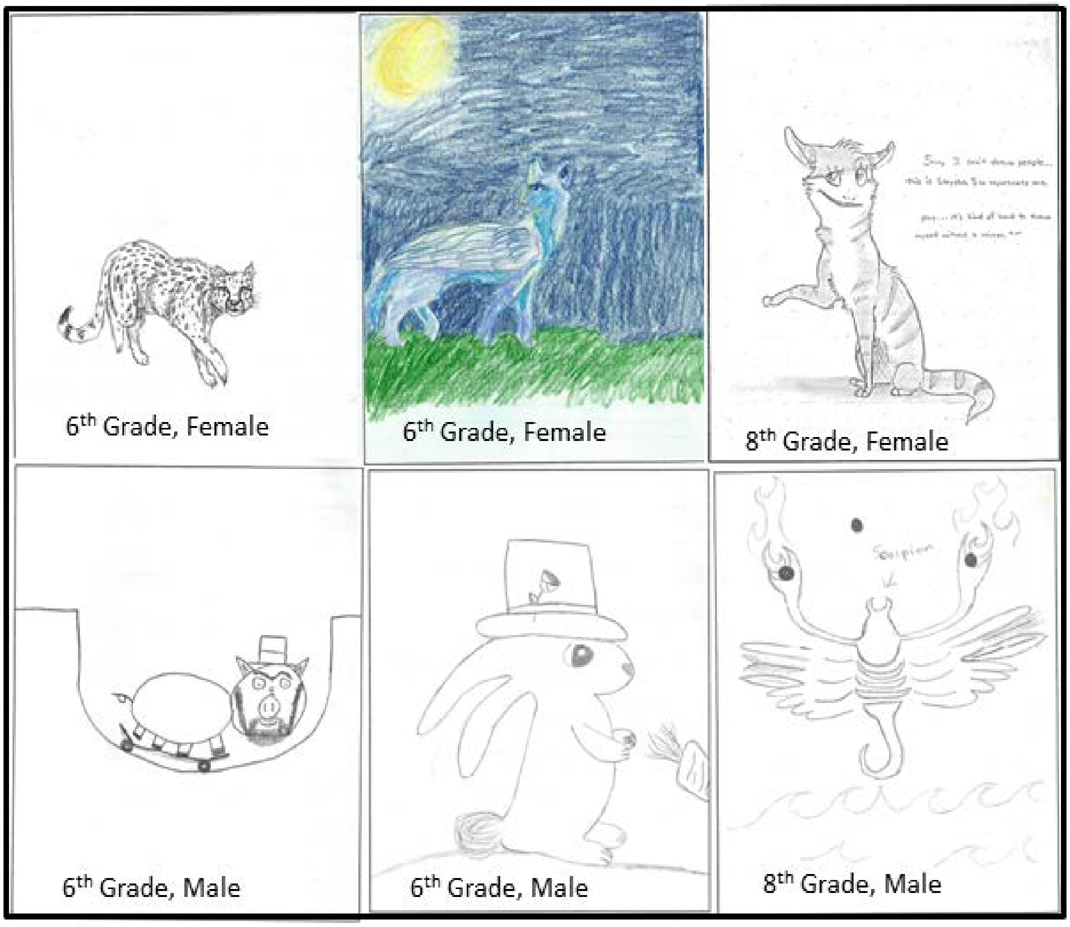

Figure 22. Examples of Waldorf students' preference for drawing animals. Comment: 8th grade female (Sorry I can't draw people…this is Loryska. She represents me. Plus…it's kind of hard to draw myself without a mirror). Comment: 8th Grade Male (Scorpion).

A total of nine Waldorf students drew animals, whereas none of the students in either the Traditional or IB school drew animals. Another notable tendency of Waldorf students were the presence of high quality violent drawings (Figure 23). A Chi-square analysis indicated that although there were more violent drawings by Waldorf students than expected, this only trended towards significance, χ^2=4.44, (2, N=299), p=0.10.

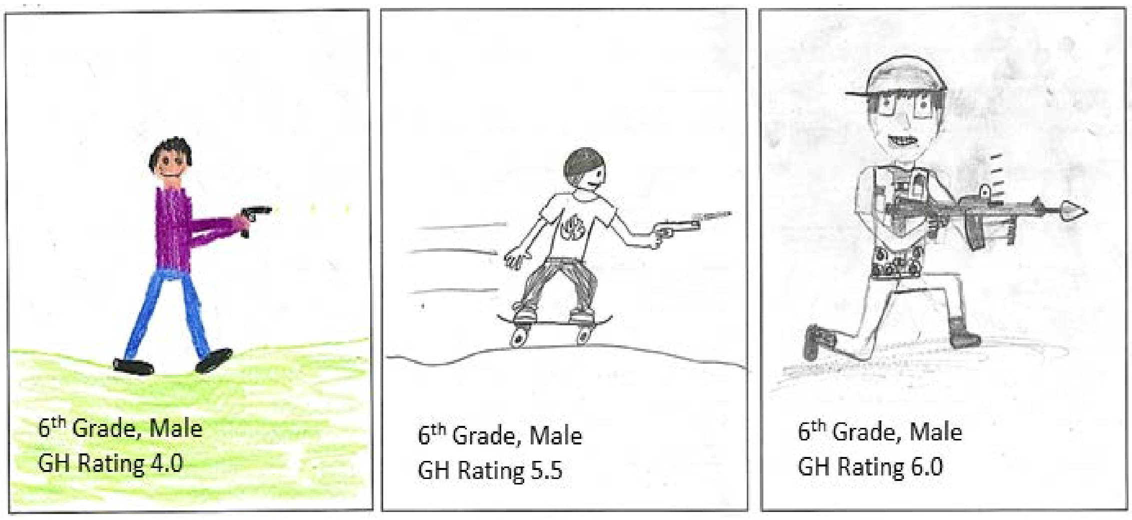

Figure 23. Waldorf students in 6th grade produced several violent drawing with high quality GH ratings.

Not restricted to Waldorf, but quite obvious in several of the Waldorf students' drawings, was the tendency for students who were sitting next to each other, as indicated by sequential survey numbers, to have very similar drawings (Figure 24). This is referred to here as "the contagion effect". A Chi-square test for independence indicated a significant difference between groups for drawings displaying an obvious contagion effect. Again this was due to Waldorf students having higher than expected values, while IB and Traditional students had lower than expected values, $\chi^2=6.85$, (2, N=299), $p<0.05$. A number of students used one or more colors in their drawings.

Color was analyzed not just for presence or absence of color, but for the number of colors used. An ANOVA comparing the use of colors across school group showed Waldorf students used the most color, whereas IB students used the least amount of color $F_{(2,227)}=3.92$, $p<0.05$. Fischers LSD post-hoc analysis revealed that IB used significantly less color than either of the other schools, and that Waldorf and the Traditional school did not differ from one another.

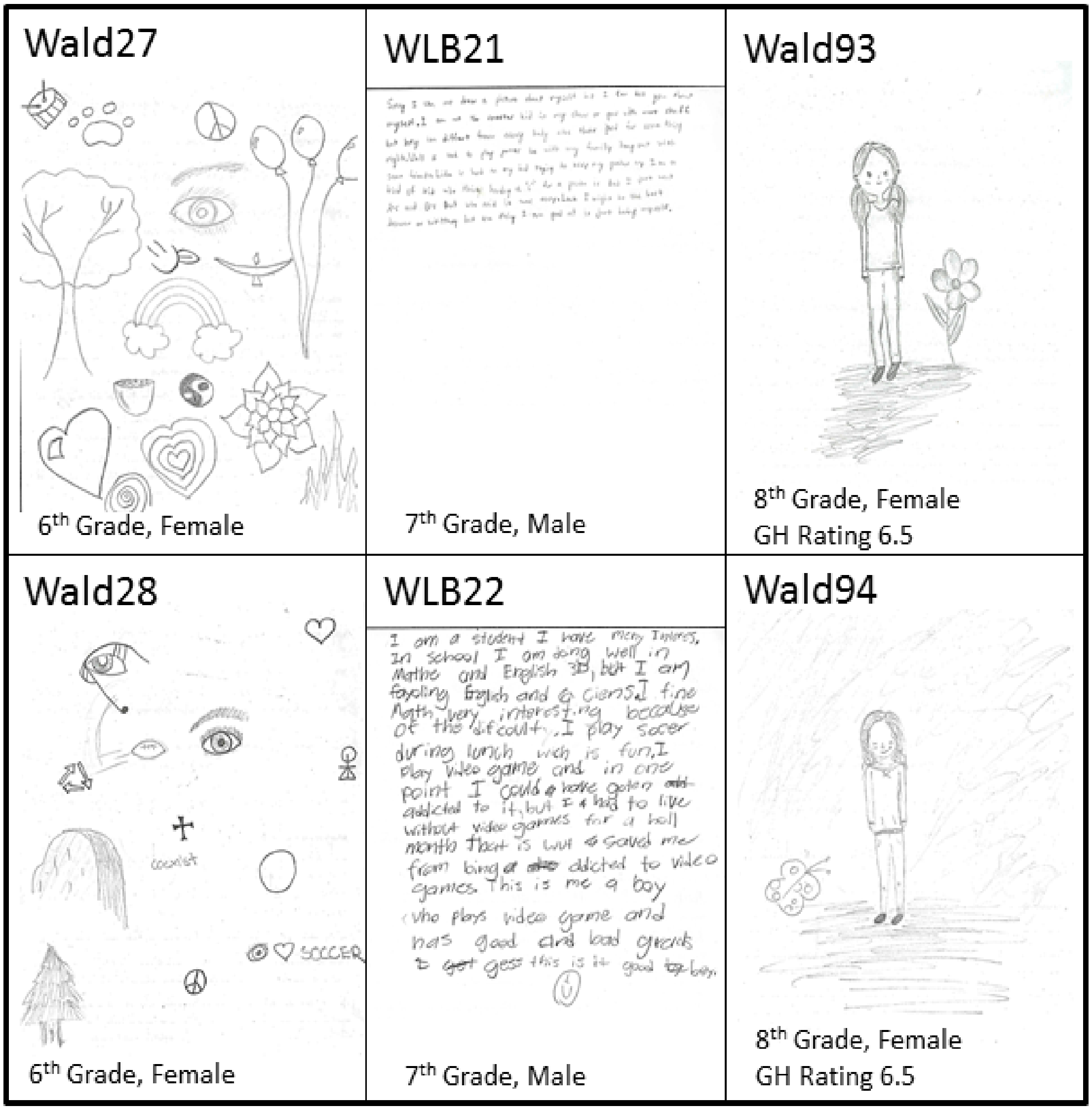

Figure 24. The contagion effect in the GH Draw a Person Task. Students sitting next to one another more frequently demonstrated similarities in their drawings, even to the extent that some were nearly identical. (Wald = Waldorf; WLB = Traditional; Numbers represent the sequence of survey administration.)

Not all student completed drawings, and there was a significant Chi-square for those students who left the drawing blank. Waldorf and IB students were more likely to skip the drawing, as indicated by lower expected values than actual values, in particular for the IB schools χ^2=12.2, (2, N=321), p<0.005.

The differences between the three school on findings from the Draw a Person Task demonstrated a rich data set that was intreguing both with respect to the findings here, but also to the potential of using such abstract tasks as research tools. It is interesting to note that by providing students with a non-verbal opportunity to express themselves we may be able to delve into aspects of personal and group behaviors that are not measurable on tasks more susceptible to issues of verbal comprehension or confounds of culture. By using open-ended measures of student development we not only measure but engage the students in the process of discovery. The use of a measure with such a long history of use as the Goodenough-Harris task provides a foundation that can be built upon. Use of non-verbal creative measures should be included as a part of student evaluation in programs of neuroeducation and as tools for developing new questions relating to student dynamics as are indicated by several of the emergent findings such as the contagion effect and how students help each other to define themselves.

School enjoyment. The ten question school enjoyment scale was developed by this researcher to ask questions specifically related to the extent to which students were engaged and enjoyed school. There was a significant effect of school group on the mean school enjoyment score, $F_{(2,319)}=23.0$, $p<0.001$. There was no significant effect of Grade, $F_{(2, 319)}=2.19$, $p=0.11$, nor was there a Group X Grade interaction $F_{(4, 319)}=1.83$, $p=0.18$, although in both cases they were approaching trend levels of significance. The group effect was due to higher levels of school enjoyment in Waldorf followed by IB and the lowest were Traditional students. Although the effect for grade was not significant, the greatest level of school enjoyment was reported for the Waldorf 8th grade students (Figure 25).

Attention scale. The attention scale was also developed by the researcher based on a long history of research in attention and attention dysfunction. For the attention scale, there were no significant main effects for any of the independent variables, i.e. Group, Grade or Gender, on the researcher constructed measure of ADHD, nor were there any significant interactions. Since the principal component factor analysis indicated two component factors for the Attention scale, a second analysis was done examining each of the two components separately. This additional analysis also indicated no significant differences in our groups for any of the main effects or interactions (see Table 32).

Notably, however, there was a significant difference when students from the Traditional schools categorized as basic/remedial were analyzed separately and compared to their matched grade level peers also attending the traditional school. Results comparing remedial students to non-remedial peers showed a significantly higher score on the ADHD scale (see Table 31). Because there was a significant difference between remedial and non-remedial classes, remedial students were removed from the analysis. Examining the same data with the two remedial classes removed did not impact the overall ANOVA.

Table 32. Means & Standard Deviations for the ADHD Scale Constructs

		Willfulness		**Distractibility**	
Group	N	Mean	*StDev*	Mean	*StDev*
Trad	130	2.47	*0.51*	2.33	*0.58*
IB	62	2.66	*0.52*	2.34	*0.56*
Wald	75	2.52	*0.55*	2.23	*0.50*

Note. Remedial students excluded.

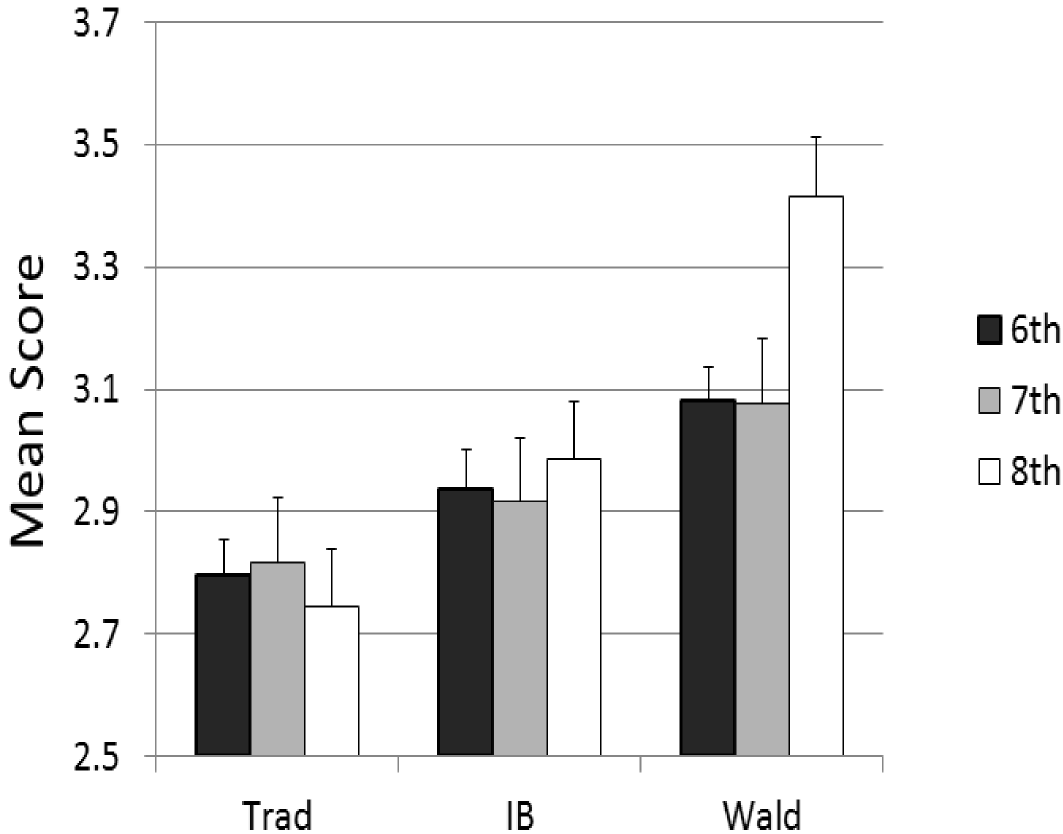

Figure 25. Group X Grade interaction for levels of school enjoyment. Both IB and Waldorf scored higher than traditional students, with Waldorf eighth graders scoring the highest. (Remedial students excluded, Error bars = SEM)

Social-emotional: TEIQ-ASF. The TEIQ Adolescent Short Form was used as a measure of social and emotional skills in our three school populations. This scale is divided into five components parts: wellbeing, self-control, sociability, and emotionality as well as providing an overall composite score including additional questions. Because these subscales are all related to a composite score of Emotional Intelligence, a Multivariate Analysis of Variance (MANOVA) was applied to these scale measures to simultaneously control the overall alpha level, and reduce spurious findings due to multiple ANOVAs. From the MANOVA output there were significant main effects for all three of our Independent Variables as follows: Group, $F_{(10,482)}$=2.95, p<0.005; Grade, $F_{(10,482)}$=2.04, p<0.05; Gender, $F_{(5,240)}$=4.03, p<0.005. There were no second or third level interactions for the MANOVA output. For the test of the between subject effects the significant differences for the main effects at each of the subscales were examined. For the main effect of Group, three variables showed significant effects: Composite TEIQ score, $F_{(2, 244)}$=6.61, p<0.005, Emotionality subscale $F_{(2,244)}$=9.36, p<0.001, and the Sociability subscale $F_{(2,244)}$=6.73, p<0.005 (Figure 27). For Grade, only one variable was significant: Wellbeing, $F_{(2,244)}$=3.8, p<0,05 (Figure 26). Likewise, for Gender, only one variable was significant: Emotionality, $F_{(1,244)}$=8.02, p<0.01 (Figure 28). Consistent with the MANOVA, there were no significant two way interaction, however, there was a small three way interaction for the variable of self-control, $F_{(4,244)}$=2.465, p=0.046. This effect was considered spurious as the non-significant MANOVA contraindicated examining the higher level interaction.

TEIQ-Wellbeing subscale & threat responsivity. The Wellbeing subscale of the TEIQ-ASF was the only subscale to fall within a single component in the factor analysis. This subscale also had the highest overall scores across all the subscales and student groups. This high score may be due in part to the sensitivity of some students to the threat of responding honestly to questions regarding their wellbeing. Drawing from the GH rating indicate that certain students who showed tendencies towards negative emotions in their drawings scored extremely high on the Wellbeing section of the TEIQ. For example, in the lowest rated drawings from the Waldorf students, the 7th grade male appears to be quite disturbed (see Figure 21). However, this student showed the highest score on the Wellbeing sub-scale, 7.0, more than one full standard deviation above the mean of the entire population (Z score Wellbeing: 1.30). This effect was not seen for this student on the School Enjoyment (Z score School Enjoyment, -0.17). It was thought this effect may have been due to the highly personal, and potentially threatening nature of the Wellbeing subscale questions, such as “My life is not enjoyable”, or, “I’m happy with my life”. These findings question the validity of the TEIQ-Wellbeing subscale.

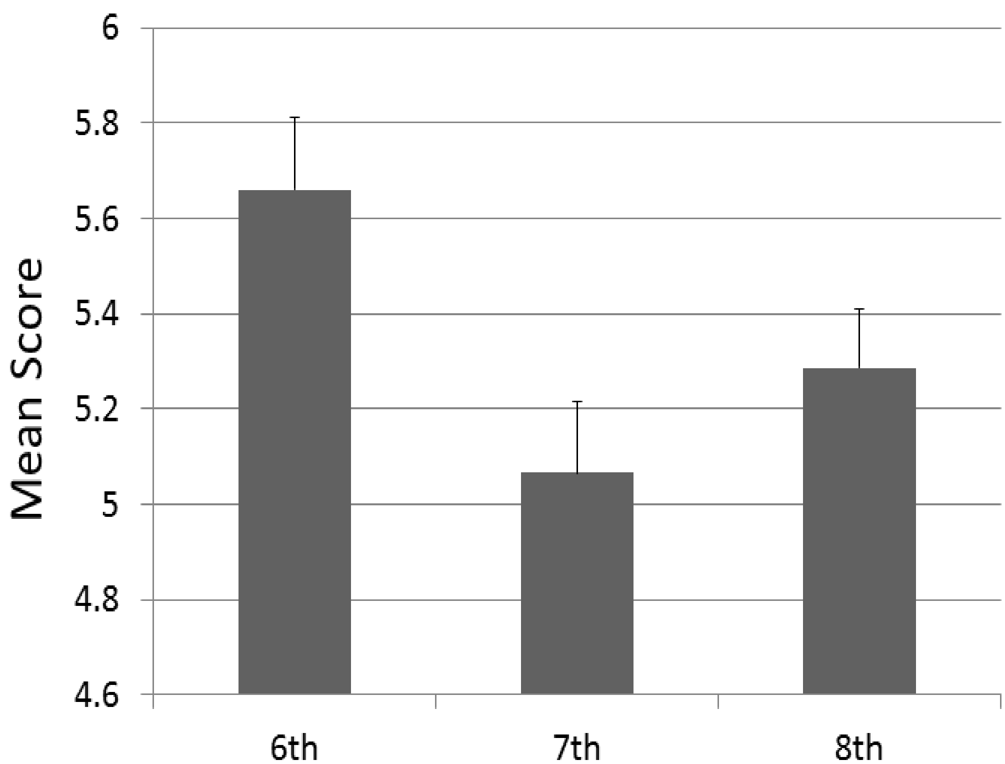

Figure 26. Grade level difference on the wellbeing subscale of the TEIQ showed significantly lower scores for those students in 7th grade. (Remedial students excluded). (error bars = SEM)

Looking across the different groups, and by grade, there was a higher wellbeing score in the traditional school than in the IB for 6th and 7th grade, and in the Waldorf school for 7th grade, although these did not reach significance (Table 33).

Table 33. Means & Standard Deviations for TEIQ Subscales

Mean / *StDev*	Wellbeing			Self-control			Emotionality			Sociability		
	6th	7th	8th	6th	7th	8th	6th	7th	8th	6th	7th	8th
Traditional	5.4	5.2	5.1	4.3	4.0	4.3	4.4	4.1	4.2	4.7	4.7	5.0
	1.2	*1.4*	*1.3*	*0.9*	*1.2*	*0.8*	*0.8*	*0.8*	*0.9*	*0.9*	*0.7*	*0.7*
IB	5.3	4.7	5.4	4.1	4.3	4.5	4.5	4.8	4.7	4.6	4.7	5.2
	1.3	*1.7*	*1.6*	*1.1*	*0.9*	*0.8*	*0.8*	*0.8*	*0.7*	*1.0*	*1.0*	*1.0*
Waldorf	5.9	5.1	5.8	4.6	4.6	4.6	4.9	4.7	4.9	5.4	5.2	5.4
	0.9	*1.3*	*0.9*	*0.7*	*0.8*	*1.0*	*0.9*	*0.7*	*0.8*	*1.0*	*0.9*	*0.9*

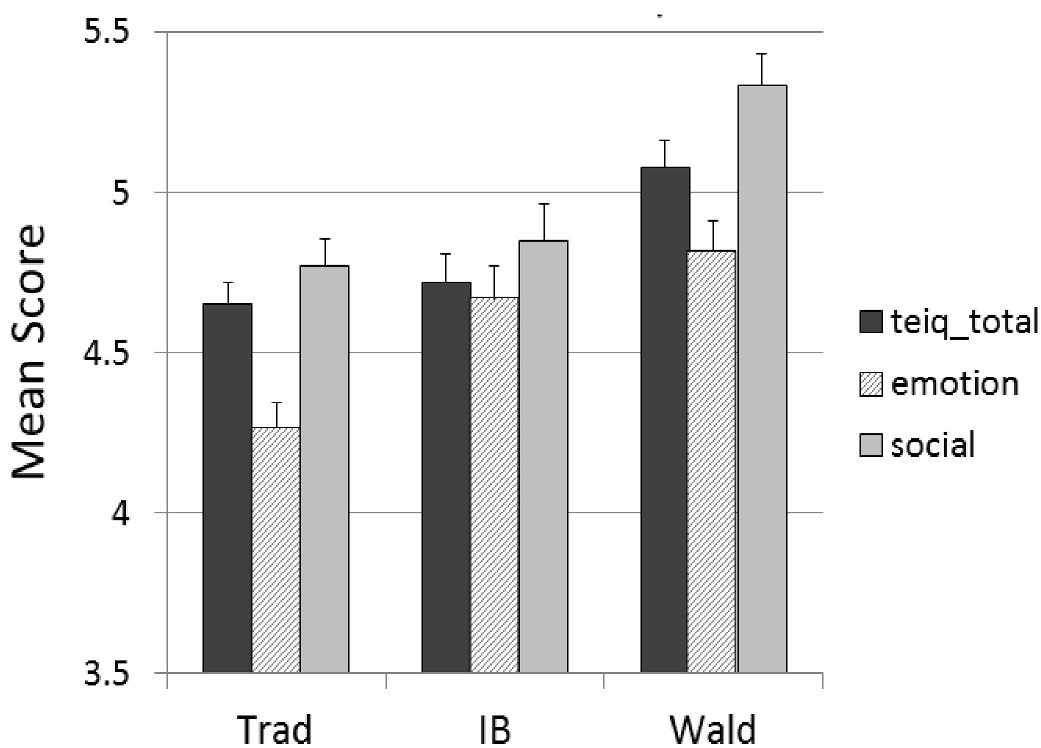

Figure 27. School type differences across the measure of student social-emotional development. IB and Waldorf student scored higher in emotional intelligence than Traditional students, while Waldorf students were higher in overal TEIQ scores as well as scores on the Social subscale. (error bars = SEM)

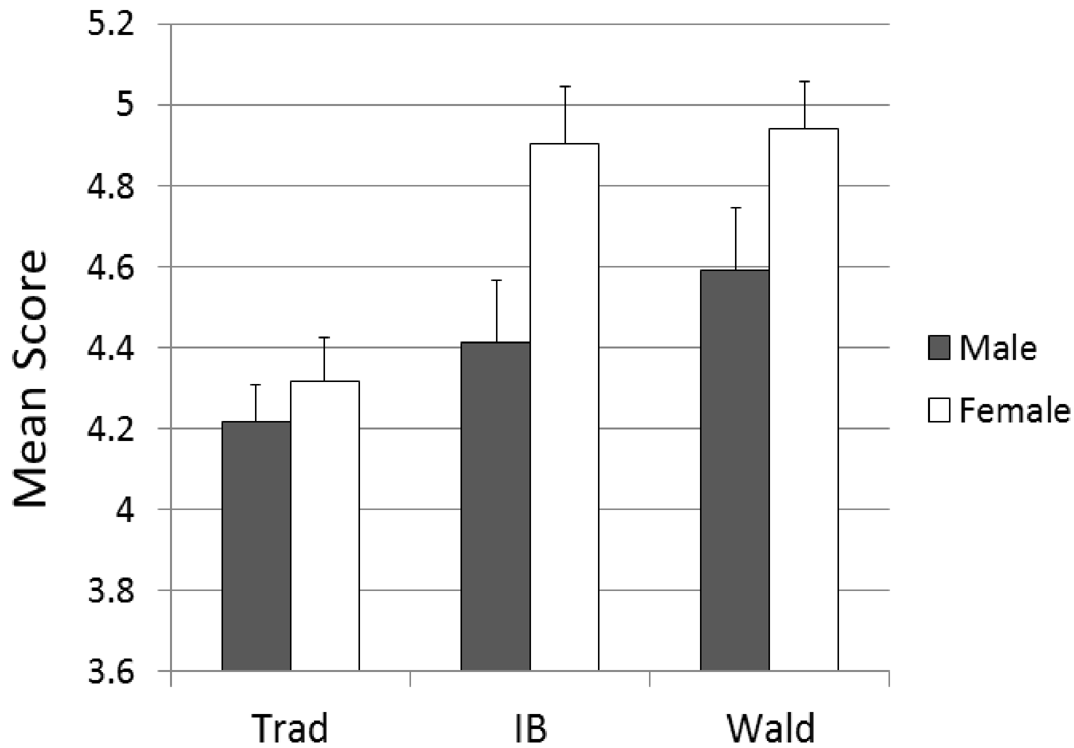

Figure 28. Females scored higher on the Emotionality subscale for the TEIQ across all schools. This gender difference was greatest for IB, and smallest and non-significant for the Traditional school. (error bars = SEM)

Critical thinking scale. The Cornell Conditional Reasoning Task (CCRT) measures aspects of logical reasoning based on conditional statements. This scale has several dimensions: Verbal logic statements using descriptive language, Algebraic logic statements using letters/variables, and statements using descriptive language that compete with Prior knowledge. The three are referred to here as Verbal, Algebraic, and Prior here. Most statements used were Verbal using familiar objects and situations, 13 questions. The second most frequent was the use of Algebraic logical expressions, five questions, and the third category, with only two questions used logical statements that contradicted Prior knowledge. The data were analyzed for the separate constructs with the exclusion of students from the Traditional school classified as remedial/strategic. Because the three constructs were related in a single scale, a MANOVA was administered to control the overall alpha level.

The MANOVA output show a significant main effect of Group $F_{(6,480)}$ =8.17, p<0.001, and Grade $F_{(6,480)}$=3.24, p<0.005 as well as a significant Group X Grade interaction, $F_{(12,723)}$=2.06, p<0.05. There was no main effect for Gender nor were there any significant interactions. Because Gender did not contribute to the model, it was removed, and the model was re-run with Group and Grade as the independent variables.

For all three constructs of the CCRT, Verbal, Algebraic and Prior, there was a main effect of Group, Verbal: $F_{(2,252)}$=20.5, p<0.001; Algebraic: $F_{(2,252)}$=12.1, p<0.001; Prior: $F_{(2, 252)}$=6.5, p<0.005, as well as a significant main effect of Grade $F_{(2,252)}$=13.9, p<0.001; Grade $F_{(2,252)}$=3.5; F(2,252)=2.9 (Verbal, Algebraic, Prior respectively) (Figure 29 and 30). Pairwise comparisons for each of the groups indicated that in all cases the traditional school scores were significantly lower than both Waldorf and IB students. There was no significant Group X Grade interaction for Verbal or Algebraic questions, however, for questions conflicting with Prior knowledge this interaction reached significance, $F_{(4,252)}$=4.8, p<0.005. Pairwise comparisons indicated that for Prior Knowledge IB students in 6^{th} grade performed significantly better than both Waldorf and Traditional schools. For 7^{th} grade, there was no difference between IB and Waldorf but both these experimental schools were significantly better performing than the Traditional schools. For 8^{th} grade, Waldorf students performed better than both IB and traditional school students, who did not differ from one another (Figure 31).

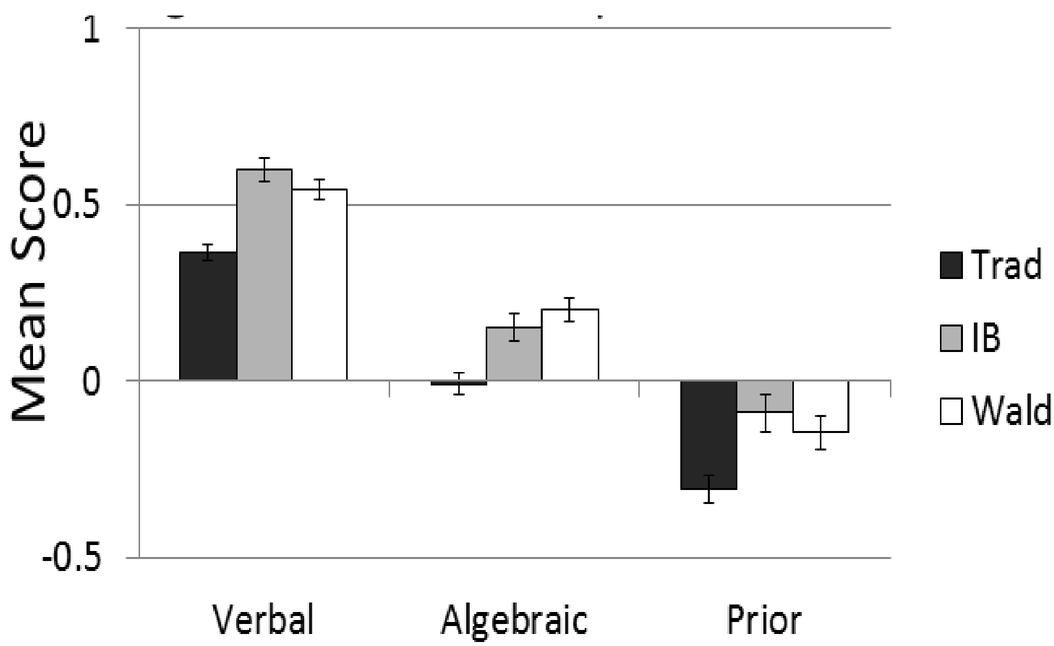

Figure 29. Group difference on the CCRT. Traditional school students scored more poorly across each question subtype.

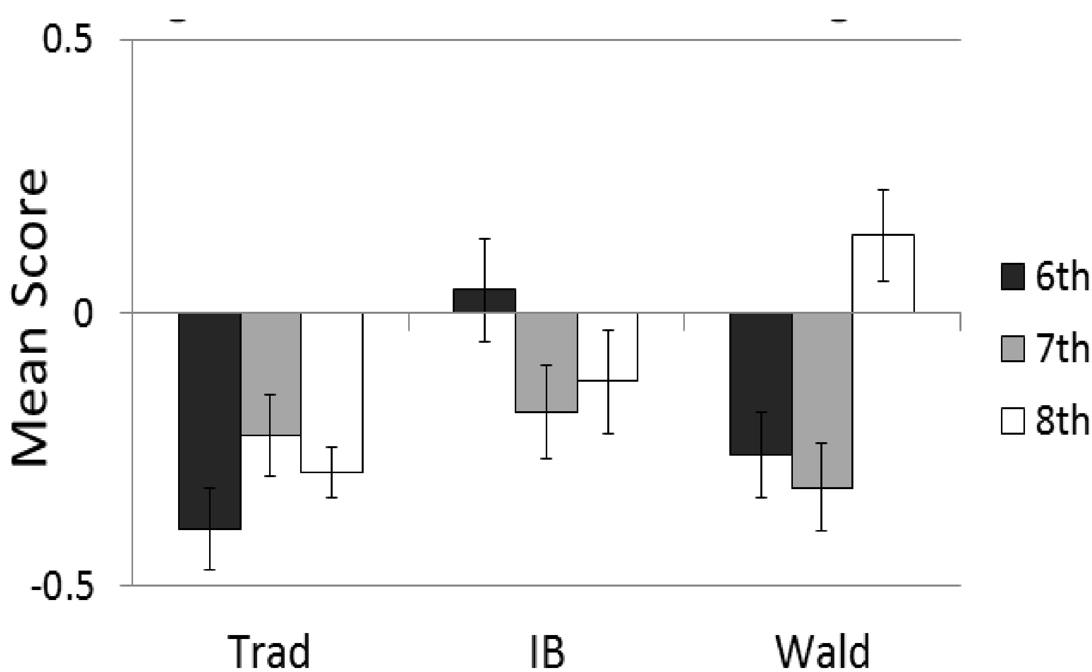

Figure 30. Group X Grade differences for questions requiring suppression of prior knowledge. IB 6th graders, and Waldorf eighth graders were the only two groups to perform above the zero line.

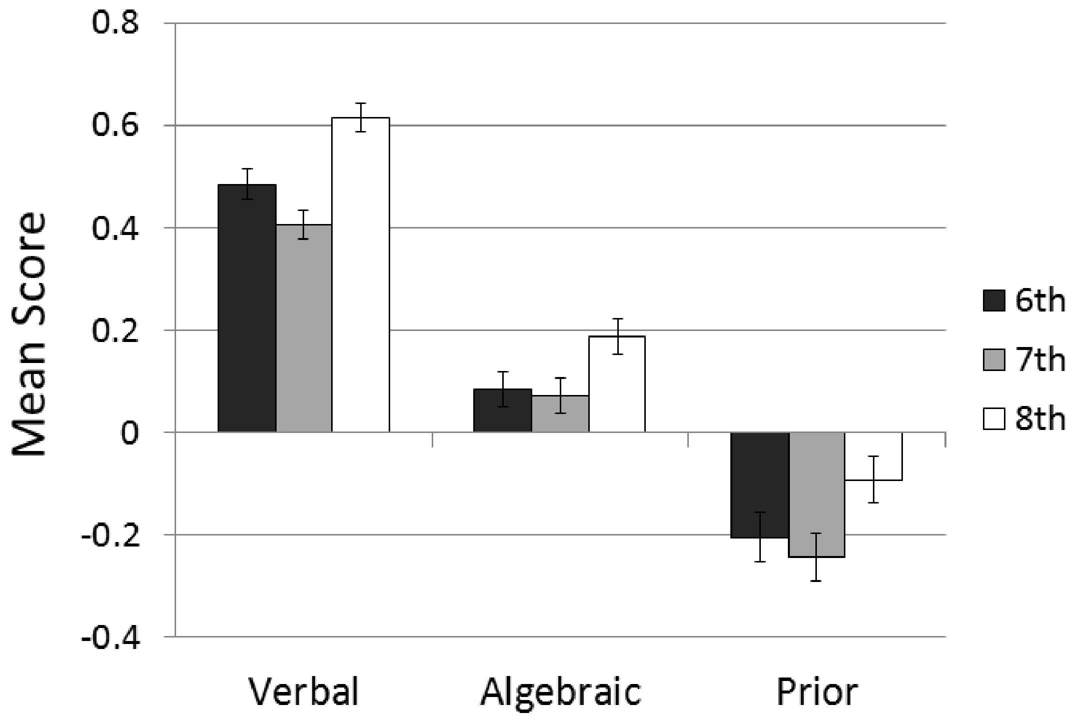

Figure 31. Grade X Task differences on each of the CCRT question types. All groups performed best on the verbal reasoning quesitons, and all performed most poorly on questions requiring students to ignore prior knowledge. Eighth graders performed better on each of the CCRT question types and seventh grades performed the worst in each category. (error bars =SEM).

Correlations between scales. A correlation matrix was run on all of the collected scales to examine the possible relationship between the measured constructs. There were several correlations between our surveys that indicated strong relationships between the variables. Most of the scales were positively correlated, with the exception of the ADHD scale which showed a negative relationship to each of the variables, several of which were significant (School Enjoyment, Emotional Intelligence and Critical Thinking both Verbal and Algebraic). All of the CCRT measures were highly inter-correlated, although they differed in the degree of their correlation with other variables.

School enjoyment showed a positive relationship to nearly all the variables, as did the TEIQ.

Table 34. Inter-correlations for the Selected Surveys

Variables	1	2	3	4	5	6	7
(1) School Enjoy (N=325)	–	-.460**	.471**	.140*	.100	.119*	.178**
(2) ADHD (N=325)		–	-.462**	-.111*	-.115*	-.052	-.009
(3)TEIQ-ASF (N=324)			–	.165**	.158**	.046	.110
(4) CritThink -Verbal (N=319)				–	.377**	.206**	.237**
(5) CritThink-Num (N=319)					–	.169**	.186**
(6) CritThink-Prior (N=319)						–	.012
(7) GH Rating (N=286)							–

*p<0.05, **p<0.01

Table 35. Correlations for the TEIQ Subscales

Subscales TEIQ	Wellbeing	Self-control	Emotionality	Sociability
(1) School Enjoy (N=324)	.355**	.292**	.407**	.223**
(2) ADHD (N=324)	-.341**	-.405**	-.338**	-.144**
(4) CritThink -Verbal (N=319)	.030	.106	.135*	.193**
(5) CritThink-Alg (N=319)	.048	.091	.189**	.126*
(6) CritThink-Prior (N=319)	.045	.061	.036	-.031
(7) GH Rating (N=286)	.028	-.017	.155**	.149*

*p<0.05, **p<0.01

Because the TEIQ-ASF had several sub-scales an additional analysis comparing the various scales to the subscales was included to look more closely at the relationship between these factors of MBE. School enjoyment was highly correlated with each of the TEIQ subscales, while the Attention-ADHD scale was negatively correlated with all of the TEIQ subscales. The Verbal and Algebraic portions of the critical thinking task positively correlated with emotionality and sociability, while the task of Prior knowledge did not correlate with any of the subscales. The GH rating also correlated with the emotionality and sociability subscales of the TEIQ.

Many of the correlations made strong theoretical sense, such as the relationship between School enjoyment and Social-Emotional intelligence as measured by the TEIQ, or the inverse relationship between the attention scale and the scale of emotional intelligence, in particular the self-control subscale (Table 35). Others made less obvious sense, that is the positive relationship between School Enjoyment ant the GH rating. The GH rating also correlated with the CCRT –both Verbal and Algebraic tasks.

Summary of Survey Findings

The differences between the school models reported here should be understood as a starting point for further investigation, nonetheless, they are suggestive. Overall, Waldorf and IB students performed better on cognitive and emotional measures than students in the Traditional school. Waldorf students, and in particular 8th grade Waldorf students, scored higher even than IB students in each of the categories. While IB students showed equivalent scores on the TEIQ emotional subscale, Waldorf student scores significantly higher in the Social and Composite score. For critical thinking, Waldorf and IB did not differ, although IB students had higher mean scores for Verbal and Prior knowledge, and the difference was most pronounced for 6th graders. The fact that Waldorf students did not excel on the CCRT until 8th grade is consistent with the developmental focus on social and emotional development with a delay in abstract intellectual engagement.

The fact that there were no significant differences between our groups on the attention scale deserves comment here. This scale, although developed by the researcher, demonstrates some construct validity in that it was negatively correlated with a number of scales consistent with what would be expected from the literature. Each of the TEIQ subscales negatively correlated with the ADHD scale, and the highest correlation was found for the subscale of “self-control” (Table 35). The fact that the students in our two experimental schools may have shown similar attention profiles may have more significance than one might think. Both the Waldorf and the IB school conversations around parent selection of their schools brought up the issues of parents seeking out their schools to better serve a child who needed a different learning experience, either slower academics, and/or especially the need for more allowance for movement and freedom in the class. In the conversation with one of the founding parents of the IB school, the impetus for participating in the formation of the school was to provide a project based learning experience for her daughter, who she believed in the traditional school would have been labeled as ADHD and required her to use medication. In fact, comments from the parent blog data remarked at how these schools often offer an alternative and become a draw for parents who are looking for options for their children with learning and attention differences.

> The school is trying hard to balance of the ratio of special needs children per classroom. Many parents have sought out this school as a place for their child who did not fit into other schools, which became a challenge.

Theoretically, a program of neuroeducation should be working to build cognitive capacities, including attention. More controlled studies will be needed to determine the extent of success various model produce in this area.

A case study approach is suited to looking deeply into a particular school philosophy, structure and success. It is challenging to use this approach with quantitative measures as the schools themselves represent diverse cultural communities. Nonetheless, it is the belief of this researcher that by beginning to look closely at models both on a broad level, and through detailed case studies, we can drill down into the potential for creating a successful program of neuroeducation in our public schools.

CHAPTER 7: Discussion

The research presented here is intended to further the agenda of MBE and neuroeducation as a framework for educational reform. The current system is not based on our knowledge of the developing brain, and as a result too many of our bright students are misunderstood. The loss of human capital, and individual potential these students represent, is a problem that society can no longer afford to ignore. Today we need a model of education that rise to the occasion and maximize our students' ability to face a challenging and unknown future. MBE and neuroeducation hold a great deal of promise in creating such a program, and it is hoped that this dissertation begins to define points of entry into this domain. This final chapter, and summary of the findings, is broken into three sections based on the three primary research questions. The discussion attempts to go beyond a discrete consideration of each of the three research questions towards a synthesis of the ideas as they were generated from this three year process of writing and research.

Research Question 1: What is MBE?

A paradigm shift is occurring in education due in large part to a growing body of knowledge in the neuro and cognitive sciences. As with any shift in thinking there is the need for a vehicle by which this change can take place. MBE provides this vehicle through the creation of organizational structures and building of collaborative engagement of multiple stakeholders. What makes MBE unique as a program of education reform is the inclusion of research scientists. Scientists from the fields impacting or providing a foundation for guiding curriculum decisions based on the developing brain and nervous system are brought to the table with the intention of creating an ideal in education never before seen. The added value of MBE is its provision for a developmental curricular framework for building student skills and maximizing individual potential. MBE is well suited for reform because it provides the organizational and structural contexts for how to achieve this goal of maximizing student potential through engaging teachers, educational leaders and school institutions. In contributing to the creation of a curricular model, MBE derives information from universal principals of learning from a diverse array of scientific disciplines. These universal principals fit within a system of developmental milestones rather than specific content, and hence because they reflect universal properties of the brain, this approach provides the opportunity to work within dramatically different cultural backgrounds while respecting the differences those contexts require. In contributing to the construction of new institutional forms, MBE creates venues for connections to be made between scientists and teachers, community members and policy makers, in order to build the infrastructure for a new way of educating. This growing effort hopes to forge the way towards a model of education that will build students' brains for higher cognitive functions, social abilities, and transfer of learning to imbue students with the courage and ability to shape the future towards peace and global prosperity.

Why MBE Represents a Unique Construct

In the interviews with academics and educational leaders, there was a great deal of debate about the ongoing distinction between MBE and educational neuroscience. In determining whether these are separate constructs, the evaluation of the similarities and differences between the goals and systems that make up the central core of the efforts should be examined. Currently, there is a popularized view that MBE is equivalent to educational neuroscience. This is exemplified by the current Wikipedia entry for "Educational neuroscience":

> **Educational neuroscience** (also called **Mind Brain and Education**; MBE) is an emerging scientific field that brings together researchers in cognitive neuroscience, developmental cognitive neuroscience, educational psychology, educational technology, education theory and other related disciplines to explore the interactions between biological processes and education. (Retrieved 12/1/2012 from http://en.wikipedia.org/wiki/Educational_neuroscience)

This definition clearly outlines some of the shared goals of educational neuroscience and Mind, Brain and Education, but the question remains as to whether the overlap with respect to the conceptual problem space signifies identical domains. In their review of the subject, Varma, McCandliss and Schwartz (2008) outline two categories of divergence between education and neuroscience where differences exist (Table 36). It is proposed here that these differences are only partially rectified in educational neuroscience, and that additional work must be done to truly address the methodological and pragmatic aspects of working within school systems and structures. This, it is believed, is better served through the creation of a separate organizational structure, which could be taken up as a central responsibility of MBE.

Educational neuroscience is technically a part of the field of neuroscience proper, and utilizes the same methodologies and theories of neuroscience as a scientific discipline. As pointed out by Varma, et al (2008) the differential methods utilized by neuroscience and education pose a problem in integrating the fields. In looking at the pragmatic barriers to applying neuroscience findings to educational practice, there is the need for a complete transformation from neuroscience as an approach, to be able to fit those findings within teaching pedagogy and educational systems. MBE is better positioned to provide the necessary connections between these educational systems than would be appropriate for the field of educational neuroscience. MBE therefore holds an important pragmatic problem space to address those aspects of neuroscience that Varma, et al. (2008) refer to as *incommensurable* to education. Some researchers have begun to address this problem space, and Hille (2011) refers to this process as translational research. Translational science was one of the preferred definitions of MBE that emerged from the interview findings presented in Chapter 4. Understanding the special role of MBE in that process of translation, as well as its unique position in other domains, can help to clarify goals, and strengthen connections between important stakeholders in the field.

Table 36. Points of Divergence between Neuroscience and Education. Adapted from Varma, McCandliss, & Schwartz (2008)

	Scientific
1)	Methods: Neuroscience methods do not provide access to educational contexts
2)	Data: Localizing different aspects of cognition to brain networks does not inform education
3)	Theories: Reductionism is inappropriate
4)	Philosophy: Education and neuroscience are incommensurable
	Pragmatic
1)	Costs: Neuroscience methods are too expensive to apply to education
2)	Timing: We do not know enough yet to apply this knowledge
3)	Control: If education cedes control to neuroscience if will never regain its independence
4)	Payoffs: Too often in the past, neuroscience findings have been turned into neuromyths.

Four points are discussed here relating to the potential unique contribution of MBE to the implementation of neuroscience into educational practice. These are: (1) MBE allows expertise from various fields, not just neuroscience, (2) MBE focuses on synthesis across fields, (3) MBE works directly with teachers in professional development, and (4) MBE is better positioned to address educational leadership necessary for reform. These four themes can be used to inform the development of MBE as an important unique discipline for advancing the cause of education reform with respect to the neuro and cognitive sciences.

MBE supports expertise in multiple fields. In discussing the possibility of developing an effective field of educational neuroscience, Hruby (2012) emphasized the importance of “respect for the expertise of others in this hybrid and necessarily collaborative enterprise” (p 1). Where MBE provides opportunity for this collaboration is through the higher degree of inclusion of related fields beyond just the neurosciences. The bridging of this gap requires more than research, and the avenue by which this information is presumed to flow to the consumer, that is the teacher, cannot be relied on by a handful of consultants, and especially not by the popular media who are renown for providing only a superficial understanding of scientific knowledge and misrepresenting the facts (Lipps, 1999).

Scholarly expertise requires a depth of understanding of scientific and pragmatic issues on a specific topic that often scholars are constrained regarding their breadth of understanding. Educational neuroscientists must be scholars in both neuroscience and the educational constructs relevant for their research to be truly effective. For example, those studying neural mechanisms of reading must also understand the educational literature on reading theory and practice, as well as knowing the history of the implementation of this research with regards to interventions and classroom practice. However, although research in educational neuroscience informed by historical and current practices in education is critical for the success of this endeavor, MBE expands this discussion to include fields such as anthropology, sociology, and educational psychology, all areas that may have relevance for creating a broad model of education beyond just what we can winnow from our current understanding in the neurosciences. It is unlikely that the depth of expertise will be found in any one field, and hence, the role of MBE in creating cross communication and collaboration amongst experts provides a solution to the information bottleneck.

In creating a meaningful model of education, we must not be limited to what can be understood from the neuroscience; rather knowledge from psychology, aesthetics and social theories with empirical strength that may not yet have neurological correlates should be utilized as we move towards a research based model of curriculum. Furthermore, issues of the mind, identity, and personal meaning are beginning to be addressed in some neuroscience research, but are better informed at the moment through other disciplines. In this way, MBE is broader than educational neuroscience, and serves as its specific purpose the creation of a synthesis across fields.

MBE focuses on synthesis across fields. Educational neuroscience has as its primary goal to work on problems relevant to education from a biological perspective. The more expansive view of MBE is to not find the biological mechanisms for cognitive processes of learning as much as it is to create avenues for applying that knowledge in meaningful ways towards models of education. Hence, MBE works more doggedly at the level of translation. MBE works from the science to inform practice, and yet, the primary function of MBE is to create a bridge between the fields to draw out what is meaningful for education in a synergistic way. As such, MBE may be considered a translational science. The idea of creating a field based on the goals of translation is one that is hardly understood. In fact, when issues relevant to teachers were addressed by over 600 educators, the least important issue was the idea of creating a translational science (Rato, Abreu & Castro-Caldas, 2011). Perhaps this is because so little is understood about what it entails to create such a synthesis. The translation of science for teachers must become a collaborative effort of sharing knowledge and deriving what is meaningful from both fields to create practical solutions to age-old problems. While educational neuroscience places the science first, and then includes the educators as collaborators. MBE has a looser positional stance, and so is better able to mediate between groups, providing equal grounding between the component players. The process of translation falls in that intermediary space between fields, and it is important for both researchers and teachers to understand that the translation of the science has its own dimension of meaning based on a synthesis of information from multiple levels of analysis.

MBE works directly with teachers in professional development. In the words of one participant (P1), "Educational neuroscience is not about creating a particular brand of teacher education program." MBE, on the other hand, had its first appearance in the Graduate School of Education at Harvard through the creation of a pre-service teacher credentialing program; and new programs in MBE, for example the University of Texas', Southwest Center for Mind, Brain and Education, are heavily focused on teacher credentialing and professional development as well as promoting teacher-directed action research. If our growing understanding of the science of learning is to have any real impact of professional behaviors, there must be a sufficient level of teacher professional development which includes mentored practice. In the words of one interview participant, it was not for lack of funds, or facilities, but for the want of trained teaching staff that neuroeducation would have difficulty entering the mainstream of public education. It is in the programs of MBE where this teacher professional development is taking place, and this must continue to be a central focus of MBE if we are to see effective change.

In addition, the involvement of not just teachers but educational leaders and administrators will be critical if MBE is to emerge as a successful educational reform movement. This is an area that is not yet formally addressed by either MBE or educational neuroscience; however, it is the belief of this researcher, that MBE holds a position able to move into this uncharted territory and to successfully address this pragmatic space through the development of a new kind of educational leader informed by the sciences.

MBE addresses educational leadership necessary for reform. The heavy emphasis on teacher development and curriculum makes MBE more closely linked to school leadership and in this matter unique from educational neuroscience. This was highlighted by the limited development of the role of leaders in the interviews. Teachers were included in a number of discussions including increasing teacher science literacy, the role of the teacher as a resource, and the importance of teacher involvement in action research and documentation of practice. Educational leaders were seen as needing to pick up the ball, and provide the appropriate training for teachers, but there was less of a framework for this to happen. With respect to this, the lack of resources for leaders in creating these changes were highlighted by comments regarding the most frequently cited journal, *Mind Brain and Education*. According to interview comments, this journal was not meeting the needs of the entire audience, especially the education community. Since the journal already has an academic readership and a large teacher following though their International Mind, Brain, and Education Society, the inclusion of a greater number of papers directed at educational leaders is one point of interaction for advancing the field. A special issue, or separate divisions of the journal, i.e. MBE Leadership versus MBE Research, could help spark conversations around unaddressed issues and provide a forum for information sharing. Indeed, curricular practice must respect the learning sciences, but unless we engage the school leadership, the implementation of these practices will never happen.

Considering MBE as a program of educational reform, it will be necessary to include district and administrative leaders as full participants in this endeavor. To encourage this change, there is an emerging body of networks for collaboration. Research schools, consortiums, and networks for sharing of databases can all contribute to the building of an empirical base necessary to move towards a proof of concept. The collaboration between scientists and educators was described as reciprocal in the interviews, however regarding neuroscience in particular, some in field have referred to the interaction as a “one-way street” (Turner, 2011). Educational leadership and research occupy different domains of action, and creating the reciprocal interactions between these groups will require building effective infrastructures. MBE holds the promise for helping to create these avenues for exchange, and it should be noted that Harvard Graduate School of Education, the local at which MBE initiative was born, has recently opened a graduate program in educational leadership, the first new degree to be offered by the school in 47 years (“Harvard University to Offer Ed.L.D,” 2009).

Critical Stakeholders in MBE

Recognizing and attending to the multiple needs of the stakeholders involved in the creation of MBE as an effective reform movement will be necessary if the field is to successfully advance. There are both shared and individual goals of each of these contributing bodies that must be recognized in order to avoid conflicting activities. Work should continue both in parallel and through collaboration to advance the message of understanding the learning sciences. Recognizing the important role of each of the stakeholders in this effort can help clarify where those points of action must take place.

In MBE, there is the space to work respectively in each member's area of expertise while still contributing to the shared vision of educational reform. For example, working in parallel, each contributing member body can work at the level of policy within their own domains. In addition, each group can provide outreach to communities in order to help inform parents and community members towards understanding the modes of learning that neuroeducation entails. But also, MBE itself is about collaborative work, and represents a cohesive organization focused on a shared goal. The points of collaboration between stakeholders is outlined here through examining the role of four main stakeholders in MBE as a serious endeavor of reform.

Role of academic researchers. The formal and informal ways in which researchers are involved in this effort of education reform represents a unique aspect of MBE. Researchers play a number of roles that may or may not be considered part of MBE specifically, but nonetheless contribute to its advancement. Academic researchers with provisory roles in the creation of social policy, or researchers studying issues with critical value for informing the understanding of learning or motivation, may contribute to the advancement of MBE in a passive manner. A more precise definition of the role of scientists contributing to MBE movement would be to take a formal and active role in creating change as part of a shared vision or within a collaborative group. MBE researchers in these roles engage in both research and teacher outreach, providing tutelage and guidance while at the same time availing themselves of the methods and problems of education. This communication and collaboration with school districts actively contributes to the advancement of effective practice, and provides teachers not only with necessary knowledge to inform their practice, but inversely helps to inform research questions to be enacted in the laboratory. This type of active involvement of researchers is what distinguishes the MBE researcher from academic researchers indirectly contributing to the body of evidence supporting our understanding of teaching and learning.

Role of consultants. There is an unsung hero of the MBE movement, the professional school consultant. Consultants are less well understood members of the MBE movement, and yet individual consultants have perhaps done more to advance the notions of practice based on the brain sciences than any of the other key stakeholders. The majority of published material providing curricular frameworks based on the brain sciences have come from consultants (Caine & Caine, 1991; Jensen, 2006, 2007, 2008; Sousa, 2011; Wolfe, 2001). Consultants and those who have written pedagogies intentionally based on the brain research must be considered as primary participants in the work of MBE. The role of consultants is not to engage in research in educational neuroscience, but to translate that research into something meaningful for teachers. Consulting can occur in schools, or at the level of advocacy and can be engaged in by academic researchers, educational leaders, or those who have devoted their life-work to consulting. It is those who are working most centrally in consulting who have been left out of much of the conversations in MBE thus far.

Although consultant may have had the most direct impact on schools, through ongoing engagement with districts, the missing component from these efforts has been the scholarly publishing of outcomes. Projects developed by consultants and engaged in through school districts should be included as part of a body of research efforts of MBE. Better documentation of results, through collaboration with outside researchers, or teachers engaged in action research must begin to become part of the practice of consultants if we are to understand the effectiveness of neuroeducational practices.

A number of models were brought up by interview participants (Appendix B) many of which were developed by consultants. Peter Chaban (2010) describes the purpose of his TeachADHD project to “bridge new research about ADHD in the field of neurosciences with classroom practices” (p 34). He works as a teacher, researcher and consultant, and this taking on of multiple roles is frequently seen in the intersection of the sciences to practice, a position ideally suited for those engaged in the work of MBE. However, as a formal definition, consulting programs might fall outside the range of educational neuroscience, as they are frequently interpretations of the literature not research programs themselves. If we are to move out of simply addressing the science to implementing programs of education, it would be advisable to include consultants as collaborative partners in the validation of programs. MBE provides a greater leeway for the participation of consultants as one of its primary purposes is to make those links between fields.

Role of teachers. Issues relating to teachers and the code of teaching came up under every major theme outlined in this dissertation. In particular, teacher training was seen as a critical component to the success of neuroeducation. One participant pointed out that in order for programs to be scaled-up to whole school or school districts, teacher training would be the critical factor, even before issues of funding or policy. Creating effective pre-service graduate programs in MBE, and not just relying on in-service trainings was thought of as important to provide the adequate foundation and to give teachers the tools to work effectively in their classroom. Teachers play another critical role in the development of MBE and that is through the evaluation of practice. Interview participants spoke to the importance of documenting practice, in part through research schools where teachers would have the benefit of formally evaluating the processes and outcomes of experimental curriculum and pedagogies. One participant suggested a new role for the teacher, that of a hybrid teacher-researcher. This position has been defined as a division of labor between teaching and research where teachers perform, document and design research as part of their duties while serving a reduced teaching load (Rodriguez, Unterman, Ohle, & Daley, 2011). The redefined roles of teachers under MBE as action researchers will help to both empower the profession of teaching, and advance the knowledge necessary for creating an effective program of neuroeducation.

Role of school administrators. An important component of MBE that has yet to be fully realized involves outreach to the administrative and leadership body of the school system. The research on the role of the principal in developing and supporting teachers in enacting brain-compatible education is limited. Although there has been at least one publication on the subject (Nunnelley, et al 2009), the field of MBE has not formally addressed this issue.

The role of the school administrator must be clearly defined if the field is to advance harmoniously. Effective teacher training will be lost when it “hits the vine” if it is not supported by school leadership (quotations indicate comment from P9). Nunnelley, et al. (2009) describe the ways in which principals can support this process, but it is the belief of this researcher that the role of school leadership must be expanded by empowering principals to become advocates for students. This requires that not only teachers develop a developmental knowledge of student ability, but that principals too are trained in the science of development and learning sciences. Principals help to create the goals of a school, impact the overall environment, and can provide the necessary support for struggling teachers. Some interview participants felt that the focus should remain on the side of education and not enter the organization end as exemplified by this quote:

> I believe there is great promise and I guess I would say I'm a neuro optimist about the potential for education but I hope the focus doesn't go to the organizational side of education but to the learning elements within them which are useful for the learner him or herself. (P13)

Nonetheless, it would be disastrous to avoid addressing one of the major stakeholders in any reform effort. It will be necessary in the near future to determine how school leadership will support changes in teaching practice, especially when they may conflict with the current focus on testing, state mandated textbooks and the convention view of learning. This doesn’t mean that the focus of the curriculum should not remain on the side of the science, it simply recognizes the need for supporting this dramatic changed in our schools, based on a true knowledge on the part of the leadership, as to how to provide the best for the student body. Through clarifying the roles of each the major stakeholders in this endeavor, it will be possible to work collaboratively towards a shared vision of education.

Policy Recommendations & Neuroeducation

From the interviews, there was a clear consensus that MBE should include engagement and involvement in policy. This was due in part to the belief by most participants that the current accountability policies and structures made it difficult or impossible for schools to engage in the principles of neuroeducation. According to interview participants, barring elimination of HST, provisions for alternative approaches at the level of policy would be necessary if a program fully grounded in the brain sciences were to be actualized. The creation of alternative policy guidelines would support practices of neuroeducation while building the empirical evidence through evaluation of student outcomes. Such programs could then become prototypes of effective education including lab schools, democratic-free schools, or novel approaches developed through collaboration with researchers. Some of the basic tenets of the proposed policy alternatives might be:

Allowance for use of alternative materials. Certain states have adopted mandated textbook laws requiring each class of each grade to utilize state-approved textbooks. Because neuroeducation is developing, and preferably should be allowed to develop in an organic manner, the use of textbooks, especially content-based texts, could reduce the flexibility of emerging programs to meet the needs of individual classes with unique interests and cultural diversity. This is not to say that textbooks could never be developed based on the properties of neuroeducation; however, it is more likely that conceptual frameworks would better serve this purpose since curricular content should be student responsive and even student selected. Steiner discouraged the use of textbooks for learning, and believed the use of original source material to be far superior. Indeed, the idea of using the richest possible material would encourage such an approach. For example, reading the actual text of the Constitution of the United States, in depth, and with interpretation through discussion would be more significant than reading *about* the Constitution or reading excerpts and then answering multiple choice questions at the end of the chapter of a textbook. But reading and interpreting material with a high level of complexity such as the Constitution requires that teachers take the time to go into depth with the material. Hence, such an approach requires that we allow for schools to create their own timelines, including their own benchmarks.

Allowance for the use of alternative standards & benchmarks. The current standards and benchmarks, as well as the coming Common Core State Standards (CCSS), were developed with input from a number of educators and educational leaders. However, these were not built around the emerging concepts from the learning sciences, but were developed primarily through the use of historical frameworks of building skills and content knowledge within discrete academic disciplines.

There are two primary reasons to encourage the development of a model of alternative standards. First, neuroeducation must be able to fit itself within the grammar of schooling if it is to be successful on a wide scale (Tyack & Tobin, 1994). The current accountability policy obstructs the ability for true alignment with the science by compelling schools to follow externally developed standards not grounded in the learning sciences. In order to be in alignment with current policy mandates, programs of neuroeducation should be allowed to develop and apply alternative standards so long as they are documented as a means of accountability.

The second, and perhaps more important reason for developing alternative standards, is to start to define a working framework for the evaluation of school approaches aligned with the development of the brain. If a program of neuroeducation were allowed to develop its own standards based on the knowledge of the development of physical, emotional, and cognitive capacities, this would create policy directives on a small scale that could serve as a model for larger initiatives. Having a set of standards that could be applied across alternative school models would allow for comparison of student outcomes. Performance outcomes on measures of cognitive and emotional skill sets, rather than academic disciplines or content, would serve as a first step in creating a proof of concept of neuroeducation, an important component of evaluating a successful curriculum. Developing empirically supported standards based on the unfolding of social and cognitive skills through the collaborative efforts of researchers and educational leaders could help reinforce the integrity of an alternative educational program.

Provision for alternative assessments. Berliner and Biddle (1995) when discussing the start of the standards and testing movement, indicated that although our nation has become obsessed with performance on standardized tests, in the history of American education, what Americans value most has been not performance on tests, but student creativity, the breadth of student experiences, and building a well-rounded, thoughtful, and responsible person. Not only do American's value critical thinking, and higher order thinking, research comparing these abilities to other countries is an approach that holds promise to show where American schools systems excel in these areas (Ben-

Chaim, Ron & Zoller, 2000; Benjamin, 2008). Berliner and Biddle (1995) state that if Americans want to see how their schools compare to other countries, they should at least be testing for those traits and abilities they value most, pointing out that, “none [of the comparative studies] examined student creativity, initiative, social responsibility , or independence of thought” concluding that “comparative studies to date seem to have deliberatively avoided looking at the strengths of American schools” (p 53).

By allowing for the use of alternative assessments for such higher order skills as critical thinking or creativity, programs of neuroeducation could follow the same frequency of testing and reporting as the other schools. This type of assessment would be useful for schools incorporating neuroeducation, as they would fit within the system of accountability while measuring what was important in developing student capacities. This would not only help provide accountability to the school in developing these skills but would help to build a solid database to work from in designing and evaluating effective programs of neuroeducation.

Self-Learning Systems, Continuous Improvement & Sustained Change

There is an effect, noticeable in many charter schools, showing a significant increase in student test scores during the first year of the school’s opening, and diminishing returns during the second and third years of operation (US Dept. of Education 2005). Some of the springboard for this success may reflect the excitement and energy generated through the possibility for change. Unfortunately, the initial excitement can quickly turn to distrust and loss of faith when schools are faced with the problems plaguing their local communities which have not been addressed for decades. MBE supports a system of sustained change, through in particular, mentored teaching experiences, continuous reflection, and constant improvement. Because neuroeducation works from theory based on the rapidly advancing sciences and experimental classroom practices, continual evaluation and revision of new approaches is a must. This reflects the importance of developing the field of MBE as a self-learning system an approach supported by organizational theory, and proponents of MBE (Tokuhama-Espinosa, 2010). As mentioned previously, there is the need for MBE to define the role of leaders. However, this may be best served through the use of existing models of organizational theory, such as models of self-learning organizations. In a self-learning organization, there is continual evaluation of the effects of implementing new approaches, and this new information is used to refine and adjust basic tenets at the top of the model, such as in the double-loop learning model of Argyris and Schon (1978). This approach is ideal for implementing change as it allows for flexibility and adjustment. In neuroeducation, new findings from the classroom and laboratory need to be fed back into the system to create a program of evolving education. Looking towards creating a leadership approach that will work best within the framework of MBE is worthy of investigation by leading members of this emergent field.

It is notable that both of the experimental school selected for participation in the case study (Chapter 6) engaged in multiple socio-emotional programs beyond their defining curriculum (i.e. Waldorf and IB) and continued to evolve and seek out new opportunities to meet the needs of their students. What is important to note is that the evolution of the curriculum was not simply about change but rather reflected the building on the foundation of the earlier programs. Once teachers developed sufficient know-how in one approach, they expanded their knowledge through new programs adding new layers and dimensions to their teaching. This was done through the school leadership, and there is reason to believe that any successful change effort, if not initiated by, must at least be supported by leadership.

One of the concerns with the current reform efforts, in particular mandated school reconstitution, is that social capital is lost through the firing of teachers and administrators (McGhee & Nelson, 2005; Rice & Malen, 2003). Rather than building on an existing strength, or addressing the causes for problems in student achievement, the system is forcing schools to close and start over, creating a kind of revolving door of reform (Tyack & Cuban 1995; Eisner 2005). A true program of neuroeducation supports reflection within the school leadership, and teacher development that focuses on building on existing skills towards success from within (Tokuhama-Espinosa, 2010). This approach is preferable for successful reform and must be considered as a top priority when examining the very real practice of school closures and reconstitution.

Universal Standards Not National Standards: MBE & CCSS

Educational leaders, administrators and teachers are already being prepared for the next wave of education reform, the Common Core State Standards (CCSS). One interview participant (P18) pointed out that teachers in his network were being allowed to preview texts and materials already written that align with the CCSS. In order to implement the changes required by CCSS, educational leaders are left facing a loaded gun. They do not have the luxury of experimenting with untested approaches. Administrators are forced to scramble to find a tested product, most of which require strict teacher fidelity hence decrease creative experimentation in the classroom. The selection of curriculum from a limited list of available texts fails to allow teachers to respond to the individual needs of students as they emerge throughout the school year and is completely misaligned with the approach of neuroeducation. Unfortunately, this may be the next wave of curriculum as we move into the CCSS.

The move to CCSS reflects in many ways the status quo of state directed public education. Although some believe the CCSS to be more process oriented, a point brought up by the interview participants, the assessments for the common core will continue to utilize multiple-choice testing, at a significant expense to schools and students. If the organizational structure remains the same, that is punishing schools that are not performing well on these assessments, the focus of education will remain on raising test scores reinforcing the pedagogy of teaching to the test. Unless this structure changes, there can be no successful curricular reform with respect to educational neuroscience and MBE.

At the annual Waldorf Public Teacher Institute conference, a program for public school teacher training, Christine Olsen opened the session with a comment on the CCSS as a mis-focus in public education. "Rather than content based standards," Dr. Olsen stated, "we ought to be asking ourselves what is the common core of the needs of our children?" Within this statement is the kernel of an idea that could transform the way we view standards. That is the idea of creating an *Alternative* Core State Standards (ACSS) based on universal principles of learning. Applying ACSS that address both the cognitive and emotional student needs could transform our practice of teaching to the test, into teaching to the developing nervous system. This idea is one that deserves further attention as the desire to create a cohesive national framework could be provided while still addressing the individual needs of a diverse student body. To do this would require a collaborative effort on the part of researchers, teachers, and educational leaders.

Research Question 2: Curricular & Instructional Principles of MBE

The second research question utilized interviews with education experts to define the components of curricular practices that make up a program of neuroeducation. In order to expand on this emerging curricular vision, data from the interviews are compared here to the findings from the literature, in particular the model developed in Chapter 2 as well as to an extensive meta-analysis performed by Tracey Tokuhama-Espinosa (2008). Comparison of the results from Chapter 4 interviews with the literature demonstrated a difference between the focus of research versus the pedagogical model generated from the interviews. In particular, findings from the literature focused more on the primary and secondary themes from the model presented in Chapter 2, while the interviews emphasized tertiary themes, or developing higher cognitive capacities. Interview findings also gave a more varied picture of classroom practice, and the dynamic interplay of apparently conflicting approaches supported by interview participants are presented as a novel way of looking at education.

Constructing a Model of Neuroeducation

The model created from the selective review of the literature consisted of four themes: primary, secondary and tertiary, as well as an overarching meta-theme (see Chapter 2 for an overview). This model was then compared to the findings from the interviews related to student issues developed in the third block of interviews focused on creating a curriculum (Figure 32).

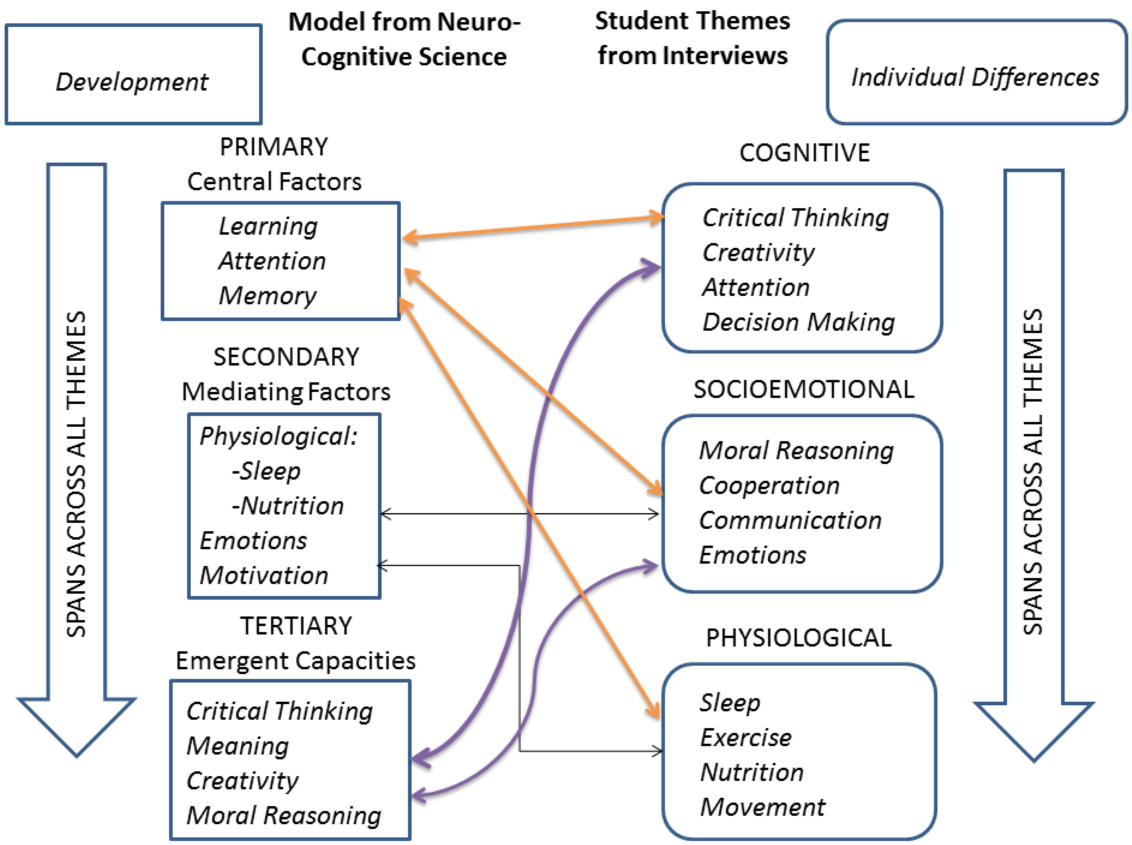

Figure 32. Comparison of the model from the literature versus findings from the interviews. Most comments from the interviews were cross-referenced with findings from the literature.

The model of neuroeducation that emerged from the interviews showed a shift in focus on a number of issues when compared to the findings from the model based on the literature. The most prominent difference between the two models was the emphasis of the themes. Learning, memory and attention, considered the central theme of the model, were infrequently discussed directly in the interviews. Rather learning, memory and attention were discussed in relation to secondary and tertiary themes. In the interviews, participants were more likely to discuss mediating factors as they *related* to the central themes, and even more frequently connected central themes to higher cognitive themes through concepts of building capacity. In addition, secondary themes, or mediating factor related to both socioemotional and physiological factors mediating learning. These themes expanded to exist as separate constructs in the interviews. Furthermore, social-emotional factors from the interviews were not limited to factors mediating learning, but were viewed as higher goals, and the development of social and emotional abilities as capacities, from the literature review. Indeed, most of the focus of the interviews was on this development of emergent capacities. Finally, in the model development spanned across all the other themes while for interview findings there was an increasingly dominant focus on individual differences as an overarching theme (Figure 29). The differences between the literature and the interview findings deserves further attention and will next be examined in comparison to an earlier meta-analysis.

Principles, Tenets & Instructional Guidelines of Neuroeducation

In the most comprehensive review of the literature to date Dr. Tokuhama-Espinosa (2008) performed a meta-analysis of over 2,250 publications. Several themes emerged as overarching constructs from the articles as they related to neuroeducation and were divided into three subcategories: Principles, Tenets and Instructional Guidelines. *Principles of Neuroeducation* consisted of those universal constructs relevant to all learners. Articles describing the *Tenets of Neuroeducation* consisted of highly individualized aspects of learning, and *Instructional Guidelines* for neuroeducation related to research related more directly to educational practices. The findings from the Principles, Tenets, and Guidelines can be compared to the original model from the literature review as well as those major findings relating to curriculum and instruction from the interviews.

In the meta-analysis, Tokuhama-Espinosa (2008) distinguished 565 articles as related to 22 Principles of Neuroeducation. Of those 22 Principles, all but three fit into one of the major themes from the model produced in Chapter 2. Six Principles related to the primary themes of learning, attention and memory, six related to the secondary themes, or mediating factors, four related to development and individual difference, and only three related to the tertiary themes, or cognitive capacities. There were also three Principles which were not part of the original model: (1) importance of feedback, (2) parallel processing and (3) the impact of novelty on learning. These related to temporal dynamics of learning from the interviews. Feedback and novelty could also be said to be related to the central themes of learning, however, they were not included as such since in creating a model it is important that these be more clearly outlined, which may indicate a short-coming of the model as it currently stands. Comparing the 22 Principles from the meta-analysis to the interview findings in Chapter 4, there was less overall correspondence between the two results. This was due primarily to the increased focus of the interviews on higher level cognitive processes, whereas the meta-analysis showed only 3 principles falling under the themes of higher cognition. Cognitive capacities produced the highest number of codes through the interviews with experts in the field of MBE.

What is interesting is that the meta-analysis of the literature corresponded well with the model created from the review of the literature presented in Chapter 2. Notably, the points of divergence were similar between the interview and both the model and the meta-analysis. The reason for this discrepancy between the literature and the interview results may reflect the nature of reporting empirical data in academic journals versus the nature of conversations as they delve into more theoretical discussions. Empirical data from the science represents the foundation for the building of theory, but rarely goes beyond the data in reporting. The discussions with interview participants, however, focused less on empirical data and more on the theoretical potential and direction of the research. Of course there are other possibilities, including the selection of literature in the review, or a progressive change in the focus of research as we move into greater understanding of higher level cognition, where the literature is behind the curve of this knowledge. It will be important to maintain continual evaluation of the field as it grows and defines itself to understand the dynamic interplay between empirical research publications and theoretical constructs useful for building effective models of neuroeducation. Understanding the trajectory of science in relation to the changes happening in education represents an important intersection and point of action for MBE.

In addition to looking at the Principles, the meta-analysis documented 12 Tenets of Neuroeducation (Tokuhama-Espinosa, 2008). The distribution of these Tenets in order of frequency was: motivation (32.3%), differentiation (31.4), stress (28.1), sleep (22.8%), learning styles/cognitive preferences (22.8%), movement (22.6%), anxiety (20.8%), nutrition (17.5%), faces (13.3%), humor (11.3%), tone of voice (9.5%), depression (5.5%). When examining this list and comparing it to the model of neuroeducation created from the review of the literature, it is apparent that the majority of Tenets fell into the secondary theme or mediating factors. In fact, eight of the twelve Tenets fell under the secondary themes. Two Tenets related to individual differences, those were (1) differentiation and (2) learning styles, and two did not fit within any of the themes from the model. (1) tone of voice, (2) facial expression. What was more interesting was that none of the 12 Tenets addressed any of the primary themes: attention, memory or learning, nor did they discuss any of the tertiary themes: critical thinking, creativity, personal meaning. Comparing the categorization of findings into Tenets appears to coincide with the secondary themes of the model. With respect to the interview findings, Tenets fit within either Social-Emotional or Physiological factors (Figure 29). Again, since the number of comments associated with Cognitive factors exceeded both Social-emotional and Physiological factors (see Table 6, Chapter 4), it is important to note, once again, this divergence between the literature and the interviews.

Instructional Guidelines & Delivery of Content

Although there was considerable divergence between interview findings and the 22 Principles and 12 Tenets outlined in the meta-analysis (Tokuhama-Espinosa, 2008), comparison of the Instructional Guidelines from the meta-analysis to the interview themes produced much better alignment. Of the 441 documents that related to Instructional Guidelines, all ten themes derived from the meta-analysis were also brought up in the interviews. In this were included: active learning, metacognition, meaning, memory, mind-body connection, and orchestrated immersion. Instructional Guidelines provided by the meta-analysis referred primarily to issues surrounding delivery of content, but additionally included context as it was relevant to the student's capacity to learn (Tokuhama-Espinosa, 2008).

Instructional Guidelines from both the meta-analysis and the interviews were focused on the goals of capacity building. Based on this, indications for content selection and delivery should be determined in part based on achieving the goals of capacity building. Examining the repeating themes from the coding of curricular themes from the interview findings, it was possible to discern three functional inter-related categories: (1) content selection, (2) capacity building and (3) delivery (see Table 12, Chapter 4). The fact that the literature from the meta-analysis was aligned with the interview responses supported the validity of these interview responses as representing accurate components in the delivery of a program of neuroeducation.

Based on the interviews, it was clear that content supported by a program of neuroeducation should be determined by the needs of the developing nervous system and the unique student body it served. Because of the variability in the development and organization of the nervous system, for example differences in the individual rates of development or cultural and personal experiences that determine the foundation for learning, there was strong agreement regarding the need for an individually responsive curriculum. This led to the need for an approach that was emergent, flexible and responsive to the enigmatic construct of the individual self. Hence, neuroeducation indicated the need for a culturally responsive pedagogy that would provide students an understanding of those things around them that have meaning to their lives. How this interacts with neurobiology is through meeting the cognitive, emotional and physiological needs of the individual. Understanding those needs, neuroeducation is able to act synergistically with the culture of a community to maximize the effectiveness of student learning experiences.

Selection of content from global universal concepts is one approach encouraged by several of the interview participants. Questions as to the origins of the Earth, the properties and qualities of matter, the rules and patterns of numbers, and purpose and meaning in life, all are universal questions facing humanity regardless of the era or culture. These universals represent the ideological perspective of neuroeducation. Unlike socially constructed pedagogy aimed at political, social and economic goals, the goal of neuroeducation lies in the ideal of fully developing the capacities of the brain and mind through maximizing each student's potential from birth to adulthood. In order to do this, there must be attention to the potential of each individual.

The Marriage of Content & Capacity Building

The idea of building a curriculum that attends not only to learning, but to developing the capacity to learn through building attentional and memory networks—among other abilities, is one that is long overdue. In examining our current education system with respect to such aspects as the structure of the day, the focus of teacher development programs, and the specific policy directives, it is clear that these institutional behaviors all continue to support the use of discrete content. In most schools, the day is broken into 50 minute learning blocks, or content based classes. Teachers are certified in a specific content area. Policy mandates create testing in discrete subject matter. Overall, we are heavily focused on isolated content in our current system of education and accountability. MBE, on the other hand, places its emphases on developing cognitive capacity and describes a more global approach to education based on universal principles of learning.

The capacity to transfer learning across subjects and to the outside world was professed by a number of participants as the critical factor for engaging students in deep, meaningful learning experiences. As such, the design of a neurocurriculum promotes fewer separate classes, and greater integration of content. The marriage of content of capacity building also encourages integration, in that activities previously designated to specific classes can now be thought of as integral to all aspects of learning. For example, movement should not be simply relegated to one hour of PE, but should be purposefully incorporated into learning experiences in all classes, adding an additional depth of meaning through engaging non-verbal brain regions. Building student autonomy and intrinsic motivation were capacities brought up as building on the goal of encouraging life-long learning as students developed curiosity and the ability to seek out answers to their own questions.

In the international project on “Learning Sciences and Brain Research” international researchers reported that brain-research in education should focus initially on three significant areas: literacy, numeracy and life-long learning (OECD, 2002). The question as to how to create life-long learners is one that works most relevantly at the level of the individual self, perceived efficacy and the autonomy of the student. Techniques in education focused on external motivation, such as external punishment and reward were seen as contrary to good education. Hence, student-directed learning, flipped-classrooms and engaging students in meta-cognitive activities designed to help students better understand their own learning were highly encouraged by MBE members.

Building capacities for learning is a direction that precedes selection of content. But perhaps more so than content selection, building capacities directly relates to delivery of content or pedagogical practices. A number of pedagogical practices reflecting a shifting focus of education towards neuroeducation and in support of capacity building are discussed below. What is most interesting regarding practice is the wide range of acceptable approaches, some of which appear to be highly conflicting. What is intended in this brief overview is to demonstrate the incredible flexibility of neuroeducation to adopt seemingly opposing approaches, while still being true to the principles of learning, and promoting the development of student cognitive, emotional and physical capacities.

From Conditioning to Metacognition

One emphasis of neuroeducation as outlined in the interviews was the movement away from simply conditioning student behaviors through external motivators, towards providing opportunities for student to become aware of their own learning process through metacognition. This represents a critical shift from conventional classroom practice where students are passive recipients of knowledge, to supporting student to become empowered as active participants in their own learning through understanding their own strengths and weakness. This transition can occur in many ways. Conditioning is a natural aspect of learning. Repeated exposure to patterns as they occur in our environment conditions us to expect causal relationships between stimuli. When recognition of these patterns is brought into consciousness, this awareness can be used for high-level creative problem solving. From the perspective of teaching, to move one step above conditioning is to include moments of reflection, so that the student can become consciously aware of those patterns and can apply them to conceptual learning.

Although most participants looked at classical conditioning and behaviorism as something to be avoided in the classroom, there was room in a program of neuroeducation for the use of conditioning if it were to be paired with higher level aspects of learning. So for example, conditioning could be used to encourage behaviors, (i.e. through praise, reward, modeling of behavior), but should include a metacognitive component and higher order thinking around it (i.e. reflection, awareness, recognition). In addition, low-level conditioning, in the sense of observation of phenomenon, where students could begin to see patterns, at first appears passive but invokes high level cognition and should be used in early grades initially without higher-level explanation. The experience of observation provides priming for understanding deep concepts. This is an appropriate means of creating developmentally appropriate practice and falls into the realm of experiential or discovery learning. Conditioning is not only about the shaping of behavior it is also the shaping of thought, and can be used as the first phase towards thinking about phenomenon or even about one's own learning process.

Teacher Directed versus Student Directed Learning

Much of the discussion by interview participants spoke to student directed learning. Student directed and selected learning experiences were seen as important for enhancing motivation, and also for increasing student autonomy and personal investment in their learning. Self-directed learning was associated with the theme of individual differences as it could better allow for the pace of learning to be self-regulated as well as encourage students to follow their personal interests. This described a new role for teachers as structuring learning experiences rather than dictating knowledge. However, unlike the free-school model in which all activities were student selected and directed, interview participants in MBE described a range of student versus teacher directed learning experiences. This was most clearly indicated by the support of Engelmann's Direct Instruction program for reading. The apparent contradiction demonstrates the extent to which neuroeducation is multi-faceted and utilizes approaches that span across theoretical domains. The next question then becomes, if neuroeducation all inclusive, what good can this approach be in guiding teacher behaviors? The secret to developing a program of neuroeducation will be to provide guidelines on when and how to apply these apparently disparate approaches to teaching in a manner aligned with the directives from developmental and learning sciences.

In evaluating the use of teacher directed versus student directed material, there are particular guidelines that can help discern when each approach is preferred. Teacher directed approaches are appropriate when high levels of scaffolding are needed. As the student begins to gain confidence, they should be allowed increasing freedom and choice. In addition, a range of teacher direction is important when students have limited exposure to topics and materials, while at the end of a unit of study, students should be able to generate their own questions about the subject that they wish to further investigate. This does not mean that teacher direction should be the foundation for early-childhood instruction. Young children are the masters of imagination and discovery learning, and hence, at this stage, children need have the opportunities to explore. Structuring the environment by teachers to provide experiential learning experiences is the foundation that will build on life-long love of learning, through the building of imagination and curiosity.

Overall, neuroeducation supported a reduction in the degree of teacher direction, as currently traditional methods allow little room for student choice. By increasing student freedom to choose their own areas of study, we encourage autonomy, intrinsic motivation and life-long love of learning.

Rote Memorization versus Conceptual Learning

The importance of using large concepts as a framework for selecting content and presenting material was brought up by several of the interview participants. Conceptual learning was seen as spanning across disciplines, providing universal ideas that bridged across culture and historical time, and allowing for the building of a foundation of knowledge in a number of subject areas. Conceptual learning was seen as a replacement of fact-based learning that required rote memorization of disconnected material. However, as further evidence of its flexibility, the holistic approach of neuroeducation was amenable to the use of rote memorization under certain circumstances. Rote memorization was thought of as a means of providing internal frameworks for information determined to be foundational for higher order skills. However, there was another potential use of rote memorization and that was the development of attention and memory systems. As neuroeducation promoted developing student capacities, but including exercises in these skills, it would be possible to build such neural systems as we know that all neural connectivity is activity dependent.

Use of rote learning was seen as allowing material to go deeply into the structural neural networks of the brain that can then be drawn upon for years to come. The secret to using rote memorization as a classroom exercise was seen as embedding the process of rote-memorization into other tasks. For example, rote memorization could be paired with other components of delivery of content, such as student-selected content, embodied cognition, or play (see Table 13). A student selected poem to be memorized and recited was viewed as providing both a practice in developing memory, and a means of sharing personal interests with classmates. Learning multiplication tables while jumping or clapping a particular pattern could both make learning fun, and allow material to be deeply engrained in long-term memory. Rote memorization was seen as a valuable tool for building foundational skills.

Based on this directive for use of rote memorization, the field of neuroeducation must determine what makes up a foundational skill and the rules by which this type of rote practice is preferable to a more global experience. Rote learning helps when building an initial skill that is needed for a higher level skill. It is important to remember that the two need not occur separately. Conceptual learning is part of our natural learning ability and even young children are able to understand numbers and even fractions at a concrete level. Memorizing the part to a play has the advantage of building memory systems and positive reinforcement through a final performance. When using rote memorization, students should have the joy of seeing themselves improve by having the chance to demonstrate their skills in ways that reflect their personal interests and abilities. In this sense the teacher must diagnose the needs of his/her students, and find materials that will resonate with their needs, and can also be used to teach, inspire and help students grow emotionally.

With rote memorization there is the need to store the information very deeply. In order to do this, time is required. Sleep is required, and so this approach is tied to the theme of temporal aspects of learning. The awareness of the importance of using the temporal aspects of learning within the structure of the school year is one that can be lost when dealing with the minutia of standards and benchmarks. When we are rushing to make sure our students know what is needed for the upcoming test, there is less awareness of the use of time; no recognition is given to respecting to how long it actually takes to learn new material. With use of the knowledge of the time-course of memory formation, in alignment with larger developmental frameworks indicating the genetic and biological unfolding of higher cognition represented in associative cortical areas, teachers can better plan their lessons for building foundational skills intended as the first step towards mastery.

Temporal Dynamics of Learning & Dynamic Systems Models

The temporal dynamics of learning is a scientific study with significant relevance to the way we structure our students' learning experiences. At a basic level, circadian rhythms highly impact our neurobiology, neuroplasticity and capacity for learning and memory. Part of the secondary themes from the model generated from the literature review, the interviews reflected on the temporal dynamics of learning in an expanded perspective. From the interviews, temporal aspects of learning included both minute by minute interactions between the teacher and student, and longer time frames utilized to allow for memory consolidation and building on deep conceptual learning and expertise. The importance of attending to daily rhythms, such as starting the day later for adolescents (as in Owens, Belon & Moss, 2010), was brought up by several researchers, and was used as evidence of the need to evaluate structural changes in the school day. It was expressed in both the literature and in the interviews that incubation periods are required for both skill and deep conceptual leaning. The use of spiraling curriculum that would allow for incubation and reintroduction of material was supported by interview participants. However, one participant pointed out that textbooks designed to repeat ideas in this type of spiraling manner usually failed to "meet-the-mark" since frequently the teacher was never able to go deeply enough into the material with the students on the first presentation. Ultimately, there was nothing for the reviewed material to build upon, and it became a waste of time. The CCSS attempts to rectify this on a long timeframe, through maintaining a consistent core from grades K-12. This approach is supported by the brain sciences, however, it was recognized by the interview participants, that learning takes place on a more intimate level, and understanding the micro timeframes for learning as it occurs between the teacher and student is less well articulated in teaching practice. The interplay between short term learning and long term outcomes must be a central focus of developing a model of temporal dynamics that will be useful to teachers.

Fischer (2010) one of the founders of MBE, had proposed the use of dynamic systems models in examining how to effectively teach using knowledge from the brain sciences. Dynamic systems models can be applied to understanding the micro-interactions between teachers and student groups, and teaching practices based on these models have been proposed to increase student depth of engagement (Davis, et al 2008). Dynamic systems models support an emergent curriculum, rather than a fixed one, and this is where pre-defined textbook pacing guides conflict with neuroeducation. Dynamic systems models also recognize individual student interests, as the generation of ideas within a classroom are followed with deeper and meaningful experiences brought by both the teachers and the students themselves. Understanding the dynamic interactions of students and teachers within a classroom will most certainly become a central focus of neuroeducation.

Idealism & the Philosophy of MBE

It is worthwhile to evaluate how MBE contributes to a philosophy of education, and there have been some small attempts to begin to look at just that issue, in particular with regards to issues of mind-brain dualism and ethics (see Howard-Jones, 2008). However, it is just as important to look at MBE with respect to existing philosophies of education, and to show respect to those philosophical constructs as they have been developed in education theory. Based on the interviews, beliefs as to the philosophy of education supported by educational neuroscience and especially MBE, education was viewed as a means of maximizing the individual potential of each student through working with their natural learning systems. Those who spoke of maximizing capacities included the reasoning behind developing those capacities as pragmatic, but also in a more theoretical and abstract sense. The goals of education were closely tied to a philosophy based on moving towards peaceful co-existence through providing students the mental tools they would need to face an unknown next century. This view of education fits to some extent with that of *pragmatism*, but also resembles those tenets from *idealism* in education. Idealism was one of the earliest philosophies guiding education and is attributed to the philosophy of education encouraged by Plato (see historical overview in Cohen & Gelbrich, 1999). Although idealism is a diverse philosophy, the area which is touched upon by MBE is through the visualizing of a shared goal and working in concert to achieve this understanding. H.H. Horne spoke of the ideal in the following way:

> This ideal nowhere fully exists on the earth. But it haunts the imagination of man. It is real in the sense of subsistence, if not existence. It is real in the sense that perfect circles are real. This ideal order consists of all those values that social man should realize in the earth.

Idealism as a theoretical framing of neuroeducation provides the guide for educators that remains universal and yet ultimately flexible to meet the needs of each individual child's individual growth. One difficulty in creating an ideal is the result of using abstractions to create a universal truth. Neuroscience and empirical data can now provide universal guidelines based on development. These guidelines only are the means of achieving higher level goals. It remains the high ideals of humanity that represent the hope of education.

Allowing for the enactment of expression of the frameworks indicated by universal knowledge is an important means of moving towards the ideal in education and are absolutely necessary in order to make headway on a topic. Such enactments, very much like this dissertation, are pale comparisons to the actual ideal. Nonetheless, it is as we understand the processes of learning in the new light of neuroscience that we work towards implementing these findings to better serve the human populace. Enacting the ideal is more about working from the spirit of the ideal as it exists as a shared vision among participating teachers, student and communities. Ideals share both universal and unique qualities, and hence will share commonalities and differences amongst groups when the ideal is enacted. This need for flexibility may be more prominent in neuroeducation than in any other curriculum in that the primary contribution from the science is continually advancing, and at a rapid pace. Hence it makes sense that at this time it would be only an experiment in futility to advance any prescribe curriculum of neuroeducation. At the same time, there is a need to move forward with experimental models in order to evaluate the efficacy of approaches supported and suggested as better aligned with the brain. The ways in which this will be accomplished must remain one of the central goals of MBE.

An Affront against Dogma

Thinking of the many conflicting approaches supported by MBE, such as rote memorization and direct instruction versus conceptual learning and student directed learning, we are faced with a common problem in the construction of any model involving social and biological problems, and that is the tendency to segregate our thinking on issues into a black and white. Neuroeducation dismisses black and white conceptual models through working from an empirical base, rather than a theoretical one. This tendency to take sides, or join a particular theoretical camp and to create dualistic models has continued to result in narrow framings and models that inevitably are shown to be wrong (Cohen & Gelbrich, 1999). Neuroeducation and MBE have taken an open perspective, not adopting rigid models, and allowing for new findings to continually redefine what is possible.

Looking at the ideals of student directed curriculum, love of learning, appropriate use of academics and arts integrated curriculum, the nature of neuroeducation could be associated with a kind of romantic progressive pedagogical model of education. The reality is that neuroeducation subscribed to a host of existing pedagogical models of education. Neuroeducation draws from teacher-directed, highly-scripted approaches, as well as, progressive, cognitivist, and constructivist perspectives (see Yilmaz 2008 and 2011 for a review). This is because neuroeducation works not from a model of education, but from an approach to education generated from the sciences. In looking at what neuroscience and related sciences infer for education, it is possible to see where they are aligned across a multitude of approaches and philosophies.

Creating a consensus amongst the interview participants with regards to the variety of pedagogical approaches supported by the brain research resulted in a number of unexpected and conflicting responses. Apparent conflict revolved around the issues of (1) student directed versus teacher directed content, (2) the extent to which the efforts required a major structural change in the system or could be worked into the state standards and testing, and (3) the pragmatic problem of drawing on knowledge from the neuroscience to build a meaningful curriculum. Very much like the philosophical debate regarding nature versus nurture, the viewing of different approaches and philosophies as incommensurable must be reconciled in a complete model of neuroeducation. Working to find the dynamic balance between various approaches as they encourage the highest level of functioning and development of an individual's potential, although daunting, is a task worth uniting around. Neuroeducation provides an objective guideline for determining best practice that is outside of the overly defining effects of adopting a single philosophy (Cohen & Gelbrich, 1999).

Research Question 3: How to Move towards a Proof of Concept

The third research question was designed to delve more deeply into the issues of evaluating the potential of a classroom model to produce the purported outcomes desired by neuroeducation, such as critical thinking and socioemotional wellbeing. This step of evaluating the potential of neuroeducation will be necessary to advance the field of MBE beyond theory and to determine whether it is possible to impact more than just learning but act to build desirable cognitive capacities. In particular, determining whether pedagogical approached promoted by MBE are able to enhance cognitive and emotional capacities must be addressed if the field will be able to move beyond theory into a true and effective reform effort.

Moving Beyond Theory: Evaluation of School Models

A number of interview participants pointed to the fact that a lot of effective practice had been developed intuitively and based on trial and error. Neuroscience was seen as being able to shed light on what made these intuitive approaches effective.

> There are things that good teachers do just by hunch. They know they should vary activities and they should be student focused, but they do this because they know it has worked in their practice, but they don't know why. So now we can say why certain things work better. That is the real exciting thing. It is powerful for teachers, because the good ones just get confirmed, and for the poor ones, now we have tools to say if you did this that and the other thing you would probably improve. (P2)

> Where you would tend to begin in research, would be to ask what have teachers learned over the years about what works and what doesn't work, what you should do and what you shouldn't do. Let's start with that…and see if there is anything that we know about how brains work and don't work that would kind of explain that practice. (P3)

What this suggests is that developing an effective model of neuroeducation should not be done in a laboratory or without reference to existing pedagogies. Designing a curriculum of neuroeducation should work at multiple levels, through laboratory and field research, using supporting literature across fields, and also through evaluating existing classroom practices. Using exiting approaches as a starting point can be an effective approach that can help to build an empirical data base of effective practice. In truth many of the existing models of education being applied in our schools today have had little empirical evaluation. Understanding how existing models effectively produce the outcomes so desired by MBE is a first step in bridging theory and practice.

Evaluating practice as it emerges in the classroom as part of understanding a model of education is one that is supported by experts in curriculum development based on process models (McKernan, 2008; Stenhouse, 1975). Furthermore, there is the start of an effort to evaluate how to encourage higher cognition through teaching (Barak, Ben-Chaim & Zoller, 2007). Hence, the creation of a model of neuroeducation which provides an explanatory framework for curricular reform can also be used to determine the efficacy of educational pedagogies as they are aligned with brain development (Willingham & Lloyd, 2007). This approach can be thought of as backwards mapping of effective practice towards a model with explanatory value based on the neuro and cognitive sciences.

IB and Waldorf were selected as exemplars based on their theoretical alignment with pedagogies supported by the criteria indicated by neuroeducation. Using extant data, it was then possible to evaluate these two models in actual schools across California and the nation. Results from these findings supported the proposed goals of these two school models. Based on parent comments, IB worked heavily on critical thinking, as a central component is problem based learning. In addition, IB commonly used projects, and hands-on learning experiences. Waldorf, on the other hand, focused heavily on development, attended to emotional needs of students, had a fully arts-integrated curriculum, and a large number of extra-curricular courses such as music, hand-work and second languages. There were a number of indications from the available data that both IB and Waldorf were achieving a respectable level of success in meeting several of the goals of neuroeducation. In particular, Waldorf showed a developmental growth curve on standardized tests, producing high student performance levels by 8th grade even when compared to the top performing school in California. IB test scores showed slightly higher performance that overall state averages, but followed the same pattern of performance as the state, and did not appear to show a developmental growth pattern.

The purpose of the third research question was to determine whether evaluation of existing models could potentially benefit our understanding of neuroeducation. Based on the discoveries from both the analysis of extant, publically available data online, and the findings from the case study, there is sufficient evidence to suggest that this approach could be fruitful. In particular, the evaluation of existing school models using mined qualitative data and QCA represents an approach that holds a great deal of potential to help reveal issues as they are experienced in working schools. As we as a nation become more engaged in online communication, the use of the growing body of data will become one means of creating an empirical data base.

The use of parent comments here was intended to examine patterns of responses, in particular in relationship to practices aligned with MBE. Waldorf schools showed a greater number of responses around holistic and MBE themes, including developmentally appropriate practice, and 21st century skills. For IB schools, the range of implementation of IB and the principles of neuroeducation varied from school to school. Using parent statements relating to their student's experiences, and perceptions of the school, it was possible to examine the relationship between the reported use of classroom practices aligned with MBE, and overall parent satisfaction. This data indicated that for those schools where parents were highly satisfied with their schools, parents more frequently commented on issues that were related to MBE. Schools that were performing poorly made absolutely no mention of MBE topics, suggesting that these schools may not be engaging in practices of neuroeducation.

The evaluation of school models for alignment with neuroeducation was an indirect means of looking at teaching practice, and a first step towards building a proof of concept. With the growth of charter schools, and the adoption of various new approaches to teaching and learning by those schools, it would be possible to extend the approach taken here to look at models such as KIPP, Montessori, or other popularized approaches for their alignment with neuroeducation principles as well as their impact on student outcomes. In addition, the beginning of school models developed from theories from MBE are beginning to be evaluated for their success (Blythe & Gardner, 1990). By working on multiple fronts, using interventions, controlled studies, and naturalistic studies of school models developed organically within a community, we will be better able to advance the purpose and understanding of pedagogies as they are aligned with the brain.

Case Study Findings: Suggestions for a Wide Scale Research Approach

After determining points of alignment between the two selected models for principles of neuroeducation, it was then possible to use best examples of those models to more directly examine student outcomes. As an approach to understanding the issues facing neuroeducation as a curriculum, case studies represent one of a number of means of building a data base which could address more than just standardized test scores in reading and math, but contribute to understanding whether specific models could effectively enhance cognitive capacities and emotional development. The individual case study used here represents and approach more than a final conclusion. To address the third research question, that is can existing models help the cause of neuroeducation to move towards a proof of concept, it is believed that this initial case study presented here points the way toward such an approach. It is believed that the case study, if compiled across a number of schools, could provide the foundation for building a proof of concept through experimentation and validation.

Rather than attempting to create a school model or intervention based on the brain science, the approach taken here was to work from existing models. Although developing interventions, or full-scale models of neuroeducation, may be preferable as an experimental design, in some ways using existing school models provides certain information that is difficult to obtain in an experimental setting. In terms of efficiency, and working within the existing school structures, the evaluation of popularized alternative models of education through this backwards comparison to practices of neuroeducation holds some promise for beginning to find patterns of student performance as the occur in a public setting. Hence the design utilized in this dissertation is suggested as a prototype that could be replicated across a number of research groups to build a foundation for understanding the impacts of various programs. Wide scale administration, or repeated small scale studies using the same or similar scales of critical thinking or emotional development, would be required to make any serious conclusions from these findings. However, the case study data support much of what was found in the online studies, and suggest that it would be worthwhile to further investigate both Waldorf and IB for the factors contributing to their success.

MBE supports the use of research schools (Hinton & Fischer, 2010). There are advantages and disadvantages to using experiments run within a research school as they support a proof of concept. The obvious advantage is the greater amount of control provided the researcher. Research schools allow for both the implementation of interventions and the close monitoring of individual students and teachers. However, there are also several disadvantages as well. Research schools are most often independent and attract a certain parent body. As independent schools do not have to engage in the traditional state mandated tests, it is difficult to determine the extent to which practices could be effectively scaled-up and applied in large public school districts.

Research schools have greater flexibility in their hiring of teachers and allocation of funds, on music or arts or technology for example. These factors make research schools less than ideal when attempting to generalize findings to the public school sector. Perhaps a better solution to building an empirical base for neuroeducation, would be the creation of research consortiums, and several of the interview participants indeed spoke about working in, or creating such consortiums. In fact, MBE communities are already in the process of creating these consortiums (Schwartz & Gerlach, 2011), although frequently these networks have also engaged independent schools outside the public requirements of testing and state standards. To expand this effort, groups of participating schools could allow school districts to conduct their own research on specific issues, and to create connections with the research community. The sharing of research across these research bodies will be necessary if we are to work more effectively in building an empirical database that will support change in the public sector of education.

Pioneering a Curriculum of Neuroeducation

The research and publications applicable to creating a curriculum of neuroeducation are still a small part of the body of research from the neuro and cognitive sciences. This limited shared vision of a curricular model appeared true both for the literature review and interview responses and has implications for how the field must move forward to address this lack of conceptual and empirical support for curriculum. In her meta-analysis, Dr. Tokuhama-Espinosa (2008) noted this same trend in the focus of the literature. There were a large number of articles surrounding issues of policy and teacher development, and much fewer articles supporting curriculum.

> This demonstrate[s] how the focus in the new field has been on policy issues, rather than with how the information in the emerging field translates into classroom practice. This is at once logical, as well as disturbing. While the rules of the field (i.e., policy) should exist, so should the actual use of the information (i.e., classroom practice). The lack of emphasis on curriculum design makes it clear that neuroeducational principles have been driven by neuroscience and how the brain learns from a laboratory perspective, rather than by practitioners and what they know actually work with students. A greater balance should emerge in the future as research begins to occur with more frequency in classroom settings, rather than being initiated primarily by the field of neuroscience. (p 153).

To some extent there was still an ongoing debate as to whether it would be possible to create a curriculum. Bruno della Chiesa talks to how we can begin to address the doubt by clarifying what is useable knowledge from the neuroscience that can be applied to education (della Chiesa, 2009). To determine what is useable, there still must be considerable conversations on those issues relevant to advancing the field. Some of the easier issues to tackle relate to practical issues between the fields, while addressing the theoretical leaps required when utilizing multiple levels of analysis will require the creation of a new approach to science (Devonshire & Dommett, 2010).

The first way in which this dissertation addressed the issue of curriculum was through focusing interview question, especially in the third round of interviews. The picture created from the interview findings was still rather incomplete, however, and was more abstract and theoretical than concrete. The ongoing challenge of defining a curriculum should be bidirectional, and not come only from the side of the scientific research, but also from examination of effective classroom models. This was the primary purpose of the second and third phases of the research examining school models. The third research question asked whether it might be possible to assist in building a curricular model through proof of concept by evaluating school models in the public sector. The data presented here supports this approach as a means of examining the efficacy of an approach to engage in practices on MBE and produce the desired student outcomes.

According to Apple and Weis (1983) with the need for efficiency “questions of ‘technique’ have replaced the essential political and ethical issues of what we should teach and why” (p 16). As stated repeatedly in the interviews, a program of education aligned with the brain does not support by the current trend of using highly scripted curriculum with rigid pacing guides. Research in psychology and neuroscience, rather than being reductionistic, support a holistic approach to education sensitive to individual differences and the emotional needs of students. As such, neuroeducation should not be imagined as a technique to teaching but may better be viewed as a broad framework, where detailed approaches can be selected based on the immediate needs of a student-body.

The (Not So) Final Word on MBE in Education Reform

The conclusion, based on the analysis of the definition of the goals of MBE versus educational neuroscience was that MBE represented a functionally distinct construct both in purpose and structures. MBE was seen as a part of the teacher training and translational aspects of bringing the neuroscience to the classroom. This differed from the primary goals of educational neuroscience namely academic research on the science relevant to how we educate and how we learn. In addition, although interview participants agreed that MBE should be engaged in developing policy through engagement with policy makers, there are those in the field who caution against the belief that educational neuroscience will provide what we need to create effective policy. Della-Chiesa (2009) believes, “it is not the job of science to make policy, which often has to consider political and ethical ramifications in addition to the researched facts. Instead, the importance of science lies in its ability to observe and describe phenomena in the world.” This again points to the important problem space that is further addressed by MBE that moves beyond just the science into institutional structures. It is the belief of this researcher that the term MBE holds explanatory value for discerning the goals and major stakeholders as an effort of educational reform based on the implementation of findings from the learning and neurosciences. MBE is most suited as the reform wing of this effort, at least with respect to the curricular reform efforts, in that it is more closely tied with schools and teachers.

It will take a matter of time for the fields to truly define their separate and shared spaces. As the unknown is faced and new possibilities for education are uncovered, novel issues affecting the field, such as neuroethics, neuroaesthetics, and the connection of spiritual experiences to sense of meaning, motivation and learning will need to be addressed. Although the debate surrounding the primary goals of the field will continue to evolve, there is great hope that this approach to education can make significant change in policy and practice that will better serve teachers and students in the future.

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APPENDIX A

Participant Numbers & Selected Career Accomplishments

P1: Participant 1 is currently a professor in a Department of Curriculum & Instruction and Director of a Collaborative Initiative with a State Department of Education

P2: Participant 2 is currently a professor of Education and Neuropsychology, Director of a Teacher's Research Institute, Director of a *think-and-do tank* that engages with policy makers to transform education, and author of several books.

P3: Participant 3 is a professor emeritus in a Department of Education. Author of more than 200 journal articles and a dozen books, P3 is recognized as an early translator.

P4: Participant 4 is a professor of Neurobiology, Chair of the Department of Biological Sciences and Co-Director of a Collaborative Research Institute.

P5: Participant 5 is a professor of Psychology and Coordinator of programs in MBE and Developmental Science.

P6: Participant 6 is assistant Dean and Director of a School of Education. P6 worked in public school administration, has created significant collaborative partnerships and developed a program of teacher development based on brain research.

P7: Participant 7 is professor of Psychology and Human Development and Co-Director of a multi-institutional interdisciplinary research group.

P8: Participant 8 is a professor Education and scientific advisor and task force member to a number of learning based foundations.

P9: Participant 9 is a former professor of Psychology and Education and currently consultant and author. P9 is recognized as an early translator.

P10: Participant 10 is a professor of Education and Human Development, and Director and founder of an interdisciplinary Research Department on Developmental Science of Learning.

P11: Participant 11 is a professor of Developmental Psychology, has worked to develop collaborative initiatives, sits on editorial boards for respected journals and has authored books and articles.

P12: Participant 12 is a professor of Education, Psychology and Neuroscience has authored award winning articles on the Brain and Education and serves as an editor on several journals.

P13: Participant 13 is a former school administrator and superintendent. P13 currently works as consultant for several school districts and has authored books and articles.

P14: Participant 14 is an author and consultant. P14 develops learning systems utilizing artificial intelligence and user-responsive technologies for schools and private groups.

P15: Participant 15 is a former school administrator and head of schools, having developed curriculum aligned with knowledge from the brain sciences. Currently, P 15 works as a consultant and is Director for a Collaborative Schools Research project.

P16: Participant 16 is a retired teacher and administrator. P16 has founded of several alternative charters, continues to publish on the brain and learning and directs a web-based resource for alternative educators.

P17: Participant 17 is a consultant and school organizer. P17 is considered one of the early translators in the field.

P18: Participant 18 is a school founder, teacher and administrator. P18 currently acts as a Director for an independent schools organization.

P19: Participant 19 is a teacher and school director for an independent alternative school. P19 has authored several books, the most recent on the subject of the brain and education.

P20: Participant 20 is a professor of Education and program director for an Interdisciplinary Research Program.

P21: Participant 21 is a professor of Education, author and founding member IMBES.

P22: Participant 22 is a former K-12 teacher, and current professor of Curriculum and Instruction and Director for a program in MBE.

P23: Participant 23 is a former teacher and administrator and has worked as a consultant for over 25 years. P23 has authored a number of books, workshops and articles on the subject of the brain and education and is considered one of the early translators.

P24: Participant 24 is a Professor of Psychology and Director of a research laboratory examining language development. P24 has published extensively on learning in early childhood and has won awards for teaching and research.

P25: Participant 25 is a former administrator and superintendent. P25 currently works as a consultant, has authored several books on the brain and learning and is considered one of the early translators.

P26: Participant 26 is a school founder, author and professor of political science.

APPENDIX B

People & Programs Mentioned in Interviews

People: A. Damasio (x3), Alfie Kohn (x2), Arnie Duncan (x3), AS Neill, Bobby Case, Brian Boso, Bronson Alcott, Bruce Harford, Bruce McCandliss, Carl Rogers, Ceszanne, Charles Lynn, Charles Silverman, Chris Mercogliano, Dan Willingham, Daniel Goleman, Daniel Kahneman, Daniel Siegel, David Bohem, David Higherly, David Sousa (x2), Diane Ravitch, Don Arstein, Don Goines (x2), Edward Deci, Einstein (x3), Eric Jensen (x3), Eric Kandel, Esther Thelen, Francisco Varela, Gene Wiley, Geoff Caine (x2), Gerald Edelman, Gandhi, Hal Pashler, Hans Selye, Helen Neville (x2), Herb Cole, Herman Epstein, Horace Mann, Howard Gardner (x3), Humberto Maturana, Jacob Hacked, James Popham, Jean Piaget (x2), Jerome Kagan, Joaquin Fuster, Joe Nathan, Johah Leaher, John Bruer (x2), John Dewey (x2), John Gabrielli, John Gatto, John O'Keefe, John Ratey, Jonathan Kozol, Joseph Chilton Pearce, Judy Willis, Ken Robinson, Katheryn Hirsch-Pasek, Keith Devlin, Kohlberg, Kurt Fischer (x6), Laura Pettito, Les Hart (x3), Lewis Water, Linda Smith, Lisa William-White, Lousia May Alcott, Lynn Nadel, Michael Gazzaniga, Michael Posner (x3), Mary Rothbart, Madaline Hunter (x2), Marian Diamond (x3), Martha Denkla, Martin Luther King, Mary Helen Immordino Yang (x4), Mary Catherine Bateson, Michael Thomas, Michelle Misako, Mike Merzinich, Mike Miller, Pat Cole, Patricia Wolfe (x3), Paula Tallal (x2), Peter Drucker, Peter Senge, Rennate Caine (x3), Robert Sylwester (x4), Rodiger, Ron Brandt, Rosa Parks, Rose Lee Fink, Sally Shaywitz (x2),Sarah Jane Blakemore, Saul Alinsky, Sean Griffin, Seigler, Siegfried Engelmann, Skinner, Spencer Kagan, Stanislas Dehaene (x2), Studs Turkle, Susan Kovalik(x2), Theo Dawson (x2), Todd Rose, Tony Buzan, Tracy Tokuhama-Espinosa, V.S. Ramachandran, Zach Stein

Schools: Albany Free School (x2), Blue school, NY, Brooklyn Free School, democratic schools, freedom schools, Friends Central-Philadelphia, Global Citizenship-Chicago, High Tech High-San Diego, Highlander folk school, International Baccalaureate, Lawrence Academy, Makato Wilson (x2), Manhattan Free School, Montessori(x3), open schools, progressive education, Quest-New York, Reggio Emelio, St Paul Open School, Sudbury, Summerhill (x2), unschooling, Waldorf (x2)

Programs:12 principles (x2), Aerobics, Annenberg media project, Apple challenge learning, Baby Mozart , Brain Gym, CAST, Discotest (x2), FastForWord (x4), Heartmath, Highly Effective Teaching, Learning to Learn, Seven Step Lesson Plan, Star Logo, Tools of the Mind (x2)

APPENDIX C

General Themes & Codes: Block1 & Block2

Caution & Skepticism: Doing harm, misuse of science data, myths fads & snakeoils, reductionistic, skepticism, too early

Creating Community: Catalyst, collaboration, community, culture, family, receptivity, social capital, social justice

Definitions & Goals: Building the field, defining the field, definition of learning, educational neurosci, goals, IMBES, need for research, neuroeducation, self-directed/self-organizing, should include, shouldn't include, social justice, terminology

Evolution of Field: Change efforts, educated consumers, future of country, future of education, future of field, growth of field, history of issues, how things are changing, need for research, state of education

Institutional Behaviors: Challenges for alternative education, change efforts, need to shift ideas about learning, receptivity, social justice, system_meme&habits

Neuroscience & Research Issues: Basic research, breadth of neuroscience, educational neurosci, ethics_responsibility, findings from neurosci, methods, need for good science, neurological correlates, piecemeal work, plasticity, value for society, value of science & research

Personal Influences: Cobbled together personal program, consultant_entrepreneurs, founder of the field, influential people inspiring career, influential work inspiring career, names of folks in the field, self-taught, worked as a teacher, worked in different arenas.

Structures & Policy: Charter schools, economics, infrastructure, NCLB, policy, policymakers, politics, public v private, reform, research schools, standards, structures & systems, testing

Teachers: Challenges for teachers, content knowledge, documentation, educated consumers, focus on teaching, information for teachers, professional development, receptivity, respect for teachers, scripted curriculum, teacher ability, working with teachers

Transdisciplinary Connections: Bridging the gap, collaboration, communication, complexity, consultant_entrepreneur, differences of opinion, forum, keeping original fields intact, levels of analysis, multidisciplinary, multiple roles, points of connection, reciprocity, shared agenda, translating, vocabulary, worked in different arenas, working with teachers

APPENDIX D

Curriculum Themes & Codes

Block 1 & Block2

Applications & Programs: Applications, best practice, bringing it to the classroom, need for research, piloting programs_flexibility, principles for teaching, programs_negative, programs_positive, promising principles, self-directed and self-organized, technology

Curriculum & Instruction: Alternative education, arts, assessment, curriculum development, direct instruction, experiential hands-on learning, holistic education, inquiry based instruction, integrated curriculum, models of education, PBL, pedagogy, play, scripted curriculum, special ed, spiraled curriculum, spirituality in education, student directed, student group work, teaching to the average, testing issues, textbooks, traditional ed

Development & Individual Differences: Development, holistic education, individual differences, learning as a growth process, natural ability cut off, natural learning, [neuro]plasticity, special education

Student_Issues: Citizenship, doing harm, focus on true abilities, maximizing student potential, play, principles of learning, relevance of education, spirituality in education, student group work, student outcomes

Student_Socio-emotional Factors: Character education, citizenship, importance of emotions, personal meaning_motivation, respecting students, social cognition, socio-emotional

Student_Cognitive Factors: Content vs capacity, create rigid thinking_one answer, creative problem solving, critical thinking_information use, depth of processing, engagement_attention, feedback_meaning needs, higher level cognition, lower order skills, perception-action cycle, personal meaning_motivation, reflection_metacognition, temporal dynamics

Student_Physiological Factors: Development, exercise, nutrition, poverty, somatosensorimotor, sleep, stress

Block 3

Cognitive Factors: 21C skills, attention, concept, creative innovation, critical thinking, curiosity, decision making, enduring-universal concepts, executive function, memory, pattern recognition, problem solving

Social Emotional Factors: Citizenship, collaboration, community, competition, defensive coping, emotion, group work, love, moral reasoning, self-confidence, socio-emotional

Meta-Cognitive: Epistemology, mindfulness, self-regulation, perspective taking, students learning how they learn

Physiological Factors: Circadian rhythms, movement, nutrition, physiological, poverty, sleep, stress

Classroom Practice: Arts, assessment, creating a classroom model, curriculum, debate, depth not breadth, dialectic, discovery, implementing practice, inquiry based, integrated learning experiences, interventions, PBL, pedagogical diversity, pedagogy, play, simulations, strengths based approach, students helping each other learn, transfer of learning, visual representation

Content: Content, mathematics, numeracy, reading & literacy

DAP & Holistic: Development, doing harm, forcing children to learn, holistic, natural learning, nature

Dynamics of Learning: Dynamic systems, experiential education, feedback, hierarchical learning, how we learn, neuroplasticity, scaffolded learning

Individually Responsive: Empowerment, individual differences, individual self, meaningful learning, motivation, personal interests, personal meaning, personality, relevancy, student directed

Models of Education: Behaviorism, brain based education, direct instruction, models, scripted curriculum, using existing classroom models, proof of concept, traditional model, tweaking system

School Structures: Class period, class size, common core, enriched environments, grades, homework schedule, learning environment, learning materials, outcomes, overhaul system, purpose of schooling, research schools, standards, things wrong w public school,

Other: Role of parents, role of teachers, role of technology, working w experts

APPENDIX E

Public Waldorf Schools

Alice Birney Waldorf [a, b, c, d]
Sacramento, CA

Blue Oak Charter [b, d]
Chico, CA

Coastal Grove Charter School [a, b, c, d]
Arcata, CA

Desert Marigold School [a, d]
Phoenix, AZ

Desert Star [d]
Yavapai, AZ

Golden Valley Charter [a, b]
Sacramento

Journey Charter School [a, b, c, d]
Aliso Viejo, CA

Lighthouse School [a, d]
North Bend, OR

Live Oak Charter [a, b, c, d]
Petaluma, CA

Monterey Bay Charter School [a, b, c, d]
Pacific Grove, CA

Mountain Mahogany [d]
Albuquerque, NM

Mountain Oak School [a, d]
Prescott, AZ

Novato Charter School [a, b, c, d]
Novato, CA

Ocean Charter School [a, b, c, d]
Los Angeles, CA

Pine Forest Charter School [a, d]
Flagstaff, AZ

Portland Village School [d]
Portland, OR

River Oak Charter School [a, b, d]
Ukiah, CA

Sebastopol Independent Charter [a, b, c, d]
Sebastopol, CA

Stone Bridge School [a, b, c, d]
Napa, CA

SunRidge Charter School [a, b, c, d]
Sebastopol, CA

The Urban Waldorf School [a]
Milwaukee, WI

The Village School [a, d]
Eugene, OR

Woodland Star Charter School [a, b, c, d]
Sonoma, CA

Yuba River Charter School [a, b, d]
Nevada City, CA

(a=Data Set A, b=Data Set B, c=Data Set C, d=Qualitative Data Set)

APPENDIX F

Waldorf Comparison Schools

Academy for Academic Excellence $_{c, d}$
San Bernadino

Alder Grove Charter $_{b, d}$
Humboldt

Apple Blossom $_{b, d}$
Sonoma

Brook Haven Elementary $_{b, d}$
Sonoma

Forest Charter $_{b, d}$
Nevada

Hesby Oaks $_{b, d}$
Los Angeles

Hooker Oak Elementary $_{b, d}$
Butte

International School of Monterey $_{b, c, d}$
Monterey

Ivy Academia $_{c, d}$
Los Angeles Unified

Julian Charter $_{c, d}$
San Diego Unified

Las Flores Middle School $_{b, d}$
Capistrano Unified

Leonardo Da Vinci $_{b, c, d}$
Sacramento

Mendocino Elementary $_{b, d}$
Mendocino

Natomas Charter #19 $_{c, d}$
Sacramento

Ottoman Way Elementary $_{b, d}$
Sacramento

Pleasant Valley Elementary $_{b, d}$
Marin

Ramona Community $_{c, d}$
San Diego

River Charter $_{b, d}$
Napa

Sanger Academy Charter $_{c, d}$
Fresno

Santa Rosa Charter $_{b, c, d}$
Sonoma

Sinaloa Middle $_{b, d}$
Marin

Sonoma Charter $_{b, c, d}$
Sonoma

Temecula Preparatory $_{c, d}$
Temecula Valley Unified

Tijeras Creek Elementary $_{b, d}$
Capistrano Unified

Twin Hills Middle $_{b, d}$
Sonoma

Vichy Elementary $_{b, d}$
Napa

(b=Data Set B, c=Data Set C, d=Qualitative Data Set)

APPENDIX G

IB Schools

Academia Semillas del Pueblo
Los Angeles Unified

Albert Einstein Charter School [a]
San Diego Unified

Alice Birney Elementary School
San Diego Unified

Amelia Earhart Elementary
Desert Sands Unified

Benjamin Franklin Elementary School [a]
Desert Sands Unified

Castle Rock Elementary School [b]
Diamond Bar

Cyrus J. Morris Elementary School
Walnut Valley Unified

El Sereno Middle
Los Angeles Unified

Elizabeth Hudson School
Long Beach Unified

Farmdale Elementary
Los Angeles

Frances E. Willard Magnet School
Pasadena Unified

Harding University Partnership School
Santa Barbara

Horace Mann School
San Jose Unified

James A. Foshay Learning Center
Los Angeles

Jefferson Elementary School
Carlsbad Unified

Kate Sessions Elementary School
San Diego Unified

Lake County International Charter
School Middletown Unified

Lexington Elementary School
Los Gatos Union Elementary

Palmdale Learning Plaza
Palmdale

Park Side Elementary
Sebastopol

Sierra Elementary School
Rocklin

Stanley G. Oswalt Academy
Walnut Valley Unified

Stowers International Studies
Cerritos

Sunnybrae Elementary
San Mateo

Thomas Jefferson
San Diego Unified

Vista Magnet Middle School
Vista Unified

William F. McKinley
San Diego Unified

Ybarra Academy
Walnut Valley Unified

APPENDIX H

Auto-codes for Waldorf Qualitative Analysis

21st CENTURY SKILLS: Century skill, century learn, creativity, critical think, imagination, innovation, problem solv, solve problem, think critical

ACADEMICS: Academic, homework, home work

ART & MUSIC: Art, music

COMMUNITY: Community, comunity

CURRICULUM: Curricul, curicul, cirricul, ciricul

DEVELOPMENTALLY APPROPRIATE PRACTICE: Develop, pace, rate of learn, speed

SECOND LANGUAGE: Foreign lang, foriegn lang, French, Japanese, Spanish

HOLISTIC: Whole child, holist, child centered, well(-)rounded

LEADERSHIP: Admin, board, director, director, leader, organiz, principal

LOVES LEARNING: Life(-)long learn, love(s) school, love(s) going to school, love(s) to learn, love(s) learn, love of learn

PARENT INVOLVEMENT: Fund raising, fundraising, parent involv, parent participation, volunteer, volunter

TEACHERS: Teacher, staff, faculty

TESTING: Score, test

WORLD CITIZENS: Citizen, citez, world, glob, future, societ, steward, environmental, earth, planet

APPENDIX I

Themes & Codes from IB Parent Comments

21 CENTURY SKILLS: Creative educational opportunities, creativity, critical thinking, curiosity, encourage individuality, encourage creativity

ACADEMICS_NEG: Academic progress hindered, academic rigor decreasing, academics average, academics, lackluster, academics low, academics weak in math, achievement low, too much work no instruction, focus on culture not academics, grade inflation, grading system confusing, lacks quality math teachers, parent must augment academics

ACADEMICS_POS: Academic excellence, academic program awesome, academic program good, academics high level, academics promoted, academics rigorous, academics strong. Level or work exceeds that of previous school, quality of instruction improving each year, taking HS classes in 8th grade, the three Rs, writing strong focus

ADMIN_NEG: Adding administrators but firing teachers, administration destroying orig culture, administration horrible, administration needs work, administration occasionally off task, administration unsatisfactory, administrator proud of waiting list, administrator salaries too high, lacks leadership, leadership inconsistent, leadership main problem, leadership refuses to address problem, leadership self-interest and ego, leadership unresponsive, need to get rid of administration, passing the buck, poor leadership, principal left, principal takes away teacher creativity, principal absent, principal bragging, principal double speak, principal ineffective, principal interim, principal lack confidence in, principal micromanages, principal negative attitude, principal not good for community, principal not very good, principal poor judgment, principal standoffish, principal too wrapped up in IB, principal unresponsive, principal values degrading, superintendent wants chaos

ADMIN_POS: Administration above average, administration helpful, administration impressive, administration involved with students, administration wonderful, administrative change made a difference, lead by example, leadership creates unity and motivation, leadership responsive, leadership strong, principal accessible, principal amazing leader, principal assigns teachers well, principal available, principal awesome, principal best interest of students, principal cares, principal dedicated, principal excellent, principal fantastic, principal five star, principal fosters team environment, principal great, principal knows all students, principal listens, principal responsive, principal rocks, principal sets standards, principal streamlining processes, principal supportive, principal visionary, working had to get new programs off the ground.

ARTS-CULTURE-LANGUAGES: Art, bilingual education, culture_understanding importance of, cutting arts and music, language arts_excellence, language_Chinese, language_German, languages, languages & culture, music, music & art, plays and performances, school activities_events, student performances superb, theater & drama

COMMUNICATION_POS: Communication with parents, communication asks parents for feedback, communication getting better, communication great, effort to maintain contact with parents, follow through on IEP

COMMUNICATION_NEG: Asked for help received none, communication not as good this year, communication poor, difficulty getting a response for concern, lack of communication, poor teacher-parent communication

COMMUNITY_POS: Alumni, alumni association, alumni happy with education, community, community activism, community awareness, community club, community participation, community pride, community service, community spirit, community family like, community friendly, diversity, everyone committed to making the school, everyone gets involved, everyone working hard, family nights, get so much accomplished, high minority population, meeting needs of the whole family, lots of military kids, working hard together for kids

COMMUNITY_NEG: Community feeling gone, community needs to pressure administrator, community needs to lobby for change, community not used for partnerships, need to foster community, needs to be more child and family centered, parents cliquish

DISCIPLINE_POS: Discipline tops, discipline zero tolerance, safe school, school security, strict discipline

DISCIPLINE_NEG: Behavior issues take away from learning, behavior of students towards teachers, bullying, bullying racial, concerned about safety, discipline issues, discipline w-o parent notification, discipline_in-school suspensions miss class time, discipline unfair practices discipline zero tolerance, eat in class, focus on behavior not education, gang mentality, gangs, lacks discipline, need more supervision, safety issues, security lax

EXTRACURRICULARS_POS: Band, college club, extracurriculars, extracurriculars deciding factor, field trips, physical education

EXTRACURRICULARS_NEG: Extracurriculars need more, extracurriculars lacking, need “resume builders”, not many extra programs

HOLISTIC – DAP: Balanced approach, challenged not stressed, develops whole child, differentiated instruction, educating all students, effect of looking on relationships, holistic approach, individualized learning, lacks differentiated instruction, lacks personal attention, meets individual needs of students, multiple ways of learning, non-competitive, not about worksheets, not busy work, not just about test scores, not just academics, not just textbooks, not like public school drones, nurturing, personal attention, slow rate of learning, teach whole child, too much pressure at a young age, well rounded, well-balanced education, work with child multiple levels

IB: Citizenship, earth education, global citizenship, global perspective, IB, IB_busywork, IB feeder-school, IB focuses on big ideas, IB for above average students, IB fosters well rounded students, IB in infancy bugs to work out, IB lots of extra work, IB not living up to what IB stands for, IB outstanding addition to curriculum, IB rules governing structure of class, IB school of choice, IB separate from rest of school, IB should be in all schools, IB should be optional, IB taking away from CA state curriculum, IB teaches communication, IB too much fluff, IB waste of money, internationalism, works for most students

ENVIRONMENT_POS: Atmosphere caring, atmosphere comfortable, atmosphere conducive to learning, atmosphere family like, atmosphere friendly, atmosphere small town feel, atmosphere welcoming, atmosphere wonderful, atmosphere positive, environment fabulous, environment family, environment fun, environment great, environment healthy, love the environment, environment nurturing, environment old fashioned, environment safe, garden and nature, gentrified neighborhood, homey feeling, ideal place to learn, learning environment dynamic, learning environment excellent, learning environment good, learning environment wholesome, learning from peers, learning in a fun way, natural environment, no racial tension, school beautiful, second home

ENVIRONMENT_NEG: Act like its juvenile hall, atmosphere unwholesome, environment not good for learning, hurried environment, learning environment terrible, learning environment disrespectful and violent, learning environment lacks structure, loss of humanity, racial tension, rudeness, rumors, school filthy

PARENT INVOLVEMENT_POS: Allow parent participation in decisions, committed families, community requirements, families committed, families wonderful, parent and child learning together, parent and teacher working in partnership, parent generosity critical, parent help in classroom, PI amazing, PI excellent, PI high, PI key, PI required, parents organizing for equipment and programs, parent participation encouraged, parent volunteers, parental involvement, parents concerns taken seriously, parents' needs respected, parents active in child’s education, parents supportive, parents well informed, PTO excellent, PTSA, school board member

PARENT INVOLVEMENT_NEG: Attempt to work with staff, parent felt misunderstood, PI discouraged, PI a farce, PI difficult to engage whole community, PI drops at middle school, PI hassle, PI needed, PI non-English speaking parents, PI not very good, PI problem bc do not live in community, PI working parents, PI over-involvement, parent-child support lacking, parents responsible for child behavior, parents controlling, parents controlling and complaining, parents expect the school to parent children, parents need to be educated about IB, parents need to teach kids respect at home, parents only help their own teachers, PTA non-existent, PTO controlled by select parents, working parents excluded

PBL: Block schedule, inquiry based curriculum, integrated curriculum, PBL, PBL as tough as college assignments, PBL developed self-teaching ability, PBL didn’t work form by kid, PBL more projects than remembered, PBL take away from class time, PBL too many projects no fundamentals

PHILOSOPHY: Alternative off the grid, alternative pushing the envelope, appreciate philosophy, didn’t agree with school philosophy, home school alternative, out of the box thinking, philosophy unique, programs multidimensional, real world attitude to education, unique decision making processes_full inclusion, unique education, unique experience different from traditional education, variety of teaching methods

CHARACTER DEVELOPMENT: Character development, character education, cliques, community service, family values, friendships, inclusiveness, making friends, moral education, personal growth, relationships, service and activism, socially accepted, socially conscious, socially responsible, students know each other, students respect each other

STUDENT_POS: Enjoying learning, enjoys schools, flourishing, great students, helping struggling students, high expectations of students, joy of learning, love learning, love school, love their world, loved experience at school, student development in personal areas, student growth_academic and personal, student participation, student progress, student activism, student being challenged, student challenged and valued, student employment, student enjoys school, student excited to go to school, student finally feels at home, student flourishing, student grades and attitude improved, student happy, student individuality encouraged, student learning and expressive, student reading above grade level, student recognized, student says good things about teacher, student self-confident, student shy, student work and think independently, students blossoming, students love academics and staff, students above average, students attentive, students doing excellently, students excelling, students experience childhood, students grade and test scores up, students happy, students hard working, students high test scores, students love principal, students motivated, students prepared for college, students respected, student significant progress, students thriving, students want to learn, students well behaved, students will go far in life

STUDENT_NEG: Bright students leaving school, falling behind academically, not good if student needs extra help, student achievement not important, student success depends on student, student begging to be taken out and homeschooled, student depressed, student did not benefit from school, student dropped out, student held back bc LD, student shy, student stressed, students academics dropped, students cannot move ahead, students graduating wo competence, students helping teachers, students teaching students, students acting out, students bored, students bored and violent, student do not respect on another, students need academic help, students need to take advantage of opportunities, students not challenged, students not motivated, students not prepared for real world, students out of control

TEACHER_POS: Dependable, enjoy teaching at the school, giving teachers special recognition, principal stretches teachers, teacher collaboration, teachers care, teachers work together, teachers accessible, teachers amazing, teachers attentive, teachers award winning, teachers awesome, teachers care, teachers challenge students, teachers communicate well with parents, teachers connect with students, teachers creative, teachers dedicated, teachers demanding, teachers devoted, teachers educated, teachers enthusiastic about curriculum, teachers excellent, teachers exceptional, teachers experienced, teachers fantastic, teacher friendly, teachers good, teachers great, teachers high expectations, teachers innovative and enthusiastic, teachers invested in kids, teachers kind, teachers know students, teachers knowledgeable, teachers loving, teachers, teachers motivated, teachers nice, teachers no nonsense, teachers on top of student work, teachers one of a kind, teachers one sided, teachers phenomenal, teachers professional teachers provide individual attention, teachers remarkable, teachers return graded work, teachers skilled, teachers supportive, teachers take it to the next level, teachers top notch, teachers volunteer time, teachers well trained, teachers willing to go the extra mile, teachers wonderful, teachers young

TEACHER_NEG: Seasoned teachers leaving, teacher turnover high, teacher poor quality, teachers a few bad ones, teachers burnt out, teachers cannot control dictates of administration, teachers determine the child’s experience, teachers do not care about students, teachers do not enforce rules, teachers do not listen to students, teachers do not provide extra support for high needs teachers efforts being undermined, teachers hard to deal with, teacher inexperienced, teachers new, teachers no enthusiasm, teachers no sense of community, teacher not doing their job, teachers not interested in teaching, teachers not nice to kids, teachers poor communication, teachers retired on job, teachers shouldn’t be teaching teachers, some good some very bad, teachers stressed, teachers substitutes, teachers terrible, teachers unresponsive, teachers wreak havoc on parent’s life, teaching to the lowest common denominator

TECHNOLOGY: Class website, computers, equipment and laptops, technology, technology lacking, technology laptops, technology poor

TESTING: Beyond standards, low test scores, more than just test scores, more than test scores, not teaching to the test, standards based, teaching to the test, test of reading comprehension, test scores, test scores dropping, test scores great, test scores low, test scores only thing they care about

VERY DISAPPOINTED: Disappointed, disappointed in leadership, disappointed w experience, do not recommend, does not support child, doing better at new school, felt disrespected, had to go to police, pulled student out, thinking of homeschooling, thinking of moving children to another school, took student out, warehousing kids, warning not to send student, will not send child, will not send younger child, would have transferred out

VERY PLEASED: Blessing goes above and beyond, couldn’t be more happy w school, feel blessed, neighborhood school grateful, pleased w school, pleased w quality of school, recommend school, recommend to parents,, recommend to students, relieved to find school

APPENDIX J

School Enjoyment & Attention Scale

	Strongly Disagree	Disagree	Agree	Strongly Agree
1. What I am learning is interesting to me.	1	2	3	4
2. I am not learning anything important in school.	1	2	3	4
3. When I graduate I am going to college to continue my learning.	1	2	3	4
4. In most of my classes we are not doing anything interesting.	1	2	3	4
5. I enjoy school.	1	2	3	4
6. When I am in school I feel comfortable and happy.	1	2	3	4
7. After a weekend or some time off, I dread going back to school.	1	2	3	4
8. We do many fun things in my classes.	1	2	3	4
9. I will be happy when I graduate and can be done with school.	1	2	3	4
10. School is boring.	1	2	3	4
11. I try to pay attention in class, but it just doesn't sink in.	1	2	3	4
12. When I am walking I often bump into things.	1	2	3	4
13. Sometimes I start something, then get distracted and start doing something else.	1	2	3	4
14. When I am reading something I often have to read it again because I don't remember what I just read.	1	2	3	4
15. I am excellent w directions and never get lost.	1	2	3	4
16. I always finish what I start.	1	2	3	4
17. I often find myself daydreaming in class.	1	2	3	4
18. The teacher never has to remind me to pay attention.	1	2	3	4
19. I have an excellent memory and never forget things.	1	2	3	4
20. I never forget my homework or hand it in late.	1	2	3	4

APPENDIX K

Sample Questions from the Cornell Conditional Reasoning Task

Verbal Conditional Reasoning

Suppose you know that All of Mary's books are about horses. None of the books on the shelf are about horses. Then would this be true? At least some of Mary's books are on the shelf.	A. YES	B. NO	C. MAYBE
All Juan's pencils are red. All the pencils on the table are red. At least some of the pencils on the table are Juan's.	A. YES	B. NO	C. MAYBE

Algebraic Conditional Reasoning

Suppose you know that All Z's are Y's All Y's are X's Then would this be true? All Z's are X's	A. YES	B. NO	C. MAYBE
All X's are Y's At least some X's are not Y's	A. YES	B. NO	C. MAYBE

Prior Knowledge Conditional Reasoning

Suppose you know that All brown animals have four legs Then would this be true? All animals with four legs are brown	A. YES	B. NO	C. MAYBE
All birds have three eyes No ducks are birds No ducks have three eyes	A. YES	B. NO	C. MAYBE