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The Promise and Pitfalls of Neuroeducation as a Grounding for Instructional Practices: An Exploration of K-12 Application and Assessment

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Abstract

The purpose of this narrative inquiry study was to explore how educators from a language-based neuroeducation program apply and assess neuroeducation-grounded approaches in the classroom, and to investigate their perceptions of the challenges and merits of neuroeducation implementation. In order to understand the promise and pitfalls of neuroeducation as a grounding for instructional practices, this study sought to share the stories of educators on the *frontlines* of this nascent endeavor. It synthesized research from the domains of neuroscience, cognitive psychology, and language theory, and applied Neuro-Semantic Language Learning Theory (NLLT) as its underpinning. The research involved five educators, all of whom have taken neuroeducation coursework, begun embedding neuroeducation into their teaching practice to varying degrees, and teach in different capacities. Findings reveal that most participants rely on visual methods and gird their instructional practices with Neuro-Semantic Language Learning Theory, because they believe language mediates learning and cognition. Findings also indicate that the majority of participants utilize informal assessments to gauge the effectiveness of their neuroeducation-grounded approaches. The study finds that teachers' self-efficacy, feelings of isolation coupled with a lack of greater buy-in, and *mindset mismatch* are barriers to neuroeducation implementation. As for the merits, the findings highlight the ability to meet students' needs, the established results witnessed by participants, and the opportunity to effect a paradigm shift. This study further bridges the gap between theory and practice, and adds to the existing body of research on a neuroeducation model predicated on language function.

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Dedication

None of this would be possible without the love and support of my incredible husband, Matt. He has gone above and beyond to assist me in my pursuit of a doctoral degree. Our 50-50 partnership has shifted to 75-25 during the past year, with Matt forgiving my absenteeism and ungrudgingly taking on the lion's share of cooking, cleaning, carpooling, and playdates so I could write. He has been my sounding board, as well as my perpetual source of encouragement and mood lifting. I am lucky to have the world's best husband. Thank you, dearest Matt!

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Chapter 1

Introduction

This chapter provides contextual background information on neuroeducation as a discipline that overlaps research from neuroscience, cognitive psychology, and language theory. It includes an overview of the challenges and merits of neuroeducation, addresses tenacious neuromyths that have infiltrated the educational system, and provides a justification for Arwood's (2011) Neuro-Semantic Language Learning Theory as a frame for this study. In addition, chapter one introduces the problem statement, purpose of the study, and research questions, all of which are explained more fully in chapter two. Lastly, it previews the research methodology, which is further described in chapter three.

Background

In order to meet the needs of learners, educators must have a foundational understanding of the brain and its workings. After all, "Can a profession whose charge is defined by the development of an effective and efficient human brain continue to remain uninformed about the brain" (Sylwester, 1995, p. 6)? There was a long-held view that educators and psychologists had no need to understand the brain's physiology or the brain's complex inner workings (Byrnes, 2001), but in recent years scholars from various disciplines have come to recognize the significance of neuroscience as it pertains to learning and cognition. Advances in the field of neuroscience have important implications for teaching and learning, as understanding *why* can lead to understanding *how to* (Sylwester, 1995). Neuroscience provides insights about the mechanisms and neural underpinnings of learning, which can in turn inform educational policies and practices (Goswami, 2008; Petitto, 2008). Although education is of course more than its

"neural aspects" (Battro, Fischer, & Léna, 2011, p. 4), the profession would be well served to seek scientific understanding of the various brain mechanisms and processes that impact learning (Sylwester, 1995).

The Neuroscience-Education Connection

Neuroscience legitimizes educational practices and informs pedagogy by providing a solid evidence base. Neuroscientific discoveries can be harnessed to understand and improve upon learning (Schrag, 2013), and to challenge "common-sense views about teaching and learning by suggesting additional systems that are involved in particular tasks and activities" (Katzir & Pare-Blagoev, 2006). However, there are inherent challenges to the brain science-and-education relationship that necessitate a degree of temperance. Tommerdahl (2010) noted it is unlikely that a single study in neuroscience will have a direct application to the school setting, but perhaps aggregations of various studies will begin to inform teaching methodologies. Even then, those methodologies would need considerable testing to deem their efficacy. Ferrari (2011) underscored the need for sensitive integration of neuroscientific insights into education, as there is danger of reductionism. Notably, neuroscience may shed light on what should be taught, but it does not specify how it should be taught. Arnold (2016) suggested that a bridge between suggestion and prescription is lacking. While neuroscience may have a role to play in education, complex relationships exist between the brain sciences and classroom-ready teaching methods, so there is still a great distance to traverse (Tommerdahl, 2010). Another point highlighted by Byrnes (2001) is that neuroscientific evidence, while intriguing, is not necessarily conclusive. Thus, it is imperative to discriminate between inferences that can be made from neuroscience data versus those that cannot.

There are larger systemic hurdles to seamlessly merging neuroscience and education. Samuels (2009) suggested that the "difficult relationship" (p. 46) that has long existed between science and education may be attributed to the fields' starkly different philosophies, epistemologies, and end goals. Another challenge of connecting education and neuroscience is that the two disciplines operate at different levels of granularity (Ansari & Coch, 2006). Perhaps the biggest limitation of utilizing neuroscientific findings to inform educational practices is that the former is not – and cannot be – prescriptive in nature (Horvath & Donoghue, 2016; Mason, 2009). Educators may seek to extrapolate and apply findings from neuroscience for their teaching purposes, but this straightforward transference is not possible (Byrnes, 2001; Bruer, 1997). It is virtually impossible to directly connect research and practice or generalize findings from laboratory to classroom (Tommerdahl, 2010).

The Role of Cognitive Psychology

In light of this transference problem, a third field of study is needed to mediate the relationship between neuroscience and education. Bruer's (1997) seminal research suggested that psychology should be the third discipline included in the triad, as the learning theories borne of psychology serve as a filter through which to interpret neuroscientific and educational research. According to Bruer (1997, p. 15): "If, in the future, brain research does contribute to educational practice, it will most likely do so via the indirect, two-bridge route, not the direct one espoused in neuroscience and education argument." Nearly two decades later, Horvath and Donoghue (2016) reiterated the assertion that cognitive psychology is the middle ground between neuroscience and education. The authors posited that "prescriptive translation" (p. 7) must traverse cognitive/behavioral psychology, with additional work undertaken at the educational level to measure for efficacy. Willingham (2009) echoed that neuroscientific data

are “primarily useful in their contribution to behavioral data when a rich body of data and theory exists at the behavioral level” (p. 545).

According to Byrnes (2001), triangulation among three fields of study is necessary: “By itself brain research cannot be used to support particular instructional practices. It can, however, be used to support particular psychological theories of learning, which in turn can be used to design even more effective forms of instruction” (p. 185). Just as psychology can mediate neuroscience, so too can neuroscience mediate psychology. Kelly (2011) posited that many learning theories that have gained traction in schools do not have requisite empirical backing. Thus, data from neuroscience can provide a solid empirical basis for theories that are “too often contingent descriptions of learning with little specification of mechanism or grounding in the larger set of findings in science” (p. 20). Lest the role of education in the partnership be underappreciated, Mason (2009) asserted that applications from education could help steer future brain research and studies. Therefore, the research affirms neuroeducation as a fruitful and worthwhile partnership for all three entities in the triad.

Biological, genetic, psychological, cultural, and social factors profoundly influence learning (Goswami, 2008; Ileris, 2009; Mason, 2009). Therefore, neuroscience research should converge with research from other relevant fields of study in order to further the collective understanding of learning and cognition processes (Mason, 2009). A model premised on interrelatedness and connectivity has the potential to propel educational practices. Neuroeducation is one such model by which to re-envision teaching and learning.

The Neuroeducation Model

In recent years, there has been an increased interest in the relationship between the *pure* sciences and their educational applications. Various stakeholders have underscored the need to

reconcile neuroscientific findings with educational theories in order to improve teaching and learning (Immordino-Yang, 2011; Purdy, 2008; Tommerdahl, 2007). While there have been various informal attempts to join the fields of education and neuroscience, Tommerdahl (2007) noted the current movement to formalize the connection. Neuroeducation is a burgeoning discipline that seeks to bridge neuroscience and education by translating research findings and utilizing learning theories from various domains as a means of providing a comprehensive, holistic understanding of learning and development processes (Ansari & Coch, 2006). It is premised on increased connectivity and collaboration among various disciplines. Although Varma (2016) cautioned that neuroeducation is not a panacea, it has important implications for educational research (Battro, Fischer, & Léna, 2008). Just as neuroscience research is beneficial for to education, education is reciprocally beneficial to neuroscience: Education can serve as an "important vehicle in formulating important research questions…and in providing more precise guidelines for behavioral measurements used in neuroscience" (Katzir & Pare-Blagoev, 2006).

There are several variants of integrated models connecting the brain sciences and learning sciences, including Mind, Brain, and Education (MBE), Educational Neuroscience, and Neuroeducation. Moreover, there exist different definitions for neuroeducation as a discipline (Fischer et al., 2010; Geake, 2004; Immordino-Yang, 2011). For the purpose of this study, neuroeducation is defined as a collective discipline that merges neuroscience, cognitive psychology, and language theory (Arwood, 2011). The consideration of language in a neuroeducation model is novel; although language has been researched by scholars and scientists for several decades, it has been seemingly overlooked in the neuroscience-cognitive psychology-education relationship. Arwood (2011) posited that language plays an important role in the triad, as language function represents thinking and is paramount to the learning process. Moreover,

language is the mediator for how neuroscience and cognitive psychology are interpreted. Therefore, this research is framed by a novel language-based model of neuroeducation and underpinned by Arwood's Neuro-Semantic Language Learning Theory.

The Role of Language

Language and Thinking. Seminal theorist Lev Vygotsky (1962) posited that the interrelatedness of thought and word is of indisputable importance. Vygotsky asserted, "Thought development is determined by language; i.e., by the linguistic tools of thought and by the sociocultural experience of the child" (p. 100). Further, Vygotsky contended, children's intellectual development necessitates mastery of language. According to Halliday (1993), developing language is learning to mean: "Because human beings are quintessentially creatures who mean (i.e., who engage in semiotic processes, with natural language as prototypical), all human learning is essentially semiotic in nature" (p. 93). Numerous psychologists and linguists have studied – and debated – the relationship between language and cognition (Halliday, 1993; Vernon, 1967; Whorf, 2012). Mercer (2013) underscored the important connection between cortical functioning, thinking, and social interaction, while Frith and Frith (2007) and Salomon (1993) addressed the role of language within the context of social cognition and learning. Yet, most neuroeducation models seemingly neglect the role of language in conceptual learning, or fail to draw from both cognitive psychology and neuroscience when seeking to contextualize language.

According to Mercer (2013), neuroscience should identify the ways in which language functions relate to learning and problem solving processes. Doing so could explain why children's early language development fundamentally impacts their subsequent academic development. Moreover, Mercer (2013, p. 164) contended that "if neuroscience research

provided more evidence that language use is indeed a wholly integrated aspect of brain function," it might encourage more educational and psychological researchers to explore the role that language plays in learning and conceptual development. If language is indeed the essential condition of knowing, as Halliday (1993) asserted, its role in learning and thinking cannot be minimized.

Neuro-Semantic Language Learning Theory. Arwood (2007; 2011) contended that the prevailing mindset in education is to treat the outward manifestations of behavior problems and learning difficulties. However, tapping into students' learning systems and increasing their language function leads to higher-order thinking and mitigates the aforementioned challenges. It is important to discern between language structures – words, sentences, and sounds – and language functions, the latter of which is the key focus of neuroeducation. "Language is a function of the neurobiological learning system, specific to being human" (Arwood, 2011, p. 32).

In accordance with this viewpoint, Neuro-Semantic Language Learning Theory (NLLT) posits that the brain creates meaning as the basis for language function, and suggests there are four neuro-semantic language learning processes. First, sensory input forms meaningful patterns. Next, those sensory patterns become recognizable sets of perceptual patterns. Third, the sets of meaningful patterns then change into concepts. Finally, language is acquired. In other words, language is used to represent the underlying concepts, and to name the thinking. This approach sheds light on how children learn language as a set of functional processes, as opposed to a set of additive structures (Arwood, 2011). It also provides insights on language as a crucial mediator in learning, behavior, and socialization. Therefore, a language-based model of neuroeducation and Neuro-Semantic Language Learning Theory were used to frame this study.

Although neuroeducation has gained traction in recent years, there is a dearth of information on how it is implemented in the classroom. This is especially true for the neuroeducation model predicated on language as a key mediator, as it is a nascent and cutting-edge field of study. This study sought to investigate how neuroeducation has filtered into the school setting, the ways in which educators' practices have been informed by Neuro-Semantic Language Learning Theory (NLLT), and what those on the *frontlines* perceive as the benefits and challenges of neuroeducation. This research extrapolated salient findings from the literature on neuroscience, cognitive psychology, language, and self-efficacy to determine where gaps exist and understand future directions for research.

Barriers to Neuroeducation

As with any new initiative, there are inherent barriers to neuroeducation. Bridging theory and practice can be problematic; this is especially true when transferring dense neuroscience research to the classroom. Additionally, further perpetuation of neuromyths may stymie efforts to promote responsible neuroeducational approaches. Lastly, there is a systemic challenge in merging disparate fields of study.

Bridging Theory and Practice. There exists a stark gap between research and practice (Edelenbosch, Kupper, Krabbendam, & Broerse, 2015), both at the individual and systemic levels. A contributing factor to this gap is educators' varying willingness to accept findings from the brain sciences. Byrnes (2001) categorized educators as follows: (a) those who wholeheartedly accept – and sometimes over-interpret – neuroscience research, (b) those who completely reject neuroscience as a means to inform practices, (c) those who are unfamiliar with or indifferent to neuroscience studies, and (d) those who are cautiously optimistic about neuroscientific findings as "being a provocative part of the total pattern of findings that have

emerged from different corners of the cognitive and neural sciences" (p. 186). In order to engender more widespread buy-in on the part of educators and move people into this fourth group, translation and dissemination of research are necessary.

According to Samuels (2009), many educators are resistant to research. This "research avoidance" (p. 47) is based on the pervasive worldview that educational psychology and hard science have no bearing on practical classroom applications. Many educators simply lack the requisite natural science background (Sylwester, 1995) to understand dense neuroscience research. Brain science may be perceived as too complex and too intimidating, and thus ignored altogether. Conversely, there are practitioners who embrace anything proffered as *research-based*. This too is problematic, whether because sources have not been adequately vetted or because the research is thin. In a time of increased neurophilia, or fascination with neurology (Smeyers, 2016), educators are vulnerable to misinformation about neuroscience as it pertains to teaching practices (Hook and Farah, 2012).

Neuromyths. When findings from the brain sciences are misinterpreted, diluted, or overgeneralized, the result is the perpetuation of neuromyths (Pasquinelli, 2012; Worden et al., 2011). While neuromyths abound, this study examined three false beliefs that prevail in education: the idea of hemispheric dominance, the premise that there are critical periods of development, and the notion that students have fixed learning styles and distinct intelligences. It is essential to continually debunk these neuromyths in order to clarify misinformation that exists and pave the way for neuroeducation as a legitimate grounding for instructional practices. Purdy (2008) and Goswami (2006) noted the potential for erroneous educational applications to discredit neuroscience, and Mason (2009) cautioned against the "dangerous misuses" (p. 549) of pseudoscience. These concerns may make neuroscientists skeptical about the educational

applications of their research (Guy & Byrne, 2013). Thus, it is imperative for educators to utilize a discerning lens and parse empirical, evidence-based findings from inaccurate *brain-based* strategies often touted in schools. Access to high-quality research will make educators critical consumers who are less susceptible to fads and false promises (Carew & Magsamen, 2010; Hook & Farah, 2012).

Merging Disparate Fields of Study. The gulf between neuroscience and education (Mason, 2009), is also due to broader systemic issues. Samuels (2009) suggested that the "difficult relationship" (p. 46) between science and education may be attributed to the fields' starkly different philosophies, epistemologies, and end goals. Another challenge of connecting education and neuroscience is that the two disciplines operate at different levels of granularity (Ansari & Coch, 2006). Historically, there has been a lack of bidirectional, transparent communication between the two disparate fields. With the addition of cognitive psychology to the triumvirate, the epistemology problem is only exacerbated. Therefore, increased communication and connectivity are essential for a fruitful partnership.

Furthering the Neuroeducation Enterprise

In order to mitigate the inherent barriers to neuroeducation and propel the burgeoning field of study, translational research is vital. Cross-pollination and communication are the cornerstones of an integrative discipline such as this. Carew and Magsamen (2010) suggested that a shared language among stakeholders will solidify the burgeoning field of neuroeducation. Other researchers (Hook & Farah, 2012; Tommerdahl, 2010) highlighted the importance of multi-level discussion and communication to inform research, policy, and practice. A transdisciplinary approach is critical in order to bridge the gap between research and practice (Edelenbosch et al., 2015) and further the neuroeducation enterprise. Convergent, multilevel research provides "deeper insights into the possible connections between educationally relevant

skills and the neuronal, genetic, and other biological factors that may underlie them" (Katzir & Pare-Blagoev, 2006, p. 72). However, while neuroeducation holds great promise, stakeholders must exercise cautious optimism (Purdy, 2008), tempered enthusiasm, and patience. According to Tommerdahl (2010), we must reconcile the desire in educational settings for immediate returns with the importance of time-tested, empirical evidence and take a careful approach to generalizing from the laboratory to the classroom.

A collectivist, cooperative mindset is vital to the burgeoning neuroeducation endeavor. Kuhl (2011) posited that neuroscientists, educators, psychologists, and other stakeholders must collaborate and share their findings in the hopes of ultimately altering students' learning trajectories. After all, the end goal of neuroeducation is to understand the mechanisms and processes that underlie learning, and to align educational practices accordingly. Neuroeducators (Fuller & Glendening, 1985; Gardner, 2008) play an important role in the transdisciplinary approach, as they serve as brokers who triangulate and share findings from the neuroscience, cognitive psychology, and education (language) domains. Neuroeducators are the crucial linchpins whose translational work can exponentially inform educational practices.

Self-Efficacy

In order to explore the school-based implementation of an initiative such as neuroeducation, there must be a consideration of teachers' self-efficacy. Bandura (1977) defined self-efficacy as people's perceived capacity – whether accurate or not – to produce a desired effect. Researchers have discussed a lag in teachers' efficacy beliefs as they attempt to put a new method into practice (Stein & Wang, 1988; Tschannen-Moran et al., 1998). According to Turner, Nicholson, and Sanders (2011), whose study centered on primary care practitioners' implementation of a behavioral intervention but is applicable to education, self-efficacy is a

factor that is highly relevant to successful implementation of an intervention. Teachers' self-efficacy is often contingent upon feedback, encouragement, and support from others (Tschannen-Moran et al., 1998). However, neuroeducators are relatively scarce and tend to work in isolation, so validation and feedback may be lacking.

Statement of the Problem and Purpose of Study

To be certain, the literature underscores the need to reconcile scientific findings with educational practices and learning theories (Immordino-Yang, 2011; Purdy, 2008; Tommerdahl, 2007). Of course, neuroscience cannot be prescriptive in nature (Horvath & Donoghue, 2016; Mason, 2009) and there is no silver bullet to transform educational practices, so neuroeducation cannot be distilled to a series of strategies to employ in the classroom. This inclination toward reductionism is certainly one reason for the abundance of neuromyths and erroneous *brain-based* strategies that exist in the educational system. Instead, neuroeducation can serve as a useful grounding for teaching and learning.

The advancement of neuroeducation necessitates linchpins who can serve as translational brokers among the fields of neuroscience, cognitive psychology, and language. By synthesizing and sharing current research from the three domains, neuroeducators can exponentially inform how learning is understood and approached in the educational sphere. However, because neuroeducation is a relatively new discipline, there is a gap in the research between neuroeducation as a broader discipline and how it infiltrates the school setting, or how Neuro-Semantic Language Learning Theory (NLLT) informs teachers' practices. Before concluding that it is an efficacious endeavor, it is important to understand both its benefits and barriers. Moreover, it is essential to explore how educators apply and assess the neuroeducation-grounded approaches they utilize in the classroom, and the role that self-efficacy plays in neuroeducation

implementation. Therefore, the purpose of this qualitative study was to explore the promise and pitfalls of neuroeducation as a grounding for instructional practices.

The following research questions guided this study:

1. How do K-12 educators from a language-based neuroeducation program apply neuroeducation-grounded approaches in their instructional practices?
2. How do these educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize in the classroom?
3. What do these educators perceive as the challenges and merits of neuroeducation implementation?

Overview of the Research Study

This research study utilized a narrative inquiry design. Narrative inquiry is a dynamic process in which a researcher studies the lives of participants and asks individuals to tell their stories (Creswell, 2014; Clandinin & Connelly, 2000). The researcher then relives and retells those stories in narrative form (Clandinin & Connelly, 2000). Five participants from a particular language-based neuroeducation program, who worked in varying educational settings, comprised the study. This research utilized three forms of data collection: pre-interviews, classroom observations, and post-interviews. Intentional heterogeneity was desired in order to illuminate how neuroeducation *neophytes* and *veterans* embed neuroeducation in their instructional practices, and to determine how participants implement neuroeducation in various school sites.

Operational Definitions

Brain-Based Learning

Instructional strategies and methods purported to be grounded in the neuroscience of learning, but which have no empirical backing (Tardif, Doudin, & Meylan, 2015).

Cognitive Psychology

The science of how the mind is organized to produce intelligent thought and how the mind is realized in the brain (Anderson, 2015).

Mind, Brain, and Education (MBE)

A transdisciplinary field that merges applied research from neuroscience, cognitive psychology, and education, which seeks to provide a solid research base for educational practice (Fischer, 2008; Tokuhama-Espinosa, 2010).

Neuroeducation

For the purposes of this research, neuroeducation is defined as a model that integrates research from neuroscience (brain), cognitive psychology (mind), and language theory (Arwood, 2011).

Neuroeducator

Practitioners whose role is to study and understand the known relationships of brain/behavior and apply those relationships to the learning process (Fuller & Glendening, 1985).

Neuroscience

The study of how the nervous system develops, its structure, and what it does. Neuroscientists focus on the brain and its impact on behavior and cognitive functions. (Georgetown University, Department of Neuroscience, 2017).

*Neuro-Semantic Language Learning Theory (NLLT/NsLLT)**

Arwood's (2011) theory, which triangulates the literature about language function, brain science, and cognitive psychology, as explained by a series of neuro-semantic steps. *The literature refers to the acronym as NLLT, as does this study, but the theory is now abbreviated as NsLLT.

Self-Efficacy

Individuals' perceptions about their capacity to produce a desired effect (Bandura, 1977).

Viconic Language Methods™ (VLMs)

Methods that translate the properties of relational, field-sensitive languages such as American Sign Language or Mandarin onto a sound-based, alphabetic language such as English, for the purpose of matching the visual-metacognition of most thinkers with the language properties that represent those thinkers (Arwood, 2011; Arwood & Kaulitz, 2007).

Summary of Chapter

Neuroeducation is a flourishing discipline that seeks to integrate transdisciplinary research in order to provide a comprehensive understanding of learning and cognition, and to enrich teaching practices. The particular model of neuroeducation that grounded this study merges neuroscience, cognitive psychology, and language. It is transdisciplinary approach that seeks to illuminate the learning and thinking processes, and as such, it has meaningful implications for educational practices. Notably, a fruitful partnership necessitates multidirectional communication, shared findings, a common language, and a collective mindset. Perhaps most importantly, this endeavor requires well-informed neuroeducators who can synthesize, translate, and disseminate findings from the three domains. Yet, furthering the neuroeducation enterprise means overcoming inherent barriers and considering the role of teachers' self-efficacy in the implementation process.

This chapter provided contextual background information on neuroeducation as a model that overlaps neuroscience, cognitive psychology, and language theory. It included an overview of the challenges and merits of neuroeducation, highlighted pervasive neuromyths that have maintained a stronghold in education, and provided a rationale for Neuro-Semantic Language Learning Theory (NLLT) as a frame for this study. This chapter also introduced the problem statement, purpose of the study, and research questions. Finally, chapter one previewed the methodology utilized in this study. The remaining sections of the dissertation are organized as follows: Chapter two provides a review of the germane literature, chapter three explains the research methods, chapter four shares the findings, and chapter five offers an analysis of the study results, as well as suggestions for future research.

Chapter 2

Review of the Literature

This chapter provides an extensive review of the germane literature on the rationale for neuroeducation as an efficacious endeavor. It also includes literature on the three domains that comprise the multidisciplinary neuroeducation triad: neuroscience, cognitive psychology, and language theory. The chapter also includes research on the barriers and merits of the neuroeducation model, as well as pervasive neuromyths that exist in the educational sphere. It provides literature on language and Neuro-Semantic Language Learning Theory as frames for the study, and also explores the role of teachers' self-efficacy in the implementation of a burgeoning initiative such as neuroeducation.

Background

Neuroeducation is a burgeoning discipline that lies at the nexus of neuroscience, cognitive psychology, and education. The field of study, which is a variant of similar models such as Mind, Brain, and Education (MBE) and Educational Neuroscience, rests on the premise that the three fields of study can and should inform one another. The burgeoning neuroeducation initiative has profound implications for educational practices, as it can provide a more holistic understanding of how the brain functions and offer insights into the most effective ways to facilitate learning (Ansari & Coch, 2006; Limb, 2010; Sylwester, 1995; Wolfe, 2010). Although there are several transdisciplinary models that fall under the umbrella of neuroeducation, this study focuses specifically on a neuroeducation triad that connects neuroscience, cognitive psychology, and language theory (Arwood, 2011), because language is a key mediator in the learning process. This neuroeducation model is novel in its consideration of language function, therefore there is a dearth of research on how it is implemented in the educational system.

Although educators would likely agree that knowledge of the brain is essential for teaching, there exists a mismatch between neuroscience knowledge and education practices (Potomac Institute for Policy Studies, 2014). According to Hardiman (2014), education can be transformed by grounding instructional practices on evidence-based research about how students acquire, retain, and apply information. Understanding the brain and the nervous system can "offer new insights for a different concept of learning as a physical and dynamic process that may lead to new approaches in education" (García Carrasco, Hernández Serrano, & Martín García, 2015, p. 152). Thus, the field of neuroeducation plays a pivotal role in the expansion of translational research and the dissemination of relevant findings on learning and cognition, as a means to ultimately inform education. Although there have been various attempts to connect brain sciences and social sciences, the partnership has yet to reach its fullest potential (Devonshire and Dommett, 2010). There are inherent challenges to merging three starkly different and historically disjointed disciplines, each with its own epistemologies, theories, goals, and perspectives (Beauchamp & Beauchamp, 2013; Samuels, 2009).

Thus, Battro, Fischer, and Léna (2008) highlighted the need for dynamic, comprehensive integration as opposed to a "patchwork of unrelated research" (p. 5). Transdisciplinary communication and collaboration, including the creation of a shared language, are essential to a fruitful partnership (Carew & Magsamen, 2010; Edelenbosch, 2015; Kuhl, 2011). However, Rose and Rose (2016) noted that no common language between educators and neuroscientists has been created, despite numerous callings for such a language. Despite the challenges of the neuroeducation model, the endeavor is a worthwhile one. Educators who are knowledgeable about the brain's mechanisms and well informed on current neuroscience research will be better

able to evaluate brain-based products and interventions (Devonshire & Dommett, 2010). More importantly, they may be better suited to optimize student learning.

This review of the literature explores how and why neuroscience, cognitive psychology, and language theory should inform one another, as a means to justify neuroeducation as a grounding for instructional practices. The literature review provides a rationale for Neuro-Semantic Language Learning Theory (NLLT) as a frame for the study. It also investigates potential barriers and tenacious neuromyths that exist in education, both of which may serve to hinder the neuroeducation endeavor. The synthesis also culls literature on collaboration and shared language as fundamental features of a transdisciplinary approach, explores neuroeducators as seminal linchpins in the translation process, and addresses the role of self-efficacy in educators' implementation of new initiatives.

Neuroscience

The last two decades have yielded significant neuroscience research that challenges what historically has been interpreted about the brain and its functions (Sousa, 2011). These strides in neuroscience have relevance for education (Ferrari & McBride, 2011). As Sylwester (1995) asserted, educators must understand the brain's basic workings and stay abreast of developments in the cognitive sciences in order to comprehend, discuss, and evaluate research. Neuroscience and education are inextricably linked (Frith, 2013; Lalancette & Campbell, 2011), and there is great potential for the brain sciences to inform educational practices and policies (Blakemore & Frith, 2005; Sousa, 2011). According to García Carrasco et al. (2015, p. 152), "There is no doubt that neuroscience provides key biological reasons to be taken into account in discussions on learning and explanatory arguments of the educational sciences."

Hardiman (2014) suggested that teachers should understand fundamental information about brain structures and functions. The education profession hinges on the development of an "effective and efficient" (Sylwester, 1995, p. 6) brain, so it is imperative that educators be informed about the brain. Blakemore and Frith (2005) highlighted the importance of anchoring education in neuroscience evidence. There are myriad examples of neuroscience findings that have directly impacted education. For instance, research on prefrontal cortex development has informed the use of instructional strategies that scaffold students' executive functions (Ferrari & McBride, 2011). According to Galinsky (2010, p. 4), executive functions "manage our attention, our emotions, and our behavior in order to reach our goals." These functions encompass more than just academic skills; they interweave social, emotional, and intellectual capacities. Neuroscience can also shed light on the mechanisms that underlie attention difficulties, by providing a clearer understanding of the areas of the brain and cognitive sub-skills that are involved in certain tasks (Ferrari, 2011). Strides in brain imaging techniques have illuminated myriad brain processes that are salient to educators, including literacy and language learning (Devonshire & Dommett, 2010; Katzir & Pare-Blagoev, 2006; Kosaruju, Gorman, & Berry, 2014; Kuhl, 2011). Although education should not be reduced to a set of neural components, and there is no direct prescription from laboratory to classroom, findings from the brain sciences have salient implications for teaching and learning (Battro, Fischer, & Léna, 2008; Blakemore & Frith, 2005; Kosaruju et al., 2014).

Limb (2010) suggested that the allure of neuroscience is its ability to study the highly complex features of the brain, many of which are vital to the learning process. Advances in the field have clarified processes such as neuroplasticity, neurogenesis, and synaptic pruning, and provided insights into educationally relevant topics such as literacy and numeracy, as they

pertain to the brain. Moreover, neuroscience has shown us how synergistic and interconnected learning mechanisms and processes are.

Neuroplasticity is one of the most important recent discoveries to come from neuroscience (Masson & Brault Foisy, 2014). This concept relates to the brain's capacity to be modified with experience (Hardiman, 2012), and to reorganize itself on the basis of input (Sousa, 2011). Learning involves the connections between neural synapses after a sensory input is received. Neurons themselves, of which there are millions, each with its own specialized function, continue to morph over time and with experience (Sousa, 2011). Neurogenesis is the production of new cells in certain brain regions, and this too continues over time. Baars and Gage (2010) point to synaptic pruning as another key process in the brain, wherein synapses that make useful connections tend to thrive while unconnected synapses may "wither" (p. 516). According to researchers (Geake, 2003; Masson & Brault Foisy, 2014), Hebbian theory proposes that connections between cells are strengthened when they fire at the same time, commonly stated as, *'neurons that fire together, wire together.'* This has implications for teachers because efficient synaptic connections are the cornerstone of learning and memory (Baars & Gage, 2010). It explains why learning takes time and persistence, why students may forget things, and why some systematically made mistakes are harder for students to change (Geake, 2003; Masson & Brault Foisy, 2014). Another relevant concept for educators to understand pertains to the brain's ability to inhibit and integrate. According to Arwood and Young (2000, p. 55), inhibition refers to the "neurological ability to suppress non-meaningful patterns of input," whereas integration refers to the "neurological ability to connect more than one set of incoming patterns." This information explains students' filtering and processing abilities, both of which can be potentially misunderstood by teachers.

Although there is still a great deal that is unknown about the brain's intricacies, there have been incredible advances in the field of neuroscience. Thanks to strides in brain science, including new-and-improved, if controversial, brain imaging techniques, we now have greater knowledge of the brain's structures and functions, as well as the neurobiological mechanisms that underlie cognition and perception (Baars & Gage, 2010; Kosaruju et al., 2014). There is also a clearer picture of the brain's circuitry as it pertains to learning (Kelly, 2011). Neuroscience has helped to provide a more comprehensive understanding of processes such as sleep, memory, attention, and emotion as they relate to the brain. Additionally, neuroscience has made gains in elucidating neurodiversity, or atypical neurological wiring (Singer, 1998), although from a purely science-based perspective. Notably, there is still a need to address emotional and cultural influences when attempting to explain the disorders and disabilities that impact learning; we cannot rely on pathology alone. Already, neuroscience has shown that cognitive and emotional processes are integrated in the brain at various levels (Goswami, 2008), and has investigated how the brain develops through children's social interactions and during the learning process. In addition, brain research has provided important insights about the vital role of executive function, or the cognitive processes that underlie goal-directed behaviors and higher-order thinking skills (Hardiman, 2012).

It is essential to consider the factors that affect neurobiology, in order to fully comprehend how learning takes place. According to Goswami (2008), "The specialization of neural structures occurs within developmental trajectories that are constrained by both biology and environment" (p. 383). Thus, there are several key questions and considerations that are pertinent to education, such as determining which neural structures play a role in certain learning functions, which interconnections between structures are important, and how to distinguish cause

from effect. Examining the structures and functions of the brain, and studying the aforementioned developmental trajectories, may prove relevant to education (Goswami, 2008). As García Carrasco et al. (2015) articulated, "When studying the processes with an influence on human learning (memory, attention, perception, reflection, language, intelligence, sensitivity, and self-awareness, amongst others), it becomes unavoidable to approach the functioning of the brain" (p. 157).

Neuroscience findings are germane to educators because they pertain to students' learning and thinking capacities. They help teacher practitioners more fully understand the barriers that impede learning and provide useful information on the structural and functional differences related to neurodiversity. Blakemore and Frith (2005) asserted that understanding the brain mechanisms that underlie learning and teaching can transform educational practices, and Hardiman (2014) suggested that teachers who have a foundational understanding of the brain are more purposeful practitioners as a result. Thus, there is merit in underpinning educational policies and practices with neuroscience findings (Petitto, 2008). This is especially important because, as Petitto (2014) posited, schooling and educational programs are often structured in a way that flies in the face of what is understood about biological information.

However, a sense of cautious optimism (Varma, McCandliss, & Schwartz, 2008) and a critical eye (Purdy, 2008) are necessary when transferring ideas and findings from neuroscience directly into the classroom. According to Tommerdahl (2010), educators must reconcile the need in educational settings for immediacy with the importance of time-tested, empirical evidence and avoid generalizing from the laboratory to the classroom. Furthermore, it is essential to understand the limitations of neuroscience, as there is only so much that it can tell us about the social and contextual aspects of learning (Varma et al., 2008).

Clearly, neuroscience has produced findings that are of high relevance to education (Hardiman et al., 2011). As postulated by Katzir and Pare-Blagoev (2006, p. 70), "Neuroscience has provided fascinating glimpses into the brain's development and function; advances in our knowledge of the brain hold promise for improving the education of young children." Further, the researchers contended, brain science may serve as "a vehicle for advancing the application of our understanding of learning and development." Yet, neuroscience should not be the only lens through which to view learning. Frith (2013) asserted that a neuroscience perspective "recognizes that each person constitutes an intricate system operating at neural, cognitive, and social levels, with multiple interactions taking place between processes and levels" (p. 9). While perspectives from the brain sciences are informative, learning and cognition cannot be distilled to just neural mechanisms and brain functions. Neuroscience alone cannot be prescriptive to education (Varma et al., 2008). A holistic, comprehensive viewpoint is needed. Thus, this particular model of neuroeducation also integrates research from the cognitive psychology domain.

Cognitive Psychology

Bruer (1997) argued that not enough was known about brain development and neural function to make meaningful connections to the classroom: "Neuroscience has discovered a great deal about neurons and synapses, but not nearly enough to guide instructional practices" (p. 15). Similarly, García Carrasco et al. (2015) posited that neuroscience seeks to explain the "biological requirements and neuronal counterparts" (p. 154) of learning processes, whereas education also attends to individual and social processes. Therefore, the general consensus was that a third field of study was necessary in order to bridge neuroscience and education. Bruer (1997) suggested that cognitive psychology could serve as that bridge. Cognitive psychology, the study of the

mind and the mental processes that underlie observed behavior, should be used to mediate neuroscientific and educational research (Bruer, 1997). According to Anderson (2015), cognitive psychology took form in the two decades between 1950 and 1970, during which time "the cognitive revolution…overthrew behaviorism" (p. 7). The primary focus of this field is the understanding of how the mind is realized within the brain. Cognitive psychology has explored various topics that are decidedly germane to education, such as attention, memory, perception, and thought (Anderson, 2015). Thus, it can be argued that cognitive psychology is an appropriate intermediary in the relationship between *hard science* and *soft science*. According to Frank and Badre (2015), in the absence of cognitive theory, neuroscience runs the risk of cataloging brain phenomena without gaining understanding or explanation. Moreover, Bruer (2008) asserted that cognitive psychology could potentially identify specific student deficits and in turn shape curriculum designed to ameliorate those deficits.

Contrarily, Horvath and Donoghue (2016) took a decidedly different approach to the cognitive psychology-as-mediator argument, by positing that only "behavioral enactment and measurement" are relevant to educators, and knowledge of the brain is not necessary in order for teachers to perform their educational duties. Their research postulated that brain activity itself does not guide education; rather, it guides sets of observable behaviors that in turn impact education. That viewpoint flies in the face of most research on neuroeducation, which is predicated on the notion that neuroscience can and should inform education, and cognitive psychology is an effective mediator in that relationship. Byrnes (2001) underscored the need for triangulation among the domains of neuroscience, cognitive psychology, and education: "By itself brain research cannot be used to support particular instructional practices. It can, however, be used to support particular psychological theories of learning, which in turn can be used to

design even more effective forms of instruction." Frank and Badre (2015) contended that cognitive theories provide a functional analysis of how the brain has evolved, and also frame and motivate new neuroscience investigations.

Cognitive science "makes many valuable contributions without a demand to constrain or influence neuroscience" (p. 18). The mediating relationship among the fields is multidirectional, with the various fields serving to inform and legitimize one another. Neuroscience can provide a solid empirical base for prevailing learning theories by explaining the underpinning mechanisms at work and grounding these theories in larger science (Kelly, 2011). So too, education can inform neuroscience by shedding light on the practical classroom applications of findings and guiding future research. Strides in neuroscience have advanced an understanding of the neurological architecture of the brain, and cognitive psychology has furthered an understanding of the psychological structures of the mind (Stringer & Tommerdahl, 2015). While neuroscience and cognitive psychology inform education, Arwood (2011) asserted that language plays an essential role in the learning process, as it mediates thinking. Therefore, language is the third area of study within the neuroeducation triad utilized in this study.

A Language-Based Neuroeducation Model

The most typical way to convey concepts is with language. Language can be defined as "a set of conventional and arbitrary symbols that represent a person's underlying thoughts or concepts" (Arwood & Kaulitz, 2000). According to Halliday (1993), the ability – or necessity – to make meaning is a distinctive characteristic of human learning, so "the ontogenesis of language is at the same time the ontogenesis of learning" (p. 93). Therefore, language should inform learning theories and instructional practices.

According to Arwood and Young (2000), cognition pertains to the way people process information, or the way they think based on the way their brain functions. The authors contended that while some students are auditory processors, the majority of students are in fact visual learners who need to create pictorial images or visuals in their minds. Further, they asserted that there is a stark disparity between the learning systems of students and the predominantly auditory-oriented US educational system. Arwood (2011) posited that only 15 percent or fewer of today's students are auditory processers, who form concepts through the use of both visual and acoustic patterns. While some of the 85 percent or more who have visual thinking systems are able to train themselves to match sounds with their own visual representations, there are many others for whom sound disrupts their visual representations. In other words, the sound of a teacher reading – or the sound of the student's own voice when asked to read aloud – actually "makes their mental pictures disappear" (p. 126). And yet, the education system is solidly rooted in an auditory curriculum. Thus, there is a mismatch between school culture and language function that has important implications for students' conceptual learning.

The consideration of language in a neuroeducation model is novel; although language has been researched by scholars and scientists for several decades, it has been seemingly overlooked in the neuroscience-cognitive psychology-education relationship. Arwood (2011) posited that language is a key mediator in the triad, as language function represents thinking and is paramount to the learning process. Therefore, this research is framed by a novel language-based model of neuroeducation (See Figure 1) and underpinned by Neuro-Semantic Language Learning Theory (NLLT).

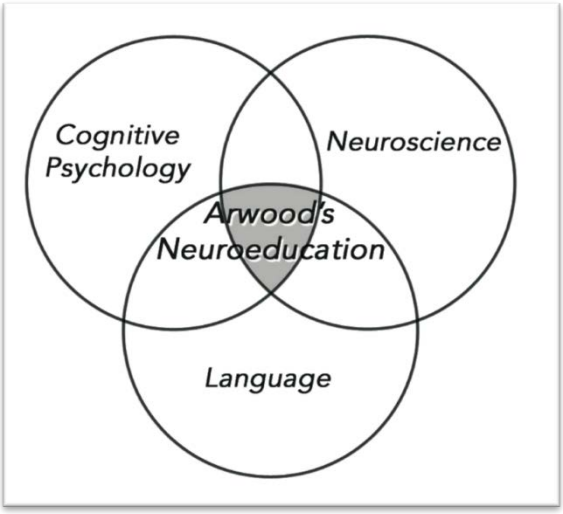


Figure 1. Arwood's Neuroeducation Model.

Making the Case for Language

Seminal theorist Lev Vygotsky (1962) posited that the interrelatedness of thought and word is of indisputable importance. According to Mercer (2013), Vygotsky argued that language is a cultural tool and a psychological tool. Vygotsky asserted: "Thought development is determined by language; i.e., by the linguistic tools of thought and by the sociocultural experience of the child" (1962, p. 100). In his view, children's intellectual development necessitates mastery of language. According to Halliday (1993), developing language is learning to mean: "Because human beings are quintessentially creatures who mean (i.e., who engage in semiotic processes, with natural language as prototypical), all human learning is essentially semiotic in nature" (p. 93). Numerous psychologists and linguists have researched the relationship between language and cognition (Halliday, 1993; Mercer, 2013; Vernon, 1967; Whorf, 2012). Yet, despite empirical knowledge that the quality of children's early language experiences often predict their subsequent academic achievement (Mercer, 2013), most neuroeducation models seemingly neglect the role of language in conceptual learning. However,

if language is in fact the essential condition of knowing (Halliday, 1993), then its importance cannot be disputed.

In addition, communication and learning hinge on social reciprocity (Twachtman-Cullen, 2007). For instance, when young children play games such as peek-a-boo or pat-a-cake with their caregivers, they engage in back-and-forth interactions that are the precursor to eventual "two-way, dialogic exchanges" (p. 92). Those reciprocal interactions are the bedrock of learning. Moreover, social interactions and interpersonal experiences play a significant role in concept formation. Concepts, which are unique to the individual, are construed internally and represented externally via language. The way in which a person represents mental concepts using language reflects their level of thinking (Arwood, 2011; Arwood et al., 2009).

Visual Thinking Systems. Arwood (2011) posited that a vast majority of today's students have visual thinking systems, and yet, education is firmly rooted in auditory curriculum. This mismatch has negative implications for conceptual learning. Language function plays a significant role in the learning process, because language names thinking. Students with visual learning systems require visual strategies that tap into the learning system. Too often, students are taught with auditory strategies that restrict conceptual understanding and ultimately, limit their language development. Visual representations have the ability to promote students' conceptual understanding. For instance, Schmeck and colleagues (2014) performed a study to determine the effectiveness of drawing pictures while learning from a scientific text. Their finding was that the students who utilized learner-generated drawings when reading performed better than peers who did not draw while reading. Interestingly, their study noted that the same effect was not found when students were given a drawing; the visual representations had to be

constructed by the learner. This underscores the point that students must be able to make their own mental pictures in order to deepen their conceptual learning.

Viconic Language Methods™. According to Arwood et al. (2009), Viconic Language Methods™ are a means of imposing visual language functions onto auditory English language characteristics, the purpose of which is to translate auditory culture into visual thinking. Several strategies have been highlighted as effective tools for tapping into students' visual learning systems. One such strategy is bubbling the outline of words, because for some children, including those with autism spectrum disorders, the shape of an idea is more important than the sight of what is seen (Arwood et al., 2009). This relates to visual perception, as "shapes develop through the reflection of light on the edge of a plane, or from the movement of eyes or body across the visual plane (like an edge) of an object" (p. 22). In other words, for some learners the bubble of a word may resonate more than the word inside the bubble. Picture dictionaries are a learner-generated reference tool, wherein students add words or ideas with which they are unfamiliar. Students add the word, bubbling the outline of the shape if needed, and create a picture to accompany the word. Importantly, Arwood (2011) noted that these strategies cannot be coopted or used in isolation. That would further perpetuate the parts-to-whole approach to learning. Moreover, the processes of learning rely on multiple points of access and layering.

Some students develop concepts by making meaning from movement patterns. The sensory input for patterns of movement comes from the motor system (Arwood & Kaulitz, 2007). It has been shown that movement actually enhances cognitive processing (Sousa, 2011). For some learners, patterns of movement create mental shapes of ideas. In other words, motor patterns can neurologically form shapes of ideas, which is another form of visual language function. An example of a Viconic Language Method™ that is especially useful for learners

who make concepts by the use of motor patterns is hand-over-hand strategies (Arwood, 2011). In this method, an adult places his or her hand over the learner's hand to help the learner make the mental shapes of meaning, and ultimately, acquire concepts.

Notably, Arwood (2011) differentiated between language structures and language functions. Language structures, such as spelling and multiplication tables, are easily quantifiable and teachable because they pertain to pattern-based learning and external products. Moreover, they can be practiced and memorized. However, practice and repetition does not necessarily equate to conceptual understanding, according to Arwood (2011). On the other hand, language functions represent students' thinking. They are more difficult to observe and measure because they pertain to internal processes, but they are key to higher-order thinking and conceptualization. Thus, this particular definition of neuroeducation highlights language function as a crucial mediator in learning, behavior, and socialization. For these reasons, a language-based neuroeducation model – which is underpinned by Neuro-Semantic Language Learning Theory (NLLT) and which utilizes Viconic Language Methods™ (VLMs) as a primary method of implementation – was used to frame this study.

Neuromyths

Oftentimes, the brain sciences are misunderstood, resulting in the perpetuation of neuromyths (Pasquinelli, 2012; Worden et al., 2011). In recent decades, so-called brain-based strategies for teaching and learning have gained traction in educational settings despite the fact that they are not based on empirical evidence (Tardif et al., 2015). This is in part due to the fact that the *neuro* prefix has been attached to myriad terms; it is a buzzword that seemingly adds instant credibility to any title (Giedd, 2014). Therein lies the problem, because it further obfuscates educators and laypersons, making it difficult to differentiate between solid science

and pseudoscience. According to O'Connor, Rees, and Joffe (2012, p. 220), "Scientific information is rarely transplanted intact into the public domain." Rather, it is filtered through various worldviews and cultural meanings, which can have potentially consequential results.

Neuromyths may be propagated due to dilution and misappropriation of scientific findings, as well as information that is outdated or taken out of context. Tardif et al. (2015) described studies that suggest in-service and pre-service teachers are exposed to teaching methods that purport to be brain-based, but that educators actually have "limited knowledge and… misconceptions about neuroscientific facts" (p. 51). The problem is further exacerbated by information that is couched in jargon or overly scientific terminology. Varma et al. (2008), building on the work of Bruer (1997), deemed neuromyths "irresponsible extrapolations" (p. 144) that inflate limited neuroscience findings into dubious educational prescriptions. This assertion was echoed by Battro, Fischer, and Léna (2008), who asserted that findings from neuroscience have on occasion led to "bogus recommendations for educational practice based on oversimplification and unsupported conceptual leaps" (p. 13). Varma (2016) posited that curriculum purportedly wrapped in neuroscience language often gains instant credibility, despite repeated warnings from scholars and scientists to the contrary.

As Howard-Jones (2014) noted, there is typically a seed of truth underlying neuromyths, but the information has been distorted over time. While it is often difficult to pinpoint the genesis of certain longstanding neuromyths, they tend to have staying power. There are three neuromyths that have been particularly prolific within the educational realm: the notion of hemispheric dominance, the premise that there are critical periods of brain development, and the idea that students have fixed learning styles and distinct intelligences.

Hemispheric Dominance. One longstanding neuromyth pertains to brain lateralization, or hemispheric dominance, which is the overly reductionist idea that people are right-brained or left-brained (Worden et al., 2011; Purdy, 2008). In this viewpoint, the different brain hemispheres are responsible for certain discrete academic functions. However, neuroscience has proven that brain structures do not work in isolation. Although some cognitive processes are lateralized and certain neural activity is distributed within the brain (Howard-Jones, 2014), generally there is a high degree of synergy between brain regions, with cross-modality and interconnectivity among cognitive processes.

The roots of this neuromyth may stem from early brain research on patients who had a severed corpus callosum. The corpus callosum is a band of tissue that connects the hemispheres and allows cross-communication between the two. Oftentimes individuals with severe seizures underwent a procedure to sever their corpus callosum; this typically reduced or eliminated the seizures (Alferink & Farmer-Dougan, 2010). Afterward, these patients functioned relatively normally, but there were marked differences in their language abilities. This provided brain researchers an opportunity to study the hemispheres in isolation and determine the specialized, lateralized functions of each.

Specifically, the left hemisphere has been linked to language and the right hemisphere to spatial processing. Neuroscientists have come to understand that while certain regions of the neurotypical brain are targeted to specific functions, there is integration and simultaneous functioning between both hemispheres (Alferink & Farmer-Dougan, 2010) and the brain can be more accurately likened to a series of interconnected neural networks (Sherman, 2013). Geake (2008) noted that some brain functions are modular. For instance, language production has long been assigned to Broca's area (Geake, 2008; OECD, 2007). However, it has been shown to be

associated with a much broader range of linguistic functions. Worden et al. (2011) noted that all complex learning tasks involve various networks across brain areas, and that even relatively simple tasks show, via brain imaging techniques, a high degree of widely distributed network activation. According to Tommerdahl (2010), oftentimes neuroimaging studies are used in an attempt to ascribe certain functions and isolate certain behaviors to specific brain regions. This can prove both problematic and limiting, as it does not take into account the brain's synergy.

Although recent findings have disputed this hemispheric specialization myth, misconceptions about lateralization abound. There is no shortage of right-brain/left-brain programming in the educational realm, based on the premise that people may "selectively use one hemisphere of their brain at a time for separate academic functions" (Alferink & Farmer-Dougan, 2010, p. 43). This serves as a prime example of brain research that has been distorted or misinterpreted over time. More concerning, this neuromyth, which falsely pertains to students' capacities and capabilities, could result in the perpetuation of stereotype threat (Worden et al., 2011). It also creates a focus on students' deficits and shortcomings, which is counter to the move toward strengths-based teaching.

Critical Periods. According to Pasquinelli (2012), another prolific misconception is that the brain has critical periods of brain development, such that capacities are fixed and immutable. The resulting implication is that learners are at a deficit if they do not get requisite knowledge and skills during those formative periods. This myth is often applied in the context of language learning (Worden et al., 2011). Goswami (2006) described the commonly propagated notion that "direct teaching of certain skills must occur during the critical period, or the window of opportunity to educate will be missed" (p. 3). According to Howard-Jones (2014), this myth

perpetuates the idea that adults are in a race against time to supply stimulation to children before their synapses are lost.

To be certain, there are *sensitive* periods (Howard-Jones, 2014; Lewis, 2015; Purdy, 2008) of rapid synaptic development, brain volume surges, glucose uptake level increases, and synaptic pruning (Alferink & Farmer-Dougan, 2010; Bruer, 1999). There are also important stages during which stressors and nurturing experiences can have lasting effects (McEwen, 2011). Kuhl (2011) noted that early experiences are especially important for language and literacy, so educators should maximize the opportunities afforded by the brain in early life. For these reasons, the focus on preschool and early learning experiences is valid and should not be discounted. However, because brain development, synaptic pruning, and neuroplasticity continue into adulthood, educators must be mindful to avoid oversimplification and misunderstanding of students' capacities for learning.

The neurotypical brain continues to mature with experience and development, and new neural connections are formed as a result (Limb, 2010; Nelson, 2012). According to Howard-Jones (2014), "Human development and learning arise from a range of interrelated neural circuits subserving a range of cognitive and other skills, which develop at different rates until adulthood, sometimes in a discontinuous manner" (p. 4). Maturation may not be fully realized until people are in their mid-20s (APA, 2016), and tremendous brain changes continue to occur during the aging process (Hardiman, 2012; Lewis, 2015). According to Masson (2014), students' brains demonstrate remarkable plasticity over time, with connections between neurons continually altered by learning, therefore educators should understand that brains can change.

Teachers may have the deep-seated belief that all students can learn despite challenges, but now that belief can be supported by neuroscientific evidence proving the brain is a dynamic

organ that constantly adapts its architecture to its environment (Masson, 2014). Based on this information, the pervasive *use it or lose it* belief is erroneous and potentially damaging to learners, as it could negatively impact students' growth mindsets (Dweck, 2015) or result in a glass ceiling of sorts. Hardiman (2012) posited that this myth could influence teachers' attitudes and perceptions about children's learning capacities. This information has been seemingly taken out of context or extrapolated by educators, which is problematic in that it is a too-narrow interpretation of neuroscience (Alferink & Farmer-Dougan, 2010). Hence, the notion that students' window of opportunity closes after the critical juncture of early childhood is faulty.

Learning Styles. The term *learning styles* has been bandied about for years, despite the fact that there is no legitimate science behind it. A study performed by Pashler, McDaniel, Rohrer, and Bjork (2008, p. 105) concluded that "there is no adequate evidence base to justify incorporating learning-styles assessments into general educational practice." The idea that students have specific learning styles, such that teachers should tailor instruction to match those learning styles, is one that is often introduced in teacher preparation programs and reinforced in school settings. The learning-styles view has acquired significant influence within the field of education (Pashler et al., 2008).

The tenacity of the learning styles – often referred to as Visual, Auditory, or Kinesthetic (VAK) – neuromyth has been especially tenacious in the education sphere. In fact, Howard-Jones (2014) asserted that this is the most popular and influential myth that exists among educators. Hardiman (2014) said this practice was widely adopted in schools even though there was no credible research behind it. The myth likely originated from the idea different areas in the brain play roles in visual, auditory, and sensory processing (Howard-Jones, 2014). According to Pashler et al. (2008, p. 107), most learning-style taxonomies are "type" theories

that seek to categorize people into distinct groups, perhaps because there is some underlying appeal in "finding out what type of person one is."

However, neuroscience has debunked the learning-styles neuromyth by illuminating the brain's interconnectivity. Arwood and Kaulitz (2000) pointed to the tendency for learning styles to be conflated with learning systems: "Learning styles tell us that different people have different preferences. Learning systems tell us how the child learns new concepts best. Modalities are the way that material is brought to the senses" (p. 5). This does not diminish the importance of varying instructional modalities as a way to support students' learning. Perhaps the learning-styles viewpoint garnered interest because people wanted to ensure that they be treated as unique individuals (Pashler et al., 2008). Dispelling the learning-styles neuromyth does not mean negating the necessity of personalizing instruction. Luckily, Hardiman (2014) explained that teachers often naturally combine modalities to give students differentiated learning experiences. Thus, a distinction must be made between differentiating as a best practice, and overtly teaching to individual learning styles.

Similarly, Gardner's Multiple Intelligences theory, which posits that people have independent, discrete intelligences, has had incredible staying power in the educational realm (Howard-Jones, 2014). However, brain science has shown that the brain is incredibly complex and integrative, so "it seems neither accurate nor useful to reduce the vast range of individual differences at neural and cognitive levels to any limited number of capabilities" (p. 2). Learning styles and multiple intelligences are prime examples of reductionist ideas that have been dispelled, at least in part, due to neuroscience and cognitive psychology. Yet, the educational field has not yet caught up with these findings, so misinformation abounds. According to

Pashler et al. (2008), this is a glaring example of a popular approach that continue to circulate within the educational system, despite no credible evidence to support it.

These three neuromyths – the notion of hemispheric dominance, the idea of critical periods of brain development, and the prevailing view of learning styles – have been particularly prolific within education. While some persistent neuromyths are seemingly innocuous, other misconceptions about students' learning capacities may prove more insidious. Moreover, Goswami (2006) cautioned that the dominance of neuromyths and misinformation obscures the strides being made in the area of cognitive neuroscience. As such, a critical lens is imperative. Educators must evaluate research (Ansari & Coch, 2006), rely on sound, evidence-based science, and continually debunk the commonly perpetuated neuromyths that tend to gain traction in schools. They need to be critical consumers (Sylwester, 1995) who "sort through the hype surrounding brain-based learning products in order to determine the critical active ingredients and design elements shown to be effective for building targeted skills" (Burns, 2015, para 4).

Additionally, neuroscientists must use caution when generalizing findings into the educational realm and resist the temptation for interventions that are only loosely based on research or have not undergone rigorous testing (Ansari, Coch, & De Smedt, 2011). All stakeholders should work collaboratively to curtail the bevy of *brain-based* resources that proliferate pseudoscientific myths and dispel inaccuracies. According to Costandi (2015), by disseminating accurate information, researchers may stem the tide of misunderstanding about the brain. In addition, Dekker et al. (2012) underscored the need for improved communication between scientists and practitioners, as well as explicit initial teacher training centered on enhancing neuroscience literacy, in order to banish persistent neuromyths and ensure an accurate information exchange between the two fields.

Transdisciplinary Collaboration

In order to further the neuroeducation enterprise, shared language, translational research, and collaboration are required. A key facet of the transdisciplinary approach is the need for a shared, accessible language. Ansari and Coch (2006) suggested that although neuroscience and education may share common questions, differences in conceptualizations and vocabulary lead to "misconnections" (p. 149), which in turn serve as a barrier to merging the two areas of study (Beauchamp & Beauchamp, 2012). Neuroscience language can be highly specialized, precise, cumbersome, and even incomprehensible to laypersons (Cheng, 2016; Varma et al., 2008). According to Howard-Jones (2014, p.2), "cultural conditions, such as differences in the terminology and language used by neuroscientists and educators, can be implicated in the processes that transform scientific knowledge into self-propagating and misleading ideas."

Another problem lies in the nuance of terminology. Academics and educators may use familiar words that have very different meanings ascribed to them (Cheng, 2016; Howard-Jones, 2015). In order to mitigate the challenges of bridging the vocabulary of education, which is rooted in social science, with the language of neuroscience, which is rooted in biological science, stakeholders must develop a shared language. The creation of a shared language can facilitate fruitful communication and translation of findings across disciplines (Ablin, 2008; Beauchamp & Beauchamp, 2012).

According to Ansari, Coch, and De Smedt (2011), the potential for the brain sciences and education to mutually benefit one another lies in collaboration. Varma et al. (2008) posited that education and neuroscience can be bridged only when researchers collaborate across disciplinary lines on "tractable problems of common interest" (p. 140). Neuroscientists, educators, psychologists, and other stakeholders must share their respective findings in the hopes of

ultimately altering students' learning trajectories (Kuhl, 2011). Bidirectional communication and reciprocal interaction among the disciplines are imperative (Ansari, De Smedt, & Grabner, 2012; Eden, 2014). According to Battro, Fischer, and Léna (2008), progress requires genuine collaboration between researchers and practitioners, with both contributing to investigation and the greater body of knowledge. Effective dialogue can create newfound understanding and awareness, which can in turn inform educational practices (Battro, Fischer, & Léna, 2008).

Ultimately, an efficacious transdisciplinary endeavor does not require a shared theoretical perspective or methodology, but a common issue to which all stakeholders can apply their expertise for the collective good (Samuels, 2009). García Carrasco et al. (2015) cautioned that a hegemonic relationship, wherein neuroscience asserts its dominance over education or drives education theory and action, must be avoided. Rather, multi-level interaction is necessary, with neuroscientific findings complementing the work being undertaken in education – and psychology, for that matter. According to Petitto (2014), the time is ripe for neuroscience to inform educational policy, teacher training, and societal expectations. Already, "interdisciplinary collaboration has yielded considerable educationally relevant information about learning mechanisms that could not have been acquired solely through behavioral methods" (Hardiman et al., 2011, p. 2). Continued communication and cooperation among the domains of neuroscience, cognitive psychology, and learning theory is necessary in order to further these advances, propel the neuroeducation enterprise, and recast the way teaching and learning are approached.

Barriers to Neuroeducation

Although there have been great strides in neuroscience over the past two decades (Hardiman et al., 2011; Sylwester, 1995), it has limited capacities (Fischer, 2008) and cannot be

prescriptive to education (Varma et al., 2008). Therefore, a degree of temperance is necessary. Bruer (1997; 2008) cautioned against making leaps from neuroscience to education, such as generalizing findings from non-human subjects to students and making inferences based on functional imaging techniques alone. Bruer (1997) also warned that overreliance on neuroscience can lead to pseudo-implications for teaching and learning. Therefore, stakeholders must be careful not to overreach when looking for educational implications or conclusions. Rose and Rose (2016) cautioned against the pitfalls of unquestionably embracing *all things brain* without having the credibility or evidence to support them. While neuroscience may eventually inform teaching practices, currently there is inadequate concrete evidence to support the claim (Rose & Rose, 2016), and the collective understanding of how neuroscience can inform education is still too nascent (Varma, 2016).

Although a new era has been ushered in, and the relationship between the sciences and education has garnered increasing enthusiasm, neuromyths abound. Until misinformation can be reconciled, educators must be wary (Rose & Rose, 2016). According to Hardiman (2014), many educators are amenable to neuroeducation, but they are inundated by brain research from various sources, not all of which is reputable or sound. This can lead to confusion and frustration. Oftentimes, teachers simply want help making sense of the research and pulling-together the salient information. According to Hardiman et al. (2011), there are too few channels through which teachers can access relevant research, and some educators may not "possess the background knowledge that is necessary to parse research articles and apply findings in appropriate contexts" (p. 2). Thus, accessibility of information is a significant challenge barrier to neuroeducation.

Moreover, in order for the neuroeducation endeavor to thrive, the disparate worldview problem must be considered. An integrative, transdisciplinary approach such as neuroeducation is inherently problematic because the disciplines has their own epistemologies, philosophies, and theories (Beauchamp & Beauchamp, 2013), which can result in "disciplinary polarity" (Samuels, 2009, p. 48). There are challenges to seamlessly integrating three historically insular disciplines, so parity is a relevant concern. For example, scholars from different domains may cultivate drastically different definitions of learning (Guy & Byrne, 2013). Thus, Howard-Jones (2014) highlighted the "cultural distance" (p. 1) that must be traversed between neuroscience and education in order for the neuroeducation model to be efficacious.

Another barrier to neuroeducation is the concern that the neuroscience perspective is too reductionist and narrow in scope to have direct relevance to education (Ferrari, 2011; Lalancette & Campbell, 2011). Varma et al. (2008) and Horvath and Donoghue (2016) underscored the difficulty of scaling up from basic neuroscience findings to an understanding of complex cognitive processes. For instance, mapping the brain and isolating the locations of certain functions does not allow us to then design curriculum that helps teach those functions. This reiterates the difficulty of direct transference from one field to another (Bruer, 1997; Purdy, 2008). Moreover, neuroscience cannot be prescriptive to education; it can only be descriptive (Ansari & Coch, 2006; Devonshire & Dommett, 2010; Mason, 2009). According to Mason (2009), the brain is only one component of learning; biological processes interact with social, cultural, and contextual forces. Therefore, neuroscience should be considered in tandem with – or filtered through – other relevant fields of study.

A review of the literature highlights a bevy of other barriers to the neuroeducation enterprise. Ansari, De Smedt, and Grabner (2012) pointed to three primary obstacles that may

hamper neuroeducational advances: the unrealistic need for immediate returns and impacts in the educational realm, methodological challenges, and a lack of interdisciplinary training on the part of stakeholders, the latter of which confounds the problem of miscommunication among scientists and educators. Miller (2016) posited that there inherent roadblocks to getting something efficacious into practice, as the education system is not optimally designed for easy penetration of information.

Willingham (2009) outlined three problems in the "marriage" (p. 545) of neuroscience and education: a goals problem, a vertical problem, and a horizontal problem. The goals problem relates to the aforementioned issue that the artificial sciences and the natural sciences have different goals and desired outcomes. The vertical problem pertains to the fields' differing levels of analysis, as neuroscientists often view structures and functions in isolation, which excludes the other interactions and factors that children's impact learning. The horizontal problem concerns the translation and application from one domain to another, as it is impossible to rely solely on neuroscientific data (Willingham, 2009). Further, Varma (2016) explained that neuroeducation is in its infancy, and there is still much to be understood about the potentials and limitations of how neuroscience informs education.

N**euroeducators as Linchpins**

The literature underscores the need for ongoing triangulation and dissemination of findings from various domains. Hardiman (2012) suggested that a primary goal of neuroeducation is to translate salient research from neuroscience and cognitive science in order to help educators interpret and apply findings in the classroom. If translation of research is vital in order for the neuroeducation enterprise to thrive, then neuroeducators (Fuller & Glendening, 1985; Gardner, 2008) serve as crucial linchpins in the translation process. Well-informed

stakeholders who have resisted professional insulation and instead embraced collaboration among various fields have the capacity to be change agents. They are practitioners and pioneers (Fuller & Glendening, 1985) who bridge the gap between theory and practice by brokering communication between the disciplines.

According to Tokuhama-Espinosa (2010), the term neuroeducator refers to both educators who know about the brain and how it learns best, as well as neuroscientists and psychologists who are concerned with teaching practices. The author proposed that teachers need neuroeducation training because their focus historically has been on teaching practices as opposed to how students learn, while neuroscientists and psychologists need neuroeducation training because their focus has been on learning mechanisms instead of teaching (Tokuhama-Espinosa, 2010). However, Hardiman and colleagues (2011) cautioned that in order for neuroeducation to be a successful long-term venture, the onus cannot reside solely with mediators and translators. Rather, teacher preparation institutions and professional development programs should help pre-service and in-service educators become well versed in neuroscience and cognitive science research that could inform their practice.

A collectivist approach to the neuroeducation venture, which is premised on the notion that the whole is greater than the sum of its parts and which includes multidirectional communication and shared findings, may strengthen each respective profession and serve to legitimize neuroeducation as a discipline. In order to make strides in neuroeducation, stakeholders must continually seek to debunk neuromyths and pseudoscience, both of which have the potential to obscure the strides being made in cognitive neuroscience (Goswami, 2008). Educators must rely on sound, evidence-based science and use a critical lens when faced with pseudoscience or *brain-based* initiatives, which tend to gain traction in schools. For their part,

neuroscientists must use caution when generalizing findings into the educational realm. There is a clear need for improved communication between scientists and practitioners, as well as explicit initial teacher training centered on enhancing neuroscience literacy (Ansari & Coch, 2006; Dekker et al., 2012).

Defining Learning

Although educators, neuroscientists, and psychologists have different goals and agendas, there is common ground in neuroeducation. According to Tokuhama-Espinosa (2008), neuroscience seeks to demonstrate how the brain learns through "neuronal changes" (p. 38), psychologists seeks to chronicle changes in behavior based on knowledge of the mind and cognition, and education seeks to improve best practices in teaching. Despite these different desired outcomes, each discipline seeks to explain the learning process. Neuroeducation is the shared field of study by which to do so.

In order to understand neuroeducation, it is necessary to first define learning. Although neuroscientists, cognitive psychologists, and educators may differ on the precise definition of learning, there seems to be a consensus that learning equates to permanent change in the brain. Ileris (2009) defined learning as "any process that in living organisms leads to permanent capacity change and which is not solely due to biological maturation or aging" (p. 3). Learning is more that brain architecture and mechanisms, and it extends far beyond genetics. Nelson (2012) noted that although genes provide the basic blueprint for brain development, experience is what shapes the underlying brain circuitry. Learning and experiences alter the physical structure of the brain, creating new neuronal pathways. (Burns, 2015; Lewis, 2015). This further affirms how dynamic brain development is (Cutting, 2014). The human brain undergoes dramatic, adaptive changes in structure and function in response to its environment (Petitto, 2014; Sukel,

2015). Thus, natural brain changes coupled with environmental adaptations and epigenetic factors physically alter children's brains. While educators may already believe this to be true, credible neuroscience research substantiates the assertion.

Additionally, neuroeducation is premised on the idea that learning is not linear. There tends to be a pervasive assumption that all students are at the same level, with the same capacities, at the same time. In fact, our educational system is predicated upon an additive, parts-to-whole orientation (Templeton, 1991). This is an erroneous belief, however, as learning does not take place in a linear manner (Rodriguez, 2013). According to Fischer (2008), many people incorrectly assume that development involves progression along a ladder when in fact, learning can be more closely related to a web of various strands. Moreover, learning involves an interplay between external factors, such as learners' social and cultural environments, and internal processes, such as psychological acquisition (Ileris, 2009). As Ansari and Coch (2006) noted, brain development is influenced by genetic, epigenetic, neurobiological, social-emotional, and cultural factors. While neuroscience has illuminated various findings on the brain's structures, functions, and mechanisms, its scope may be too narrow because it does not consider the influential roles of cognition, experience, and interpretation in the learning process.

According to Immordino-Yang (as cited by Sukel, 2015):

> We're learning that what's happening on the outside – the same story, the same lesson – can be interpreted differently, experienced differently, by different learners. So we really need to start to unpack the roles of school culture and individual variability when we think about how children learn. We need to understand that the way kids feel matters. Their embodied experience in the classroom powerfully influences what children take away and how they grow both academically and personally. What science is teaching us,

> in short, is the need to understand the holistic emotional experience of a person, and the need to account for subjective experience when we design and evaluate educational environments. Doing so can hopefully inform more effective teaching practices (para. 7).

Hence, a neuroeducation model must be comprehensive and integrative in nature. Moreover, Arwood (2011) contended that neuroeducation must include a consideration for language function, as language is a key mediator of thinking and learning. Language also plays an instrumental role in social development, and the social aspect is an important one. Language assigns meaning to people's learning internally, and to those around them externally.

Learning is Social

Seminal theorist Lev Vygotsky (1978) asserted that the mechanism of individual developmental change is rooted in society and culture. Thus, it has been widely understood that learning cannot be disassociated from the social and cultural influences that affect it. These forces are interconnected and help to shape the way humans think and perceive the world. Immordino-Yang (2011) contended that thinking and learning do not occur in a vacuum, but within social and cultural contexts. The social environment has a profound impact on the brain, and on the individual (McEwen, 2011). Fischer and Bidell (2006) suggested that the mind is part of the body, and the collective entity thinks, acts, and feels in relation to other people and objects. Social learning is fundamental to development, as children observe and engage with others, imitate people's actions, and seek emotional feedback.

Thus, when considering the neurobiological mechanisms of learning, there must be a consideration for individuals' subjective interpretations, which are based on their unique experiences, perspectives, and cultural lenses. Children must have access to emotional, social, and moral feedback in order for their learning to subsequently inform their real-world functioning (Immordino-Yang & Damasio, 2007), and neurological systems play a role in all of

those functions. Arwood (2011) posited that language mediates the social aspects of children's development, in addition to the academic and cognitive aspects.

Neuro-Semantic Language Learning Theory (NLLT)

Arwood (2007; 2011) contended that the prevailing mindset in education is to treat the outward manifestations of behavior problems and learning difficulties. However, tapping into students' learning systems and increasing their language function leads to higher-order thinking and mitigates the aforementioned challenges. It is important to discern between language structures – words, sentences, and sounds – and language functions, the latter of which is the key focus of neuroeducation. "Language is a function of the neurobiological learning system, specific to being human" (Arwood, 2011, p. 32).

In accordance with this viewpoint, Neuro-Semantic Language Learning Theory (NLLT) posits that the brain creates meaning as the basis for language function, and suggests there are four levels of neuro-semantic language learning. First, sensory input forms meaningful patterns. Next, those sensory patterns become recognizable sets of perceptual patterns. In the third level of NLLT, the sets of meaningful patterns then change into concepts. Finally, at level four, language is acquired. In other words, language is used to represent the underlying concepts, and to name the thinking. These levels are reflected in Figure 2.

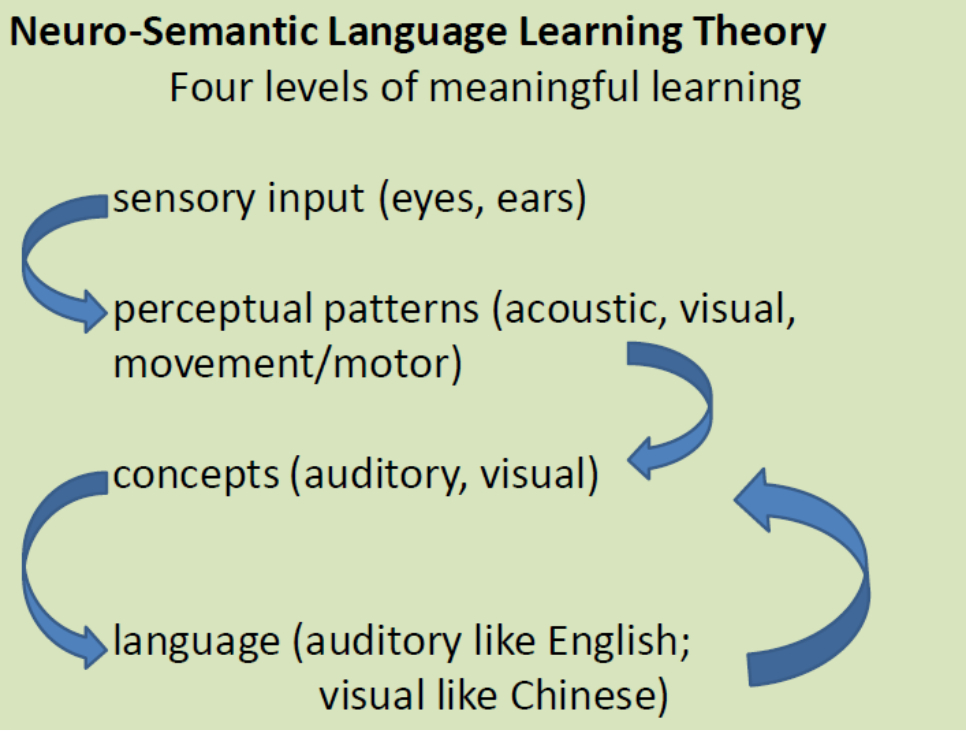


Figure 2. Neuro-Semantic Language Learning Theory (Arwood, 2011; Arwood & Kaulitz, 2007)

This comprehensive neuro-semantic approach views children's learning and language development as a series of functional processes as opposed to a set of additive structures (Arwood, 2011). It runs counter to the prevailing skill-based, "parts-to-whole" orientation of education (Templeton, 1991, p. 590). In the first stage, children receive sensory input through their ears, eyes, nose, and mouth. The acoustic and visual inputs are of particular importance to language. Moving into the second stage, sensory inputs are sorted and organized into perceptual patterns that consist of acoustic and visual features. In other words, the brain is recognizing patterns of past and present input. Arwood (2011) contended that only 15 percent – if not less – of learners are auditory processers, who use auditory and visual patterns to form auditory concepts. Conversely, 85 percent – or more – of current students rely on visual processing, wherein visual features overlap to form visual patterns, which in turn creates visual concepts.

For learners who utilize visual thinking systems, there must be a connection between what is seen and what is heard in order for conceptualization to occur. Patterns overlap and form circuits, resulting in concepts. Notably, patterns are a low-level form of brain activity and in turn, a low-level form of learning. Students may be able to mimic or repeat patterns, but this does not equate to high-level thinking (Arwood, 2011). Yet, education often defaults to pattern-based activities and assignments, such as worksheets, spelling tests, and rote memorization. Schools also tend to rely on parts-to-whole, additive instruction, which is evidenced by the use of phonics and other skill-based instructional practices (Templeton, 1991).

Four Stages of Conceptual Meaning. Drilling down from the four levels of neuro-semantic language learning, and building off of the work of seminal child psychologist Jean Piaget, Arwood et al. (2009) described four discrete stages of conceptual meaning. The first stage is the sensori-motor level, which usually applies to children from birth to 2 years of age. During this stage children usually represent simple, single ideas or semantic relationships. The second stage, typically occurring from 2 to 7 years of age, is the preoperational level. At this stage, children are sole agents in interaction with multiple actions and objects. The third stage is the concrete level, which typically occurs between the ages of 7 and 11, and in which children represent multiple agents, actions, and objects. The final stage is the formal level. It usually occurs at the age of 11 and older, and is signified by a child's capacity to represent abstract ideas that have multiple mental visuals. Conceptual learning is predicated on continual layering and meaningful overlapping of perceptual patterns. Notably, while there are distinct stages of thinking development, conceptual learning is represented by language function, which is the way a person represents the concept with language. This can occur at any stage, and at any age (Arwood, 2011).

Self-Efficacy

In order to examine the implementation of a new initiative into the school setting, there must be a consideration for the role of teachers' self-efficacy in the implementation process. Self-efficacy refers to a person's belief – whether accurate or not – in their ability to produce a desired effect (Bandura, 1977). It may also be viewed as teachers' perceptions about their ability to utilize strategies that will result in certain student outcomes (Tschannen-Moran, Woolfolk Hoy, and Hoy, 1998). At the essence of self-efficacy is perception. It is not solely a matter of whether certain initiatives or interventions are effective, but rather, whether educators believe they will be able to implement it with any level of success. Researchers have discussed a lag in teachers' efficacy beliefs as they attempt to put a new method into practice (Stein & Wang, 1988; Tschannen-Moran et al., 1998).

Research on self-efficacy has implications for the advancement of neuroeducation because, as Holzberger, Philipp, and Kunter (2013) noted, there is a reciprocal relationship between teachers' self-efficacy and their instructional quality. Teachers' self-efficacy impacts their motivation, planning, and competency, and in turn influences behavior (Bandura, 1977). Ultimately, self-efficacy beliefs impact teachers' performance (Tschannen-Moran & Woolfolk Hoy, 1998), and in this case, may have implications for the advancement of neuroeducation.

Prochaska and Di Clemente's (1982) seminal research on the change process suggested that an individual's level of self-efficacy is a key variable in long-term success in the face of challenges. Their findings underscored Bandura's (1997) assertion that "efficacy expectations are cognitions which intervene in terms of the individual's commitment to particular changes in the face of obstacles and difficulties" (Prochaska & Di Clemente, 1982, p. 286). In effect, a successful course of change entails people changing their patterns of behavior, as well as

restructuring key beliefs about themselves and their abilities. Changing teachers' practices takes time and requires ongoing professional development and support (Hall & Hord, 2001; Tunks & Weller, 2009). According to Tunks and Weller (2009), implementation of an innovation increases significantly when accompanied by continuing, regular support. Thus, there is merit to the idea that adoption and diffusion of an innovation or practice is tied to self-efficacy.

Teacher Isolation

Another facet to consider in the adoption and implementation of neuroeducation relates to teachers' feelings of isolation, or marginalization, within their respective settings. According to Lortie (1975), the *egg-crate* architecture of schools does little to engender collaboration. Insularity means that teachers have few opportunities to collaborate or observe colleagues at work (Davidson & Dwyer, 2014). A study by McQuat (2007) found that special education teachers are often isolated and marginalized. Moreover, they may lack social capital, which involves relationships, collaboration with colleagues, and ties to external experts and professional development.

Although the McQuat (2007) study was couched in a different context, it may be fair to assume that neuroeducators are similarly isolated and marginalized. It is possible that the social capital of neuroeducators, many of whom work in isolation, may be diminished if they are unable to collaborate with likeminded individuals or engage in meaningful professional development centered on a topic to which they have devoted their professional lives. In addition to addressing isolation among teachers of students with disabilities, Henley et al. (2010) discussed the separation and lack of collegiality often experienced by teachers of gifted and talented students. They suggested the merits of cooperative efforts, "based on the premise that awareness, knowledge, and cooperation bring about better working relations and less isolation" (p. 206).

Summary of Chapter

This review of the literature has explored how and why neuroscience, cognitive psychology, and language theory should inform one another, as a means to justify neuroeducation as a grounding for instructional practices. It has examined germane research on the benefits and challenges of neuroeducation and explored the dominant neuromyths that persist in education. The review has included literature on transdisciplinary collaboration and communication as essential facets of a successful neuroeducation enterprise, as well as the crucial role of neuroeducators in the translation and brokering process. It also synthesized research on language and Neuro-Semantic Language Learning Theory as an underpinning for the study, and addressed the social aspects of learning. Lastly, the literature review investigated the role of teacher self-efficacy and teacher isolation in the implementation of a burgeoning initiative such as neuroeducation.

Chapter 3

Methodology

The research study utilized a qualitative narrative inquiry design in order to gain a deep understanding of the ways in which neuroeducators apply and assess neuroeducation-grounded approaches in the classroom, and their perceptions of the challenges and merits of neuroeducation implementation. Three forms of data collection were used: pre-interviews, classroom observations, and post-interviews. This chapter provides the purpose of the study, rationale for a narrative inquiry design, participant selection criteria, and information about the data collection and analysis processes.

Purpose of Study and Research Questions

Neuroeducation may be an effective grounding for teaching and learning. Yet, the nascent discipline is not without challenges. Before concluding that it is an efficacious endeavor, it is important to understand both its merits and barriers. Moreover, furthering the neuroeducation enterprise warrants an explore how educators whose practices are grounded in neuroeducation apply and assess the neuroeducational approaches they utilize. Although there is significant literature about neuroeducation in a general sense, researchers and scholars differ on how they define it. Very few studies center on neuroeducation as defined by Arwood (2011) as the intersection of neuroscience, cognitive psychology, and language. Moreover, there is a dearth of literature on how Neuro-Semantic Learning Language Theory is bridged with teachers' practices. Therefore, the purpose of this qualitative narrative inquiry study was to explore the promise and pitfalls of neuroeducation as a grounding for instructional practices.

Three research questions guided this study:

1. How do K-12 educators from a language-based neuroeducation program apply neuroeducation-grounded approaches in their instructional practices?
2. How do these educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize in the classroom?
3. What do these educators perceive as the challenges and merits of neuroeducation implementation?

These questions were explored through pre-interviews, classroom observations, and post-interviews. Participants were educators who had completed, or nearly completed, a graduate language-based neuroeducation program in the Northwest. This specific program is based on a specific neuroeducation model that merges neuroscience, cognitive psychology, and language theory (Arwood, 2011). Intentional heterogeneity was desired in order to capture how neuroeducation *neophytes* and *veterans* embed neuroeducation in their instructional practices. Additionally, the fact that the five participants teach in different capacities provided insight into how neuroeducation is implemented across a broad range of settings: public and private, elementary and secondary, and general-education and special-education classrooms.

Rationale for Methodology

Narrative Inquiry Design. Preeminent philosopher and educational reformer John Dewey believed that examining experience is the key to education (Clandinin & Connelly, 2000). Therefore, this study utilized narrative inquiry as a means to explore how neuroeducation approaches are applied and assessed in the school setting. Narrative inquiry is a dynamic process in which a researcher studies the lives of participants and asks individuals to tell their stories (Creswell, 2014; Clandinin & Connelly, 2000). The researcher then relives and retells those stories in narrative form (Clandinin & Connelly, 2000). At its essence, narrative inquiry is a way

to understand experience. As Glesne and Peshkin (1992), explained, the crucial role of a qualitative researcher is that of learner. The researcher is a "curious student who comes to learn from and with research participants" (p. 36) as opposed to an expert or authority on the given topic. In order to understand how neuroeducational theory is bridged with practice, and to grasp the challenges and merits of the neuroeducation model, it is imperative to hear from those on the frontlines. If neuroeducators are in fact the linchpins in the furthering of the enterprise, then their voices must be heard. Narrative inquiry provides the opportunity to share their stories and insights.

Sampling Procedures and Participants

Sampling Procedures. Qualitative researchers typically work with small samples of people, "nested in their context and studied in-depth" (Miles & Huberman, 1994, p. 27). For this study, an email was sent via the university's distribution list to all current and former students of the neuroeducation program. The selection criteria were as follows: (a) completion or near-completion of a specific language-based neuroeducation program, and (b) current employment as K-12 educators. Educators from various educational capacities comprise the neuroeducation program, so heterogeneity was both expected and desired. In order to more accurately understand the challenges and merits of embedding neuroeducational principles into the educational realm, the study included elementary and secondary, general-education and special-education, and public-school and private-school teachers. Additionally, the study encompassed educators at varying points in their respective coursework. This afforded the opportunity to compare neuroeducation *neophytes* and *veterans* regarding the degree to which they understand and utilize a neuroeducation-based approaches.

Participants. Five participants were selected to partake in the study. Rachel teaches first grade in an urban public elementary school and is nearing the end of her neuroeducation coursework. Grace teaches first grade at a private faith-based school and is fairly new to neuroeducation. Sarah teaches sixth grade at a high-needs K-8 school and has completed all neuroeducation coursework. Maria teaches Spanish at a private high school and has completed all neuroeducation coursework. Pamela teaches special education at a public high school and has completed all neuroeducation coursework. In addition to the aforementioned benefits of a heterogeneous sample, the diversity of participants' stories and experiences added depth and richness to the narrative inquiry process.

Design and Procedures

Narrative inquiry is a form of research in which a researcher studies individuals' lives and asks them to tell their stories; these stories are then retold by the researcher (Clandinin & Connelly, 2000; Creswell, 2014). As a means of understanding – and adequately capturing – the five participants' stories, this study consisted of a pre-interview, a classroom observation, and a post-interview with each participant. This provided more depth to the narrative inquiry and allowed for triangulation of the data. Triangulation often provides corroboration, thereby enhancing the trustworthiness of a researcher's analysis (Miles, Huberman, & Saldaña, 2013). Per Maxwell's (2005) recommendation, several questions guided the research design: What do I need to know? Why do I need to know this? What kind of data will answer the questions? Where can I find the data?

Pre-Interviews. The first form of data collection was a pre-interview. The research utilized a semi-structured interview format, wherein interviews are "guided by a list of questions or issues to be explored" (Merriam, 2009, p. 90). The questions were flexibly worded and open-

ended in nature, in order to elicit participants' views and opinions (Creswell, 2014). Creswell (2007) recommended using an interview protocol that has been vetted through pilot testing, so the instrument was peer reviewed by a cohort of doctoral candidates, edited, piloted by a neuroeducation student who was not a participant in the study, and subsequently refined again. All interviews were audio recorded – with the permission of the subjects – to allow for accuracy and clarity of transcription, and shorthand notes accompanied the interview sessions in case of technical difficulties.

The pre-interview consisted of four demographic questions pertaining to participants' years of teaching experience, current educational position, level of neuroeducation coursework completed, and prior experience with neuroeducation or *brain-based* learning. It also included eight short-answer questions related to participants' beliefs and perceptions about the benefits and challenges of implementing neuroeducation, their application and assessment of neuroeducational principles in the classroom, and their own experiences with teaching and learning. (See Appendix A for full interview protocol). Two of the five pre-interviews were conducted at the university where the participants are enrolled in neuroeducation coursework, one was conducted at a coffee shop of the participant's choosing, and two were conducted at the educators' respective school sites. All pre-interviews were recorded using an iPad application called Voice Recorder, with subjects' permission. Shorthand notes accompanied the voice recordings in case of technical difficulties.

Information garnered from the pre-interviews helped guide the second phase of the research study, which was a classroom observation. Having a foundational knowledge of how the five participants apply and assess neuroeducation in the school setting afforded the opportunity to focus the observation, or *know what to look for*.

Classroom Observations. The second form of data collection was a classroom observation of each participant. According to Creswell (2014), qualitative observation entails researchers taking field notes on individuals' behaviors and activities at the research site. In order to answer the research questions that guided this study, the observations focused on educators' instructional practices and actions, as opposed to the children. This study utilized an observer stance, wherein the researcher's primary responsibility is to gather information, observe actions and interactions, and uncover the meaning behind behaviors (Guest, Namey, & Mitchell, 2013). This approach to observation is "associated with exploratory and explanatory research objectives—why questions, causal explanations, uncovering the cognitive elements, rules, and norms that underlie the observable behaviors" (p. 79).

In this study, the observations were open-ended and guided by the information gleaned during the pre-interviews. They offered a firsthand look at how the five participants implement neuroeducation into their classrooms, as opposed to solely relying on "once-removed accounts from interviews" (Merriam, 2009, p. 119). According to Creswell (2014), there is a risk that the researcher may be viewed as intrusive, which can have an impact on the data collection process. Each subject was observed in their classroom at a date and time of their choosing. For most participants, that equated to one or two class periods or blocks of instructional time. The observations were guided in part by information gleaned from the pre-interview and utilized a semi-structured format. A field notes protocol, adapted from a Portland State University template, was utilized during each observation. This protocol included a space to document both descriptive notes and reflective notes. The descriptive notes pertained to the setting, curriculum, and teacher actions that occurred in the classroom, while the reflective notes related to the researcher's own questions, interpretations, perceptions, and points of clarification. Specific

methods, along with examples how study participants apply and assess neuroeducation-grounded approaches in the classroom, were highlighted in advance during the pre-interviews. This information guided the observations. (See Appendix B for observation protocol.)

Post-Interviews. The third form of data collection was a post-interview. In all five cases the follow-up interviews were conducted immediately after the classroom observation, whether in the participants' classrooms or in a private space at their schools. The post-interviews, which were audio recorded, provided the opportunity for clarification and interpretation based on questions that arose during the observation. The post-interviews were more organic, open-ended, and conversational than the pre-interviews, with participants debriefing that day's lesson and sharing examples of assessments, as well as reiterating and refining their thoughts from the initial interviews.

Credibility. It was important to continually perform self-checks as a way to acknowledge researcher bias and misinterpretations throughout the data collection process. According to Creswell (2014), reflectivity is a core attribute of qualitative research. In order to maintain validity and reliability, instruments were peer reviewed by doctoral candidates, edited, piloted by a neuroeducation students, and subsequently refined again. Checks and balances are necessary in qualitative research in order to produce trustworthy results (Merriam, 2009). Triangulation, which entails analyzing data from several converging sources, is a useful method to ensure the trustworthiness of a study (Miles, Huberman, & Saldaña, 2014). This study used three forms of data collection as a means of triangulation: pre-interviews, classroom observations, and post-interviews.

Creswell (2014) recommends member checking, wherein the researcher takes final descriptions or themes back to the participants as a means of determining their accuracy, as an

important validity strategy. Member checks act as a safeguard against potential bias and misinterpretation, both of which can taint a study (Merriam, 2009; Miles, Huberman, & Saldaña, 2014). This is of paramount importance in narrative inquiry research, wherein the researcher is responsible for telling participants' stories in an accurate and responsible manner. Therefore, in this study each participant had the opportunity to review the transcriptions and narratives for content accuracy.

Ethical Considerations

The researcher received permission to conduct this study via the Institutional Review Board at the University of Portland. Although none of the participants' schools necessitated district-level institutional review board approval, the researcher contacted each participant's principal to seek express written permission for the on-site classroom observation. This research study also included several security measures to protect participants. All study participants signed consent forms, which explained that participation in the study was voluntary and stated the research requirements and time expectations. (See Appendix C for consent form.) The five research participants were assigned pseudonyms to protect their anonymity, and all identifying information about their respective schools of employment was omitted from the research study. Data were stored on a highly secure, firewall- and password-protected computer, accessible to only the researcher. The researcher took deliberate steps to ensure confidentiality and protection of all participants.

Role of the Researcher

The researcher acknowledges the potential for implicit biases to influence the research process. There were two potential sources of bias in this study. First, the fact that the researcher is pursuing a doctorate degree focused on neuroeducation means that neuroeducation is already

viewed in a favorable light. The researcher believes there is merit in neuroeducation as a model that can support instructional practices. Second, the researcher works with teacher candidates and believes that all pre-service teachers should possess foundational knowledge and understanding of brain science. The researcher sees a place for neuroeducational principles in teacher preparation. For these two primary reasons, there is the potential for an unintentional slant to the research. Therefore, in order to mitigate the potential for personal biases to imbue the research, ongoing reflection and open-mindedness were essential. Narrative inquiry is always "strongly autobiographical" (Clandinin & Connelly, 2000), so it is understood that this study was in part shaped by, or filtered through, the researcher's own experiences and beliefs. That said, throughout the study process the researcher purposefully considered how to keep the narrative inquiry from becoming overly personal or unduly influenced by her own agenda.

Data Analysis

All interviews and observation notes were immediately transcribed to ensure accuracy and provide a sense of context. This was a key step in the narrative inquiry process, which tasks the researcher with telling the participants' stories (Clandinin & Connelly, 2000). The data were examined via open coding to look for common themes about the application and assessment of neuroeducation in the K-12 classroom. These themes were subsequently organized into coding categories. According to Miles, Huberman, and Saldaña (2014), "Codes are labels that assign symbolic meaning to the descriptive or inferential information compiled during a study" (p. 71) as a way to categorize and analyze the data for interrelationships. Similarly, Glesne and Peshkin (1992) likened coding to a process of sorting and defining scraps of collected data, clumping data into major groups, breaking down data into subgroups, and eventually placing the various data clumps into a meaningful sequence.

Clandinin and Connelly (2000) explained that coding in narrative inquiry is a complex process. Narrative inquiry goes far beyond merely "telling and writing down a story with perhaps some reflective comment by researchers and participants" (p. 131). Rather, narrative inquirers spend hours reading and rereading the field texts in order to create a chronicled account. Although the initial analysis addresses setting, characters, plot, tone, and context, a deeper level of analysis is necessary (Clandinin & Connelly, 2000). Narrative inquirers then "narratively code" (p. 131) their field texts to find interweaving storylines, apparent gaps or silences, and emerging continuities or discontinuities. There is no linear process by which to move from field texts to research texts, according to Clandinin and Connelly (2000). Ongoing negotiation, reflection, and interpretation are essential to the narrative inquiry process. Thus, at the recommendation of Glesne and Peshkin (1992), the researcher made an intentional effort to reflect on the data, organize the data, and discover what the data had to say throughout the research process.

Once the data were transcribed, reviewed multiple times, and preliminarily coded, initial overarching themes were developed. As recommended by Merriam (2009), the codes were merged in order to create an outline reflecting the recurring patterns and regularities that emerged from the study. Participants' narratives were parsed to determine commonalities among subjects' stories, beliefs, and insights about neuroeducation. This process revealed several key themes, as related to the literature. These themes are discussed in chapter four of the study.

Limitations

There are inherent limitations to the research study. The researcher desired heterogeneity among participants as a means of understanding how educators who work in differing capacities, and have completed varying levels of neuroeducation coursework, implement neuroeducation-based approaches in the school setting. However, this means there was a high degree of variance, which makes it difficult to draw direct parallels between participants or generalize findings. Including additional participants, or focusing on homogeneous settings, may have strengthened the study and led to increased applicability. Moreover, because the participants were from a specific language-based neuroeducation program, all subjects possessed a foundational knowledge and understanding of neuroeducation. This too impacts generalizability, as these educators may have been more inclined to implement neuroeducational approaches in their classroom – and participate in a study about neuroeducation – based on the fact that they selected neuroeducation as an emphasis for their respective educational programs. Lastly, there was a time constraint on the research process. All data were collected in a four-month period, which did not allow the study to be longitudinal in scope.

In addition to limitations, there were inherent threats to validity in the study that must be addressed. According to Guest, Namey, and Mitchell (2013), although observation has clear benefits, there is a risk of misinterpretation on the part of the observer. There is also a danger of misperceiving information gleaned from the interviews. For this reason, member checking and triangulation of data were pivotal to the research process (Creswell, 2014; Maxwell, 2005). Three forms of data collection were utilized to allow for triangulation. In addition, participants had the opportunity to review the transcriptions and narratives for content accuracy as a means of member checking.

In qualitative research there is a chance for researcher bias to affect data collection and impact study outcomes (Maxwell, 2005). Although narrative inquiry is predicated on the idea that a researcher relives or retells participants' stories (Clandinin & Connelly, 2000; Creswell, 2014), it was essential that the researcher's own biases and perceptions were continually acknowledged and addressed as they arose, so as not to unduly influence the research.

Summary of Chapter

The dissertation research utilized a qualitative narrative inquiry design. Three forms of data collection were employed in the study: a pre-interview, a classroom observation, and a post-interview of each participant. Five educators were selected to participate in the study. Participants were selected based on the following criteria: completion or near-completion of a language-based neuroeducation program and current employment as K-12 educators. The study deliberately sought heterogeneity as far as participants' respective settings and the degree to which they utilize neuroeducation-grounded approaches, in order for the researcher to understand how neuroeducation is applied in public and private, elementary and secondary, general-education and special-education classrooms. This chapter has described the purpose of the study, the rationale for a narrative inquiry design, participant selection criteria, and specific information on the data collection and analysis processes.

Chapter 4

Research Findings

This chapter presents the findings from a study that explored the benefits and challenges of implementing neuroeducation in the school setting. It includes a description of the research sites and study participants, richly detailed narrative accounts of participants, and themes that emerged from the study as they pertain to the research questions. The study utilized a qualitative narrative inquiry design, as a means of answering the following three research questions:

1. How do K-12 educators from a language-based neuroeducation program apply neuroeducation-grounded approaches in their instructional practices?
2. How do these educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize in the classroom?
3. What do these educators perceive as the challenges and merits of neuroeducation implementation?

Narrative #1: Pamela

Pamela is a seasoned special educator who has been in her current role for several years. She teaches in a high school program special education that assists students with core subjects, as well as applied functional activities and life skills. Pamela was drawn to neuroeducation after attending a conference that contradicted everything she knew about how children learn conceptually. She said she was searching for ways to help her students make meaningful progress. Pamela explained that prior to embracing the neuroeducation model, she relied primarily on direct instruction and behavioral methods in her life skills classes:

> I could get any student to do certain things based on those strategies; I just couldn't get a student to move up. I couldn't get them to read, write, think, or speak. I could get them to

> copy and imitate and follow checklists and read things out of context, I just couldn't get them to deviate from routines or problem-solve.

She asserted that the prevailing mindset among her peers in special education was students should not be asked to do too much, as it would overwhelm them. Pamela also highlighted the dominance of the "solid auditory-based curriculum" most students have encountered, which she said fails to meet their learning needs. After learning about Neuro-Semantic Language Learning Theory, Pamela began incorporating event-based learning into her teaching. This includes utilizing visual methods such as drawing and writing, continually refining students' thinking, and providing significant feedback that is matched to students' respective neurobiological learning systems. This extends into the general-education classroom, as well:

> Basically we match the language, so when the students are out in gen-ed. [general education], we're looking at the language level of the curriculum and translating that auditory language level into the visual thinking. And we do that in the gen-ed. setting, as well as applied work, so we're drawing out their routines, we're drawing out their cooking when they're in home-ec., we're drawing out the ingredients, we're drawing out the process of how to make something using hand-over-hand drawing and writing.

In addition to *event-based learning* and an emphasis on students' individual language levels, Pamela said there is an intentional focus on prosocial learning, insofar as valuing all learners and what they have to offer.

During the observation of Pamela's special education classroom, these neuroeducation-grounded methods were evident. Pamela and her team of five educational assistants did intensive one-on-one drawing and storytelling with the students during the lesson, which centered on making Christmas cookies. Depending on their language levels, students were asked

to draw and write the various steps to the baking process. Pamela deftly handled oversight of the educational assistants, whom she has spent significant time training so that they can utilize Viconic Language Methods™ in her classroom and take them forward in their own future classrooms. She spent time with each learner, often doing hand-over-hand and clarifying the students' thinking. After the observation, she shared binders of student artifacts and assessments that demonstrate how much progress has been made over the course of the school year.

According to Pamela, neuroeducation and NLLT have led to tremendous growth in her students over the past four years of implementation, which is often manifested in visible behavioral changes. She cited the example of student who previously exhibited severe biting behavior. The student was assigned two educational assistants who had to keep a safe distance because the student had such aggressive behaviors. Pamela said the same student now has just one assistant, rarely bites, and works for six hours at a time. She related several cases of students who, prior to joining her class, could work for only five minutes who now work for three sustained hours, and students who were completely nonverbal who now can speak. Similarly, she has students who were previously unable to be included in modified classrooms who now are included.

She said there have been tangible changes in students' behavior, academics, and ability to problem-solve over the past four years. Pamela credits NLLT, and specifically visual methods such as hand-over-hand drawing, writing, bubbling words, and picture dictionaries, with the drastic improvements she has witnessed in her classroom. She described, "I feel like for the first time, I'm seeing students that are actually learning and developing." However, this has caused Pamela to question the current educational system:

> For the first time students are receiving a free, appropriate public education. It really makes me question the other types of methods we've been doing since they've been in school; most since three years old in early intervention or younger. And we haven't seen much growth and now we're seeing this level of growth. It makes me question the whole paradigm of what we're doing. Can we say we're providing a free, appropriate public education? Can we say that it's not due to lack of instruction? I can say for sure that it is due to a lack of instruction in their neurobiological learning system. I mean, we might be giving them the instruction but it's not the right kind of instruction. So it becomes to me a social justice and a civil rights issue.

Pamela said the knowledge and insight she has gleaned through neuroeducation have helped explain her own learning as a child. She spent her first six months of life in foster care before being adopted by a childless older couple. They had waited 15 years for a child, so they lavished Pamela with attention and read to her often. As a result, she said she had very good language from a young age. However, when she started first grade, her teacher relied on phonics and symbols to teach reading. Pamela was required to read aloud on demand, which was difficult because it took away her pictures. She said she understood when she read but could not demonstrate it when forced to read aloud. Pamela was subsequently placed in the middle reading group instead of the high group, which shook her confidence. As a result, she said she lost her love of reading over time, much to the chagrin of her parents. She has come to realize she was a pattern-based and "slow" learner in school. She was always the last person to finish a test, she would miss things on exams even though she studied relentlessly and knew the answers, and she gravitated toward math because of its basis on patterns. She now understands that she needs constant layering in order to learn something new. Pamela credits neuroeducation, and NLLT in

particular, with clarifying her own learning and explaining the learning of her son, who has autism, as well as her neuro-atypical students: “Every single student I’ve ever worked with, and every situation I’ve ever dealt with can be explained by this theory and through the levels of learning!”

Although she has no doubt about the merits of neuroeducation, Pamela said she is continually asked by her superiors to justify her methods: “I’ve been told to collect all this data to prove it because I’m going against the grain.” She formally documents students’ progress by completing charts that measure communication, behavior, and literacy. She keeps binders of artifacts that reflect student progress and demonstrate how far they have come, not just for her own records but to corroborate for others her neuroeducation methodologies:

> I could say, *Okay, the student started here* – I looked at their IEP and I could remember – *and here they are now*. So I looked at where they were and where they are. I rated the severity – very severe, moderate – and then frequency. Because that’s how DD – developmental disabilities – that’s how they rate need for services for adults. So I kind of modeled it after that, because this would give someone a picture without them really understanding; you could see the change. When my director came in and saw, he was like, ‘Oh, I can see.’ So it’s constantly just trying to prove it.

In addition to formal documentation, Pamela relies on informal and “self-evident” assessments. She said she looks at students’ academic improvement, as well as their marked changes in behavior. She and her staff collect data on increases in prosocial behaviors and decreases in antisocial behaviors, and use behavioral findings to modify their instruction and match the support level accordingly: “So if I have a student who’s pulling away or this or that, I might be too high; I’m not at their language level, I’m not at their developmental level.” These

informal, on-the-spot assessments, conducted in tandem with formal documentation, affirm to Pamela that neuroeducational approaches work:

> You see the changes so drastically. I have students who did not work at all, and now they're doing five, six and seven hours straight. I have students who could not be included in modified classrooms, and now they're being included. I had one student who had Down syndrome and who was hearing impacted, who was functioning at a – I mean, he could say maybe 10 words – and then after four years I was having conversations with him where he was telling me about people and places and drawing at a concrete level and moving himself, so his language was more displaced and not as restricted. That's the case with every student I've had. There are students who were so prompt-dependent, they'd stand and wait to be prompted for everything and now they're like different people!

Despite her staunch belief in the efficacy of neuroeducation, Pamela is realistic about the inherent challenges of implementing it in the school setting. She cites high turnover of special education support staff and cost of training and implementation as potential hurdles. However, she believes a primary barrier to neuroeducation progress is a lack of greater buy-in:

> Honestly, I'm having a really hard time moving it forward. I was excited when I first started out; I thought I could get people onboard. But I couldn't get the special educators in the building onboard at all. They're very set in their ways. That's a big barrier: I can't get the buy-in. Even from people that I've had good professional relationships with, and friends… There's almost a fear: a fear of the unknown, a fear of having to be out of your comfort level, a fear of not being able to do it.

According to Pamela, this significant barrier necessitates a paradigm shift, both at the school level and the systemic level. She said in the current system, everything is based on a checklist. Moreover, she feels teachers don't understand the research behind the methods they use. In her view, teachers need to be more inquisitive and more discerning: "I don't see a lot of educators really wanting to think deeply about learning. There's just some assumptions that are made and they're not questioned." She cites the example that many teachers believe learning simply unfolds; they do not actually understand how learning and thinking occur. In addition to a shift in teachers' thinking, Pamela believes a broader systemic change is in order, especially as it pertains to the inclusion of people with disabilities:

> I really think from a whole systems level, at even a state level, there's so much misinformation about how to include people who have disabilities. I think the whole inclusion movement is a barrier, just because sending a student into a classroom…how inclusion is interpreted…is that really inclusion? If somebody isn't learning, if people aren't really interacting with them socially, is that inclusion? Sitting in the back of the classroom? It's that whole, 'I don't really know how learning occurs.' It's a huge barrier. People have good intentions, like, 'Let's just put them in here.' You're just exposing them again. That's just exposure, and they don't learn by just exposing them. There has to be feedback and meaningful assignment of meaning; that whole language theory and language acquisition of how meaning gets assigned. It has to be done in a social way between two agents…and the student has to be engaged. So in some ways the whole inclusive movement is a barrier. The way it's interpreted. I'm not saying inclusion is not good, but it's this all-or-nothing aspect, and it's not based on the research. They're not integrating the fields of research.

Pamela is admittedly disenchanted with the educational system. She feels she is "fighting against a huge system at every level," which often seems like an insurmountable challenge. She said if people were to stop and question why there are more students with disabilities nowadays, and why educators are having a difficult time achieving results with this student population, they would find the answer is in front of them. She likens it to Occam's razor, where the simplest idea is usually the best. For her, that simplest idea is neuroeducation.

Narrative #2: Sarah

Sarah has worked as a certified educator for 19 years, both as a classroom teacher and an instructional coach. In her current role she serves as a Teacher on Special Assignment (TOSA), with a focus on English Language Development (ELD). Part of this position entails teaching kindergarten, fifth-grade and sixth-grade science at a high-needs urban elementary school. Sarah, who had no exposure to neuroeducation or *brain-based learning* prior to her graduate coursework, said she selected neuroeducation as an emphasis for her studies because she hoped it would shed light on brain function and processing, as well as enrich her pedagogy. Her own brother has an intellectual disability, so she has always been passionate about working with high-needs students. Most of her educational career has centered on children who live in poverty, migrant students, and English language learners. In regard to her own learning, Sarah noted that she has never been one to memorize and regurgitate facts. Rather, she learns best when she can manipulate and contextualize information and make relevant connections among ideas. She is a proponent – both for herself and her students – of discussion-based, hands-on, and experiential learning. In Sarah's view, "oral communication and drawing are key."

Sarah is an unflappable and easygoing teacher whose connection with her students was evident. During the classroom observation, Sarah taught a science lesson about the states of

matter to 17 middle school students. As part of the lesson, she asked the class to make hypotheses with their table groups, and then she used hands-on experiments to prove or disprove those hypotheses. Throughout the activity, she drew pictures for students on chart paper to cement their understanding. She explained during the post-interview that she has always incorporated visuals into her teaching; this strategy was not a product of her neuroeducation coursework per se:

> There are practices and different strategies I use in the classroom that are neuroeducation-like or neuroeducation *lite* maybe, but they're practices I used prior to any training in neuroed. Things like, as I talk to kids I'll draw things out for them. Also – and it's probably part of my culture – is I tend to…when describing things to children who need understanding, I'll do story form. I'll have them develop their own picture of what's going on. And I don't know if this is really neuroed, but I'll use things like acting it out; I try to use realia whenever possible. But those are things I've done just because they're good teaching practice, and also built on how I learn and experiences I had when I was younger, working with people that had special learning needs. So it's sort of like a conglomeration of many different things.

Although she has long utilized visuals to further students' understanding and small-group discussions to promote higher-order thinking, these methods been affirmed by her neuroeducation coursework. However, she still has doubts about the efficacy of neuroeducation.

Sarah is a self-professed skeptic about neuroeducation. She selected the program because she wanted to glean information that could deepen her understanding of brain mechanisms and enrich her pedagogy, but she approached it from an academic standpoint as opposed to a prescriptive one.

> I was looking more to enrich my own knowledge, and I was not looking for pedagogical strategies, so I think understanding anything more deeply… When you're talking about being a teacher and being part of a learning process, any time you can understand that learning process from different perspectives – from a socioemotional perspective or from a racial perspective or from a brain function perspective – that knowledge combined with pedagogical strategies can enrich your teaching. So I look at it as another spoke that supports a deeper understanding of teaching and how to reach people to help them learn, and understand where their learning needs lie.

Despite Sarah's reservations, she contended that, "Neuroeducation has supported the idea that students need to develop a conceptual understanding of things in order to really retain learning."

In Sarah's view, a primary barrier to neuroeducation is that many educators lack the requisite depth of knowledge required to implement neuroeducation in the school setting. She explained that her own understanding of neuroeducation, while greater than that of the average classroom teacher, is still in its infancy. This makes it difficult to determine how to implement neuroeducation-grounded approaches in a natural, rich way. Sarah said her confidence about neuroeducation implementation serves as a roadblock:

> In all honesty, I feel insecure about saying, 'Oh, I'm gonna implement this,' because I don't feel like I know enough to make that jump to the implementation. I feel like I have some background knowledge that has broadened my perspective on things and given me a deeper understanding of brain function, but to make the jump of, 'Okay, so the brain functions in this way, and in order to use that knowledge, I'm gonna use this action in the class'… that's where I think I'm lacking. It's that link between the academic knowledge

> and the pedagogy. That link is weak, and I don't know if I know where to go with it. I don't feel like I have enough knowledge to speak authoritatively on neuroeducation.

Moreover, Sarah contended that expecting neuroeducators to translate and disseminate research from three domains is unrealistic:

> Part of it is, many people don't have the baseline knowledge or experience coming into a neuroeducation program. They don't have a neuroscience background, and a good portion don't have any cognitive psychology background. So you're trying to develop all that in a very short amount of time and it just doesn't translate, because there's no depth of knowledge there to begin with. No one can tell you, 'This is how you do it.' And so you have to have enough content knowledge in all the different fields in order to be able to connect them. Your traditional educator in the United States – not that they're not capable, they just don't have that content knowledge in order to know what to do with all these disparate bits of information.

According to Sarah, another barrier is the lack of time, although she conceded she dislikes using that "as an excuse." She explained that she has only 40 minutes with her students, many of whom live in poverty and have experienced trauma. Sarah said it is unrealistic to consider applying intensive neuroeducation methods, especially those that necessitate one-on-one assistance, when she has a great deal of content to cover in a short timeframe. At a more systemic level, Sarah pointed to the transference problem that occurs when merging neuroscience and education. In her view, this may be the most significant hurdle for the field of neuroeducation:

> We have neuroscience – they're scientists and they're used to working with lab rats and having control groups. And then you're jumping over to education and that's a huge

jump when you start applying to human subjects and you don't have control groups. It's not the pristine science experiment; it's messy and you have all these different variables that come into play. It's that connection between all the different teaching variables in a classroom and the messiness of that, and what do you do with that? Educators look at things through a social worker lens, through a pedagogical lens, through a content lens… They're looking at it differently than a neuroscientist does. So since the focus isn't on one specific function in the brain, it's on multiple functions happening simultaneously, that's what gets difficult to enact it. You're not just talking about what happens when a person is learning x, you're talking about what happens when a person is learning x but they're also thinking about y because they're stressed out, they're worried, and they also have hormones… So there are all these different variables that need to be considered. I think that makes it difficult.

I think most educators are also humanists, so they don't necessarily think as scientists do. Therefore, when they hear neuroscience stuff they try to apply it in a humanist way. And they misinterpret things or take research that might imply something small and – that's probably the biggest thing – is educators take neuroscience research and too broadly apply it. Like, oh, wine is good for a mouse so everyone should drink it! People hang onto these things because it's something they like and already believe, and it sort of validates what they already believe. So it's not necessarily that they're reacting to the research; they're reacting to the research that supports something they already believe. They're not necessarily changing their mind about something, they're just feeling justified. So in that way, it's not that people believe in neuromyths, they just glom on and generalize things that shouldn't be generalized. They don't have the content

> understanding to know that it shouldn't be generalized. There's certain background knowledge you need to have before moving on to other things; that needs to be worked out. But it's also systemic: You're talking about years of understanding that has to be done before you can start melding these fields together.

Sarah said despite the challenges of neuroeducation implementation, there is merit in arming teachers with knowledge about the brain in order to meet their students' needs: "If you don't understand how the brain functions and something happens, then you do the best you can and react with strategies you've been told to do, without understanding why you're doing it." If those tried-and-true strategies are ineffective, she furthered, teachers have nothing to fall back on and are unable to adapt. While Sarah contended there are limitations to expecting teachers to possess a deep-seated understanding of brain functions, and it is unlikely that a teacher preparation program could equip educators with the necessary level of neuroeducation knowledge, she suggested that neuroeducation is an important addition to in-service teachers' continuing education. This may expand educators' knowledge about the brain, help to dispel neuromyths, and ultimately promote students' learning.

Narrative #3: Rachel

Rachel is an elementary school educator in her fourth year of teaching. She was drawn to neuroeducation because she was tired of the "one-size-fits-all method of teaching" and wanted to better understand how children – especially those who have experienced trauma and those who come from low-income backgrounds – learn on a neurological level. Rachel said the neuroeducation program has emboldened her to re-envision her pedagogy and all but abandon her former practices. She said she was trained in her teacher preparation program to rely on token economies, behaviorist approaches, and a practice-makes-perfect approach to teaching, all

of which have been debunked by her neuroeducation coursework. Rachel learned about the crucial role of language in promoting conceptual thinking and learning and subsequently began using Viconic Language Methods™ (Arwood, 2011) such as picture dictionaries, flow charts, and hand-over-hand drawing. Rachel explained that she has seen marked improvement in her students' writing and reading capabilities as a result of these neuroeducational approaches. She credits neuroeducation with putting the emphasis "back on the student" as opposed to the teacher, and said her neuroeducation studies – particularly Neuro-Semantic Language Learning Theory (NLLT) – have made her question whether the current educational system adequately meets the needs of students:

> We have so many students in one room and we're trying to make this plan that works for all of them, so we've kind of lost sight of what we're looking for. When you go into the neuroeducation program you're presented with this idea that maybe we're not doing everything we need to be doing for the kind of thinking we need for our society, and to be honest it can be a really tough pill to swallow. When I took my first few neuroeducation classes I was just devastated, like, I've been doing everything wrong and I probably ruined my past students for life! It was just really hard for me to hear because I was like, *No! They tell you to do phonics, they tell you to do this; I should be doing letters and sounds*. But when you get into the theory and you really look at it, it makes a lot of sense, and all of a sudden you realize this was the key that was missing. You don't want to be resistant to that missing piece because it's what everyone has been looking for. We need to change the way we're doing things, and that can be a very daunting task. But what I really like about the neuroeducation program is it really brought me back to my

focus of, *We're doing this because we're trying to help kids learn to be the best members of society they can be*.

Rachel was raised in a small town, attending schools in which everyone knew and supported each other. Similarly, her early teaching positions were in schools where the teachers worked closely with one another and knew all of the students. In her current role, she teaches at an urban public elementary school that has a culturally and linguistically diverse student population, more than half of whom receive free and reduced lunch. While Rachel cares deeply for her students, she said she misses the personal, community feel of the schools she previously attended and in which she taught. The lack of collaboration and collectivism in her current school often give her a sense of isolation and stagnation. Moreover, Rachel feels that she is fighting against skepticism from colleagues:

> I don't have anyone to collaborate with in my school. In fact, my grade level team – they teach phonics and they teach sight words and word families, and they'll ask me what word family I'm working on this week. When I tell them I don't teach language that way or do word families, they go, 'Oh, what do you do?' and I try to explain it to them, but there's so much behind the theory. I try to simplify it but I don't want to take out the important parts when simplifying it, so it can be really hard to tell people what you're doing and it can create a disconnect between you and your grade level team because you're really not all doing the same thing. When I try to suggest to them what I'm doing, I worry that it might sound preachy or they might think, *Well you're doing this new theory that doesn't seem to have any other literature behind it*. It is pretty cutting-edge and it's really new, and I think some people are pretty skeptical. I do a lot of defending what I'm doing while also kind of feeling like, *Well I'm just trying it out and I hope I'm*

> *doing this right*. So I'm always second-guessing myself and wondering if I'm doing this correctly, but I figure all I can do is try it out, right?

Additionally, Rachel said lack of time and support are significant barriers to neuroeducation implementation:

> I'm in a Title I school and I still have 21 kids in my classroom: three who are SPED, eight who speak another language, and most of them from what I have learned are visual learners, so they need to see things and make a picture, or their hand needs to move or my hand needs to move in order for them to be engaged. The problem is the way our schools are set up, including my school, is you don't have the time in the day to always be drawing for every kid, and it's really hard to figure out, 'How do I meet this group of visually motivated students and movement access students in a school that demands me to teach in an auditory way?' One of the biggest times that's been challenging is during writing because I don't have any volunteers or para-educators or any support during that time, so it's me with 21 kids, and if they need an idea for their story and they don't know how it looks and how to spell it, there's just one me trying to run around and help them write these words. The other struggles are with kids with behaviors. When I have 20 other kids in the room and one kid's having a meltdown, I don't always have the opportunity to stop what I'm doing and pull out a piece of paper and draw with that kid.

Rachel perceives that advancing neuroeducation within the school setting is difficult because educators are already overtaxed. She said her current district has given its teachers such an enormous workload that "everyone is stressed to the max, and if you tell them to do one more thing they're going to lose it." Rachel said communication between administration and teachers,

as well as among teachers, is lacking. This has caused "a separation that makes any kind of progress – neuroeducation included – very difficult."

Despite the aforementioned challenges, Rachel wholeheartedly believes the neuroeducation-based methods she is utilizing are effective. Her students began writing on the first day of school and have written each day since, and Rachel has seen significant strides in their academic progress:

> What I'm noticing is their writing is tremendous. It is, by far, way more advanced than first-grade writing has been for my past students. My students right now are writing at a level that most of my prior first-grade students finished at the end of the year, and it is only November. I have not taught one lesson of phonics yet this year, and yet my kids can write beautiful stories; they're writing chapter books right now. I have these kids who supposedly can't read, and they're reading.

In reading groups, she said students are able to read words that cannot be sounded out, such as *light*. This affirms to Rachel that some previously struggling students are now above their assigned reading level thanks to the neuroeducational approaches they have been exposed to. Conversely, she has several supposedly high-flying readers who, when given a picture and asked to create an event-based story, are unable to do so. Rachel said these students are good at patterns but do not actually have the level of language that they are believed to have. This has caused Rachel to question the way students in the school setting are assessed:

> The assessments that would be given to me don't necessarily measure what I'm looking for at this point. A lot of the traditional assessments that the district gives us that we see in public education are very pattern-based skills like, *If I give you a pattern, can you spit me back the pattern?* And that's not what I'm looking for. I'm looking to see what it is

> they're thinking and if they are able to use that thinking in another context. I've tried to create my own assessments for running records and things I would use in reading groups, so those assessments look more like, *Does this student use a picture dictionary for the words they're not sure of, and how often do they reference the picture dictionary?* So I'm just monitoring how many times they need to check, and I do have a little spot for, *Are they still trying to sound it out and use the sounds, or are they looking at the whole idea?*

Rachel said she has included a "comprehensive piece" in her version of running records, which is left out in traditional assessments. She assesses whether the students include a who, what, where, and why in their written stories. In addition, Rachel provides pictures and *Dick and Jane* books to students, and asks them to orally identify who is in the picture and what the character is doing. She gauges students' progress each trimester using a rubric she created. Rachel said she came up with her own tools to assess student growth because "the assessments we use in school right now are not adequate for what we should be looking for." This underscores Rachel's point that she is the lone person using neuroeducation in her building, and that she often feels she is swimming against the current:

> I go to these IEP meetings and they tell me, 'He doesn't like sound because he's always covering his ears during loud assemblies, so he needs to wear noise-canceling headphones' or 'You need to get him a weighted vest because he won't sit still.' And I'm sitting with this whole panel of people who don't know the theory of this neuroeducation model. It can be really frustrating to listen to what they're saying and to be a younger teacher and to try and give them suggestions for what I know. A lot of times it's shot down right away. They're like, 'No, no, we need to give him finger fidgets' or, 'We need

> to push on his pressure points.' And when I try to tell them, 'No, we need to draw with him and I need someone to help me do drawings with him,' I don't always get that support and it's all on me right now.

Rachel's first-grade classroom is colorful and inviting. It was evident that visuals are a mainstay in her curriculum and practices. There were drawings of the students' families, drawings of the daily agenda and routines, and various examples of lessons that had been drawn-out for students. During the classroom observation, Rachel did a whole-class opener about Thanksgiving in which she drew out big ideas and created a picture dictionary for the entire class. Then students went to stations for reading time, at which point they referred to – and added to – their own picture dictionaries. Rachel was actively engaged in checking her students' progress, monitoring the room and doing hand-over-hand drawing as needed. She frequently reminded the students not to "take other people's pictures away." Rachel drew new words and ideas on butcher paper for the group, and then asked students to draw and tag them in their own picture dictionaries. After the observation, Rachel shared examples of student work and the aforementioned assessments she created. She was clearly proud of the students' growth, which she credits to neuroeducation and NLLT.

Although Rachel believes in the efficacy of neuroeducation as a grounding for her instructional practices, she knows neuroeducation isn't a panacea. She noted that she had a misconception when she first began taking neuroeducation coursework:

> When I first took all the classes and started getting into neuroeducation, I was like, *This is the magic trick, this will solve all my problems – I won't have any behavior issues, all my kids will be above grade level, everyone will meet the standards*. And what I'm seeing is, no, you're still going to have some kids who are pills and who need a little extra support,

> you're still going to have some kids who struggle a little bit. So it's not like I can snap my fingers, start doing neuroeducation, and everything's better. What I've realized is this is a process for me, and this is the first year of this process. I'm figuring out what's working and what I need to tweak to further help my kiddos.

Anecdotally, Rachel spoke to a fellow educator who is well versed in neuroeducation, and she told Rachel it takes "about 10 years to iron it out." Rachel knows it will take time and practice, but she has decided to "jump in and try it out" because she believes that neuroeducation will make a significant difference in her students' learning. She feels teachers should have an understanding of how the brain works and become well versed in neuroeducation, because in her estimation, the model has the potential to shift the educational landscape:

> I think one of the biggest points with neuroeducation is that you should question things and you should look at why you're doing it. I think if teachers just took what I said, like, 'Okay, you've got to use picture dictionaries, and you can't do phonics' without knowing why, then they're just another kid following a pattern. I want them (teachers) to know why because then it's more meaningful. Otherwise, it's, *This is the new thing we have to do in education and it won't last for long.* But if it's something they understand… This doesn't seem like a theory to me, it's just, *this is how we learn*. At a neurological level. This should be fact. And if you understand it as fact, and if you're a teacher who wants the best for your students – and I hope every teacher does – then why wouldn't you decide to start teaching this way instead? If it's a fad, then you probably won't care. But if you understand the reasoning and theory behind it, you'll probably care a whole lot more and you'll probably do it for longer. And it'll probably help you through the

struggles, because there are struggles with implementing it. If you don't believe in it, you're just going to give up early.

Narrative #4: Grace

Grace is relatively new to the teaching profession, with five years of experience under her belt. She is even newer to neuroeducation, so she has only recently begun dabbling in visual methods such as having students use picture dictionaries, drawing out concepts, and retagging ideas. In fact, this is her first year implementing neuroeducation methods into her teaching on a whole-class scale. She said she was drawn to neuroeducation because she was fascinated by how small children's brains work, and she had a particular passion for literacy. Specifically, she always wondered why some students pick up reading so quickly while other struggle to read. Grace's ultimate end goal is to help students become more confident readers by the time they leave her class, and she hopes that neuroeducation may provide the conduit for doing so.

She currently teaches first grade at a private religious school with small class sizes, significant parental involvement and in-class volunteer support, and relatively few behavioral issues. Grace said these factors have proven incredibly beneficial to the implementation of neuroeducation in her classroom: "I'm lucky because I have 20 kids in my class, so I can do a lot of these things. Where I student-taught, there were 38 students, and there's just no way; you couldn't possibly do it." She acknowledged that time, lack of resources, and large class sizes can hinder an initiative such as neuroeducation, which often necessitates intensive one-to-one work with students who struggle.

Grace's classroom was neat and inviting, with students' artwork and colorful visuals in abundance. Grace had a natural ease and warmth with her first-graders. During the classroom observation, the lesson topic was favorite holiday traditions. Grace invited the students to the

carpet for circle time, at which point she did a framing activity for the class. She told the students about her own Christmas traditions, illustrating and tagging a picture to accompany the story. Occasionally Grace prompted the students to "put their hands on their brains" if they had a personal connection to something she said. Once the drawing was complete, Grace asked the students to help her write a sentence to accompany the illustration, focusing on the what, when, who, and why. After the whole-class activity, students were asked to draw their own holiday traditions, using their picture dictionaries and first-grade dictionaries to assist them. The picture dictionaries contained commonly used words from the particular unit of study, which in this case meant several words related to Christmas. Next to each object or idea was a simple drawing and the word to accompany it, often bubbled so that students get a feel for the shape of the words. Grace floated around the room, monitoring students' progress and doing hand-over-hand drawing with those who needed extra assistance.

Grace said she has seen drastic improvement in the students' work quality and understanding since the beginning of the year, including longer and more-accurate writing samples, as well as an eagerness to write on the part of the students. Admittedly, though, she conceded the effectiveness of neuroeducation methods may depend on the group of students and their specific needs. For instance, she said one incoming first-grade class may have been more academics-focused in kindergarten while another may have been more play-centered, which impacts students' readiness and baseline knowledge when they enter her classroom.

Teachers' varying instructional methods and beliefs may be indicative of a bigger issue, according to Grace. She said there is mixed buy-in about neuroeducation among her fellow teachers. While some colleagues have embraced the neuroeducation methods Grace has shared with them, others are more skeptical and resistant to change. She explained that one teaching

partner has taken neuroeducation classes and is trying out drawing and writing methods in her own classroom, while another teaching partner of their "thinks we've completely lost it!" Grace said other colleagues are intrigued by the neuroeducation-based approaches she is using, but she does not feel well-versed enough in neuroeducation to explain it to others. She said it would be helpful to have the entire grade-level team – and entire school, for that matter – onboard. Until that day, however, Grace takes comfort in the results she has witnessed firsthand in her class, as well as the increasing parental buy-in. She said some parents have begun drawing-out behaviors and helping their children practice writing using visual techniques they have learned from Grace. That gives her hope and resolve to forge on.

Grace credits neuroeducation with giving her a new perspective on teaching. As a result of her coursework and research, she has revisited many of her former strategies, such as having students sound out words, giving traditional spelling tests, and using word families. She has made an effort to steer away from pattern-based learning toward more conceptual learning. Grace said the biggest takeaway from neuroeducation is the focus on the big picture, as opposed to the prevailing *additive* mindset of education, wherein the pieces make the whole. Despite the benefits of neuroeducation, she acknowledges that there are "a million barriers, which is why it never picks up." Aside from the aforementioned challenges of diverse student needs and lack of greater buy-in among colleagues, there is a nagging self-efficacy issue. Grace said she still questions whether she is implementing certain techniques accurately and feels unsure about her own depth of knowledge pertaining to neuroeducation:

> I think I get the reason behind it and I have bits of it, but then I hear myself still saying or doing things that go the opposite way. So I think you have to be all-in or it doesn't work. I just don't feel like I have all the pieces. I feel like I need [name redacted] to come to my

> room for a month and tell me everything I should be doing. And then I could really do it. That's what you'd need. You need people who can describe everything and tell you how it goes, and to get the practical pieces.

She said despite being a relative neuroeducation novice, she has seen "amazing results" and feels excited about the possibilities. Grace plans to continue embedding additional neuroeducation approaches in her teaching.

Narrative #5: Maria

Maria came to the United States as an adult who spoke no English, putting herself through school and working odd jobs to support her three children. She took a position teaching Spanish at a private school 18 years ago, and she remains there today. Maria said she relates to her students because of her own experience learning a second language. She has kept abreast of research on second-language acquisition, citing as influences Patricia Kuhl and others who have used neuroscience to explain language learning. Maria also credits her neuroeducation program with expanding her understanding of the acquisition process. She said the notion that people learn a second language in the same way they learned their first language has been "totally debunked" by the program and by her own personal experience, and her teaching has changed as a result.

Another factor that compelled Maria to pursue neuroeducation was a decidedly more personal one. She shared that her own son, who was diagnosed with ADHD as a child, had "absolutely terrible teachers who would not address his interests or needs." This led into a discussion about teachers who are resistant to change and those who lack understanding about the brain, both of which act as potential barriers to widespread neuroeducation implementation:

> You have the old teachers who've been doing their job for many years, and they're not willing to change: 'I have been doing it this way, the kids are learning, and they go from my level to the next level, so why change?' But you also have some new teachers who say, 'I don't know how to draw.' Or they confuse the behavior of the student such as, 'He's not putting in any effort.' So you give up on the student if you think the student is not putting in any effort. But the thing is, it may be that the student doesn't put in the effort because he doesn't have any idea what you're saying. Or [they say], 'The student is distracted.' Well, maybe the student is looking at pictures in your classroom because what you're saying is all mumbo-jumbo in his head. So there are some teachers who just don't know, and there are some that say, 'I would not bother with that.' There is both.

During the interview, Maria explained that she relies primarily on drawing in her high-school Spanish classes. Using an iPad and projector, she draws out stories for her students while speaking in Spanish. Then she has students go back and retell the story in English, while she retags the pictures in the story with the Spanish words. She said the retagging and continual layering are incredibly beneficial for her students because they increase their conceptual understanding. Maria has received feedback from numerous students and their families that the drawing has been helpful. She related the story of a mother who was incredulous because her son, who previously loathed Spanish and struggled greatly, asked if he could take Spanish again the following year. Moreover, Maria said all students in her school who have learning differences are placed in her Spanish class, citing this as a testament to the effectiveness of the neuroeducation methods she utilizes.

Maria has developed a great rapport with her students. During the observation, which took place during a Spanish 2 class, laughter and high-fives were in abundance. Maria made a

concerted effort to individually connect with her students to gauge their understanding of the lesson and to reinforce concepts. She explained that building community and knowing her students helps increase their engagement in the lessons. She said the personal anecdotes she illustrates for the class, which are used to teach Spanish vocabulary and grammar, would have less meaning and, ultimately, less impact if she did not intentionally connect the stories to her own students' lives. Thus, Maria believes relationships are necessary in order for her neuroeducational methods to be effective.

During the observation, she exhibited an ease with the drawing, which she credits to having experience. When prompted, she explained that she no longer needs to sketch out each lengthy story beforehand, but rather takes shorthand notes and creates the illustrations on the spot in real-time. She reiterated that the students benefit greatly from the drawings. At one point after the dismissal bell had rung, Maria shared a metal lunchbox full of thank-you notes from students. One former student had written to tell her how much he appreciated not only her warmth and humor, but the way she drew-out ideas for him. She also related the story of a former student who uses the drawing strategies she learned in Maria's Spanish class in other coursework, with great success. Maria was clearly proud of her ability to provide students with tools for success in her class and beyond.

Asked whether teachers need to possess an understanding of brain mechanisms in order to meet the learning needs of students, Maria made the following parallel:

> They absolutely need to know. Just like a nutritionist needs to know how the body processes food and how your particular body is allergic to this or that, that way they can help you sort what you should eat or not, and how much. It's the same thing with a

> teacher: We need to know how learning occurs in order to maximize the learning capabilities of the students.

Maria believes there are several findings from neuroscience that have direct relevance to educators. For instance, she pointed to the fact that memory consolidation occurs when students sleep at night. "Children nowadays are not sleeping enough, so teachers need to know that they should not assign four and five hours of homework." Another example she shared pertained to second language learning:

> When I found out that knowing your first language can help or be detrimental to your learning of a second language, it made total sense. You are already hardwired with, 'There is no gender. The book, the table, the chair – they're all the same.' So it's really hard for a non-native Spanish speaker to make the distinction between masculine and feminine that you have in Spanish. Knowing that helps me understand and helps me explain it.

In Maria's view, brain studies have already shed light on educational practices and will continue to inform instruction, so teachers should keep current on research: "I'm not saying we should all be neuroscientists, but now that we can see the brain better, why not?"

According to Maria, the challenge of neuroeducation is that it flies in the face of the traditional approach to education: "The system isn't set up for it." While she has embraced the idea of process over product, she must reconcile that belief with parents' and administrators' need for tangible results. Maria explained that students in her school are required to take traditional final exams, the teachers are required to utilize traditional assessments, and the expectation is that students will be prepared for the SAT and college in a traditional manner. In

her view, this mindset runs counter to the neuroeducational approach to teaching: “That’s one of the hurdles: How do you balance what is expected and what you want to change?”

Maria credits neuroeducation with illuminating her own learning system and those of her students, as well as recasting the way she approaches teaching:

> Based on what I’ve learned in the program, I realize I might be an auditory learner; I process through words. So I think we teach all with words in a lecture type of thing. And while that is okay for me, I realize that’s not okay for everybody. This idea makes sense to me that there are people who process in different ways. And we need to bring that into the classroom. You have to make it possible for everyone in the classroom. You have to give pictures to people that need images and you need to stop talking as a teacher and let them process. I don’t think we give them time to really chew.

Although Maria acknowledged that her understanding of neuroeducation is still rudimentary and she is far from an expert, she decided to move forward and put into practice various methods she learned during her neuroeducation program. She feels she does serve as a linchpin, of sorts:

> I convinced another faculty member to go through the program, so she’s doing it. And I’m talking about it all the time. I have a couple faculty members to come and observe my classroom. I don’t do drawings every single time, because they [students] need to process, so I give them time to work. But when I introduce something new, I do the story with all the drawings, and I’ve invited the administration and other faculty members. That would be my hope is to work with new teachers, and teachers who want to try something different, and bring about a little – or a lot – of change in the way we teach.

Themes: Barriers to Neuroeducation

Discussions with participants regarding barriers to neuroeducation elicited several common themes. While ancillary themes such as lack of time, scarcity of resources, and large class sizes were mentioned by participants, this section focuses on three primary cross-cutting themes that emerged from the study. The first theme is self-efficacy, as it pertains to neuroeducation implementation (see Table 1). The second theme is isolation, meaning teachers' ability to make neuroeducational strides in the absence of collaboration or greater school buy-in (see Table 2). The third theme relates to the mismatch between individual teachers' beliefs and the pervasive mindset that exists within the education paradigm (see Table 3).

Self-Efficacy. The first theme pertains to educators' self-efficacy, or their perceived capacity to implement a new method into their teaching (see Table 1). Four of the five participants expressed doubts about their self-efficacy as related to their comprehension and application of neuroeducation. The educators voiced concerns about their confidence, both in deeply understanding neuroeducational theory and bridging that theory with their practice. According to Rachel, "It's tough when you're not feeling 100% solid in it. I know that if people throw a hard question at me and I can't answer it then I am going to lose the credibility of what I'm doing." Rachel elaborated that she constantly second-guesses herself and wonders whether she is implementing neuroeducational approaches correctly. Moreover, she worries that her youth works against her:

> I think my age also makes me a little self-conscious. I think that some older teachers may think, 'You're just this younger teacher who just got out of grad school and you think you know everything,' so I personally would like to see more success in my classroom first until I'm ready to be a solid activist.

According to Sarah, her comprehension of neuroeducation is in its infancy, and she lacks depth of understanding: “I have these separate areas of knowledge, but the knowledge of how they work together I don’t feel confident in. I don’t feel like I have enough knowledge to speak authoritatively on (neuroeducation).” Grace echoed this sentiment, saying she does not yet have all the pieces to feel confident. She furthered, “I still don’t feel like I totally know how to do it. And I don’t know how you figure it out. Like, is it just me? Am I just stupid?” According to Maria, she heard it takes four to five years until people have a strong handle on neuroeducation. While she acknowledged she is not yet an expert, she has decided to embrace it and begin implementing neuroeducation-grounded approaches into her practice.

Only Pamela expressed full confidence in her capacity to implement neuroeducation, and she admitted that even she has fleeting moments of doubt, particularly when she gets a new student or encounters a new challenge:

> But I just rely on the theory and I go back to it, and what I’ve realized is you don’t even have to do it well, and you get some progress. I mean, when we started out four years ago we didn’t know what we were doing; we were doing a mishmash, and we still got progress! You just have to start doing it.

Pamela also explained that she has attended more than 30 neuroeducation workshops; it is the sole focus of her professional development and she “loves the constant layering” the workshops afford. She said it took four years for her to feel comfortable with implementation. In her opinion, educators do not need to possess background knowledge of neuroscience or cognitive psychology in order to grasp neuroeducation:

> If you were open, I don’t think you have to have all the background knowledge. You just have to be open… I think there’s the practical part; the practitioner part, and there’s the

theoretical part. You do have to understand some theory to be able to respond to the learner and work off what they need. That takes time.

Notably, despite participants' concerns about their self-efficacy and confidence levels, most have decided to implement neuroeducation-grounded approaches anyway. Their doubts have not prevented them from moving forward. As Rachel asserted, "This is a process for me, and this is the first year of this process. I'm figuring out what's working and what I need to tweak to further help my kiddos. I figure all I can do is try it out, right?" Table 1 highlights salient quotes from participants regarding self-efficacy as a perceived barrier to neuroeducation implementation.

Table 1
Barrier to Neuroeducation Implementation: Self-Efficacy

Rachel: "It's tough when you're not feeling 100% solid in it. I know that if people throw a hard question at me and I can't answer it then I am going to lose the credibility of what I'm doing. So I want to answer those tough questions, but I also don't want to give false information either."
Rachel: "I feel like, *Well I'm just trying it out and I hope I'm doing this right*. I'm always second-guessing myself and wondering if I'm doing this correctly, but I figure all I can do is try it out, right?"
Sarah: "I feel like my understanding of neuroed is in its infancy. I don't really feel like I have a deep-seated understanding. I have an understanding probably greater than your average classroom teacher, but… so that's a barrier: the depth of understanding is just not that deep."
Sarah: "I have these separate areas of knowledge, but the knowledge of how they work together I don't feel confident in. It's my own lack of knowledge. I don't feel like I have enough knowledge to speak authoritatively on (neuroeducation)."
Maria: "I've started putting in practice some of those things that I've learned. But I'm not an expert; I've heard you need four or five years to learn it, but I'm just in the beginning stages."
Grace: "Even though I'm almost done with my coursework in neuroed, there's a lot of things where I'm like, I know I should be doing a picture dictionary or something, but I still don't feel like I totally know how to do it. And I don't know how you figure it out. Like, is it just me? Am I just stupid? That's my biggest thing is that I think I get the reason behind it and I have bits of it, but then I hear myself still saying or doing things that go the opposite way."
Grace: "I just don't feel like I have all the pieces."

Isolation. The second recurring theme pertains to educators' feelings of isolation (see Table 2). In the case of the five study participants, and which likely may be the case for others, they are usually the lone neuroeducators in their schools. This makes collaboration and greater buy-in problematic. According to Rachel, she and her grade-level team have vastly disparate approaches to teaching. They rely on phonics, sight words, and word families, whereas she has embraced Viconic Language Methods™ (VLMs) and Neuro-Semantic Language Learning Theory (NLLT). This has caused a disconnect between Rachel and her colleagues:

> When I try to suggest to them what I'm doing, I worry that it might sound preachy or they might think, *Well you're doing this new theory that doesn't seem to have any other literature behind it* – because it is pretty cutting-edge – and it's really new, and I think some people are pretty skeptical. I do a lot of defending what I'm doing. At IEP meetings, I'm sitting with this whole panel of people who don't know the theory of this neuroeducation model. It can be really frustrating to listen to what they're saying and to be a younger teacher and to try and give them suggestions for what I know. A lot of times it's shot down right away. When I try to tell them, 'No, we need to draw with him and I need someone to help me do drawings with him,' I don't always get that support and it's all on me right now. So the lack of people to collaborate with is tough.

Grace explained that she has one teaching partner who also relies on neuroeducation-grounded approaches, and another partner who does not. She said the ability to collaborate with the like-minded teacher is helpful. On the other hand, the colleague who does not utilize neuroeducation methods thinks Grace and her fellow neuroeducator have completely "lost it." She said that some of her colleagues are intrigued by neuroeducation, whereas others have no

interest in it whatsoever. In Grace's opinion, in order for neuroeducation to truly gain traction, the whole school must be onboard.

Pamela expressed frustration that she could not engender buy-in from her fellow special educators. She said after her school's initial enthusiasm a few years ago, the neuroeducation initiative lost steam, due in large part to teachers' reluctance to embrace neuroeducation. Since then, she has had a difficult time moving it forward outside of her own classroom: "I couldn't get the special educators in the building onboard at all. They're very set in their ways. That's a big barrier: I can't get the buy-in." Pamela suggested that the lack of buy-in may be attributed to educators' fear of the unknown, fear of being outside of their comfort zones, and fear of not being successful at neuroeducation implementation.

For her part, Maria said she is continually trying to expand neuroeducation's outreach. She often hosts visitors who are curious to see how she is implementing neuroeducation methods in her classroom. She explained, "When I introduce something new, I do the story with all the drawings, and I've invited the administration and other faculty members." So far she has convinced one colleague to enroll in the neuroeducation program, and she hopes to continue spreading the word. Maria described her goal for furthering the neuroeducation enterprise: "My hope is to work with new teachers, and teachers who want to try something different, and bring about a little – or a lot – of change in the way we teach." Table 2 highlights salient quotes from participants regarding isolation as a perceived barrier to neuroeducation implementation.

Table 2
Barrier to Neuroeducation Implementation: Isolation

Rachel: "I don't have anyone to collaborate with in my school. My grade level team, they teach phonics and sight words and word families, and they'll ask me what word family I'm working on this week. When I tell them I don't teach language that way or do word families, they go, 'Oh, what do you do?' I try to explain it to them, but there's so much behind the theory. It can be really hard to tell people what you're doing. It can create a disconnect between you and your grade level team because you're really not all doing the same thing. When I try to suggest to them what I'm doing, I worry that it might sound preachy or they might think, *Well you're doing this new theory that doesn't seem to have any other literature behind it* – because it is pretty cutting-edge – and it's really new, and I think some people are pretty skeptical. I do a lot of defending what I'm doing."
Rachel: "At IEP meetings, I'm sitting with this whole panel of people who don't know the theory of this neuroeducation model. It can be really frustrating to listen to what they're saying and to be a younger teacher and to try and give them suggestions for what I know. A lot of times it's shot down right away. When I try to tell them, 'No, we need to draw with him and I need someone to help me do drawings with him,' I don't always get that support and it's all on me right now. So the lack of people to collaborate with is tough."
Grace: "I think the kindergarten teachers are super interested in it and one of my other teaching partners has taken a few of the neuroed classes and so she's trying to too, so it's nice to have each other. Then our other partner is like, 'You guys have lost it!' I think it would be really great if you had a whole grade level. Or if you were the only first grade teacher, like at some small schools. I definitely have people who are interested in it and intrigued by it, but I think there are other people who probably think, 'What is this?'"
Grace: "I feel like the whole school has to be on board."
Pamela: "Honestly, I'm having a really hard time moving it forward. I was excited when I first started out; I thought I could get people onboard. But I couldn't get the special educators in the building onboard at all. They're very set in their ways. That's a big barrier: I can't get the buy-in. Even from people that I've had good professional relationships with, and friends… There's almost a fear, a fear of the unknown, a fear of having to be out of your comfort level, a fear of not being able to do it."

Mindset Mismatch. The third cross-cutting theme, found in four of the five cases studied, relates to a mismatch between the neuroeducators' approaches to teaching and the pervasive mindset of the education paradigm (see Table 3). For several participants, their beliefs about learning and their methods of teaching, which are grounded in cutting-edge language theory, run counter to the systemic perspective of teaching and learning. According to Pamela, "There's a whole systemic change that has to occur with educators and administrators. Most

people right now don't understand the research behind [learning]." She contended that most educators do not understand the role that language has in learning, or how language mediates neuroscience. In Pamela's view, too often teachers do not think deeply enough about learning, do not challenge assumptions, and do not question the current dogma on which much of the educational system is based. Further, she has become disenchanted with the profession because she feels she is "fighting an uphill battle," to the point where she has considered leaving teaching for good. Pamela said she constantly is asked to prove herself and her neuroeducational methods because she is perceived by others to be "going against the grain."

Similarly, Rachel said she often feels she is swimming against the current. She explained that she attends IEP meetings in which whole teams of school specialists agree on strategies for students that Rachel wholeheartedly believes are misguided or ineffective. Yet, as the lone person at the table who possesses neuroeducation theory – and as a young teacher, to boot – she often feels her voice is not heard: "(It's) feeling like I can't share that information because no one will agree with me or it would take too long to explain." Moreover, Rachel echoed Pamela's belief that too often, educators take things at face value without questioning them: "I think one of the biggest points with neuroeducation is that you should question things and you should look at *why* you're doing it." Additionally, Rachel discussed a disconnect between what is required to make neuroeducation a successful initiative, and the common format of the educational system. In her view, implementing neuroeducation on larger scale might prove difficult because schools are not currently designed to support intensive individual work with students. She explained, "The problem is the way our schools are set up, including my school, is you don't have the time in the day to always be drawing for every kid."

In Sarah's opinion, shifting the education paradigm and changing teachers' practices takes time. Educators have been inculcated with certain beliefs and approaches, many of which are couched in a cognitive psychology perspective that relies on rote memorization and patterns, so those habits cannot be broken overnight:

> Unless you have multiple years of teachers stopping the memorization, stopping that type of teaching, then you're always… Even it's just one teacher, they're battling with what came before and what came after them. To impact any real change, it gets frustrating, and then I think that frustration sort of leads to giving up.

Sarah suggested that although educators know certain teaching methods do not align with best practices, and may go so far as to renounce them, they often fall back on those default methods. She highlighted as an example teachers' use of worksheets: "Have I used a worksheet? Yes. Have I used on recently? Probably. I think it's those things that teachers fall back on, and not necessarily that they even believe them." Sarah explained that many teachers are well-intentioned, but they feel pressure to cover their content and plow forward in the most expedient way possible:

> Sometimes they know the right words to say, like, 'Oh yeah, this is the best practice to do X, Y, and Z,' but then their actions don't really show that's what they believe. There's a disjoint between understanding what is best and believing that it really is. Or believing it enough, I should say, to really enact it. And it comes out in things like memorization stuff. If you sit down and really talk to a teacher about it, they're like, 'Yeah, just memorizing a bunch of stuff isn't learning.' But then you go into the classroom and what are they doing? They're having kids memorize a bunch of facts. Then when you ask them about it, it's like, 'Yeah, I know, but we have to get on to the next thing.'

According to Grace, neuroeducation research is cutting-edge and thus not as widely understood or disseminated as competing research. She cited as an example the pervasive use of Positive Behavioral Intervention & Supports (PBIS) in schools, which starkly differs from tenets of Neuro-Semantic Language Learning Theory (NLLT):

> There's more research that supports PBIS and cognitive psych and all of that. One of the first-grade teachers in my building is the PBIS queen; it works for her classroom and she likes it. I don't like to do it, but she has so much research behind it, she so strongly believes in it.

For Maria, a mismatch exists at both the teacher level and the institutional level. Regarding the former, she said that teachers fall into one of two camps: those that don't know any better, and those that are resistant to change. Maria explained that she has encountered some educators who were uncomfortable implementing neuroeducation methods because they were self-conscious about their drawing ability or were unsure how to start. Conversely, Maria has known educators who were simply unwilling to adapt. In their view, she said, the tried-and-true methods they have relied on have served students well, so they see no reason to change. Regarding the mismatch that exists at the institutional level, Maria posited:

> The system is not set up for [neuroeducation]. In a school where parents and students want to see a grade based on something tangible, based on a product, then I have to give them that. That's what I have to do as an employee of the school. At the end of the semester, they have to take a final. That doesn't go hand-in-hand with the system we're doing. So that's one of the hurdles: How do you balance what is expected and what you want to change?

Thus, many of the educators discussed the challenge of reconciling their beliefs with the dominant ideologies found in the educational system. Table 3 highlights salient quotes from participants regarding mindset mismatch as a barrier to neuroeducation implementation.

Table 3
Barrier to Neuroeducation Implementation: Mindset Mismatch

Rachel: "At IEP meetings I often meet with huge teams and they're all saying the same thing: 'The kid needs more words,' or 'The kid's not doing good with reading so we need to give him books on tape,' or 'We need to give him more practice with phonics or letters.' It can be really frustrating to sit through those meetings and hear such a large amount of people all agree on this. And I'm thinking inside my head, *No! That's not what this kid needs!* But feeling like I can't share that information because no one will agree with me or it would take too long to explain."
Rachel: "I'm in a Title I school and I have 21 kids in my classroom, 3 who are SPED, 8 who speak another language, and most of them – from what I have learned – are visual learners, so they need to see things and make a picture, or their hand needs to move or my hand needs to move in order for them to be engaged. The problem is the way our schools are set up, including my school, is you don't have the time in the day to always be drawing for every kid."
Sarah: "Unless you have multiple years of teachers stopping the memorization, stopping that type of teaching, then you're always… Even it's just one teacher, they're battling with what came before and what came after them. To impact any real change, it gets frustrating, and then… that frustration sort of leads to giving up."
Pamela: "I would hate to leave public education but I'm pretty dismayed by it right now. You feel like you're on an uphill… Districts don't even know what they're doing. They just throw the money [at initiatives] and it's like a hodgepodge, there's no theory behind it. There's no theory about learning. They don't know how or why. I was told to collect all this data to prove [Neuro-Semantic Language Learning Theory] works, because I'm going against the grain. So it's constantly just trying to prove it."
Pamela: "Right now everything is based on a checklist, so there's a whole systemic change that has to occur with educators and administrators. Most people right now don't understand the research behind [learning]. They're just looking at the Western psych lens and they do not see the role that language has or how it mediates with the neuroscience. And so there has to be a more inquisitive… teachers have to think deeply about things. I don't see a lot of educators really wanting to think deeply about learning. There's just some assumptions that are made and they're not questioned. They might think deeply about their subject areas, they might have passion about how to apply that socially, but when you think about learning, there's no depth; they just accept that learning unfolds. So that whole paradigm shift has to happen."
Maria: "You have the old teachers who've been doing their job for many years, and they're not willing to change: 'I have been doing it this way, the kids are learning, and they go from my level to the next level, so why change?' But you also have some new teachers who say, 'I don't know how to draw.' I think it's a little of both. Some people not knowing and some that say, 'I would not bother with that.' So there is both."

Maria: "The system is not set up for [neuroeducation]. In a school where parents and students want to see a grade based on something tangible, based on a product, then I have to give them that. That's what I have to do as an employee of the school. At the end of the semester, they have to take a final. That doesn't go hand-in-hand with the system we're doing. So that's one of the hurdles: How do you balance what is expected and what you want to change?"

Grace: "I think…there's more research that supports PBIS and cognitive psych and all of that. One of the first-grade teachers in my building is the PBIS queen; it works for her classroom and she likes it. I don't like to do it, but she has so much research behind it, she so strongly believes in it."

This section addressed the three cross-cutting themes from the study, as related to educators' perceptions about the barriers to neuroeducation: self-efficacy, isolation, and a mindset mismatch. The following section provides common themes that emerged in regard to the perceived benefits of neuroeducation.

Themes: Benefits of Neuroeducation

Despite the aforementioned barriers, four of the five participants expressed a firm belief that neuroeducation is a groundbreaking, efficacious model on which to base their teaching. The three key themes that arose in regard to the perceived benefits of neuroeducation are: the capacity to meet students' needs (see Table 4), the potential for neuroeducation to result in a paradigm shift (see Table 5), and established results (see Table 6).

Meeting Students' Needs. A recurring theme among the educators is their perception that the neuroeducation model addresses a variety of student needs (see Table 4). Neuroeducation has provided a new lens through which to understand learning and approach teaching. As Pamela stated, "When I use this [NLLT] theory, it explains every single student I've worked with. Every situation I've ever dealt with can be explained by this theory and through the levels of learning, so that's what keeps me motivated." Pamela said she only sees the progress offered by neuroeducation; she sees no detriment. She credits neuroeducation with

vastly improving students' learning, and she has witnessed tangible results that affirm its merits: "I feel like for the first time, I'm seeing students that are actually learning and developing."

For her part, Maria explained that while neuroeducation is often targeted to students with special needs, she has seen great success using neuroeducational approaches with her neurotypical students. According to Maria, virtually all of her students appreciate the drawing techniques she utilizes in her Spanish classes, and many have begun coopting them for use in other subjects. This transference validates for Maria the merits of neuroeducation as an effective approach. Notably, she further posited that if in fact most students rely on visual learning systems, the onus is on teachers to embrace neuroeducation as a means of meeting those students' needs:

> We need to know how learning occurs in order to maximize the learning capabilities of the students. This idea makes sense to me that there are people who process in different ways. And we need to bring that into the classroom. You have to make it possible for everyone.

Rachel echoed this point, stating that schools are responsible for meeting the needs of all students: "It's not fair to me that we expect [all students] to learn the same way, because they have different brains and they learn differently." She credits neuroeducation with shifting the collective focus back to finding what works best for children and helping them thrive. As for Grace, she said she pursued neuroeducation because she was interested in better understanding how children learn, specifically in regard to literacy. She wanted to learn why reading comes easily to some, while it is a major struggle for others. Neuroeducation, she said, has illuminated that process and subsequently impacted her practice: "I've seen it do amazing things!" Grace added that neuroeducation has helped to recast her approach to teaching. As opposed to relying

on her former additive methods, which entailed "starting with the pieces and building up from there," Grace has adopted a new viewpoint. She said the neuroeducational approach of "starting with the big picture and breaking it down" has had lasting resonance.

Although she is a self-professed neuroeducation skeptic, Sarah said it is paramount that teachers continually deepen their understanding of learning. She acknowledged that neuroeducation is one vehicle for doing so: "I look at it as another spoke that supports a deeper understanding of teaching and how to reach people to help them learn, and understand where their learning needs lie."

Table 4 highlights salient quotes from participants regarding neuroeducation's ability to meet students' needs as a perceived benefit.

Table 4
Benefit of Neuroeducation: Meeting Students' Needs

Pamela: "When I use this theory it explains every single student I've worked with. Every situation I've ever dealt with can be explained by this theory and through the levels of learning, so that's what keeps me motivated. I only see the progress, I don't see any detriment."
Pamela: "I feel like for the first time, I'm seeing students that are actually learning and developing. I'm getting some of the students who are functioning really as low as in that sensory level, who now are making over a year of progress in a year."
Maria: "I think this has been targeted to a lot of kids who have learning disabilities, but the bulk of my students are neurotypical learners and it works really well."
Maria: "We need to know how learning occurs in order to maximize the learning capabilities of the students. This idea makes sense to me that there are people who process in different ways. And we need to bring that into the classroom. You have to make it possible for everyone."
Rachel: "It's not fair to me that we expect [all students] to learn the same way, because they have different brains and they learn differently. What I really like about neuroeducation is it brought me back to my focus of, *We're doing this because we're trying to help kids learn to be the best members of society they can be*."
Grace: "I think it's great to start with the whole big picture and work down from there, as opposed to starting with the pieces and building up from there. I really enjoy that part of it – starting with the big picture and breaking it down."

Grace: "I teach little kids and I'm interested in how their brain works. I am especially interested in literacy and why some kids can pick up reading so quickly and why it's such a struggle for others. So that was kind of my pull to neuroeducation, and that's also what I'm hoping to get out of it. How can I help kids who are having such a hard time reading throughout all of first grade leave as more confident readers? And I've seen it do amazing things!"

Sarah: "When you're talking about being a teacher and being part of a learning process, any time you can understand that learning process from different perspectives – from the socioemotional perspective or from a racial perspective or from a brain function perspective – that knowledge combined with pedagogical strategies can enrich your teaching. So I look at it as another spoke that supports a deeper understanding of teaching and how to reach people to help them learn, and understand where their learning needs lie."

Paradigm Shift. Several participants expressed the belief that neuroeducation has the capability to alter indelibly the educational system (see Table 5). According to Rachel, neuroeducation has completely altered her perspectives about teaching and learning, and she believes it has the potential to do the same for the greater teaching profession. However, that means a willingness to change and to admit mistakes:

> When I took my first few neuroeducation classes, I was just devastated. I was like, *I've been doing everything wrong, I probably ruined my past students for life!* It was just really hard for me to hear because I was like, *No! They tell you to do phonics, they tell you to do this, I should be doing letters and sounds*. But when you get into the theory and you really look at it, it makes a lot of sense. All of a sudden you realize this was the key that was missing, and you don't want to be resistant to that missing piece because it's what everyone has been looking for. And we need to change the way we're doing things, and that can be a very daunting task. You have to think about, *Well now I have to completely change the way I teach and run things, and the way the school wants me to run things, and I have to be able to justify that to people who might argue with me*.

Rachel said neuroeducation has reenergized her and renewed her focus on meeting students' needs. She shared, "I haven't been in the teaching profession for too long, but what I've seen so

far is that it's kind of a one-size-fits-all method of teaching." Rachel believes a change is in order, and neuroeducation is the model that can effect that change. She explained that in her view, neuroeducation has provided "a light at the end of the tunnel." With hope, she said, others will buy in: "This is what we've been looking for. We don't need to be defensive about it; we should embrace it and think, *What a wonderful collection of knowledge we have to use to change education for the better!*

However, Rachel asserted that educators must understand the theory and research behind neuroeducation, as opposed to simply appropriating its methods. Doing so will ensure that teachers have a fundamental understanding of how and why neuroeducation addresses students' needs, and will sustain the neuroeducation endeavor:

> I think if teachers just took what I said, like, 'Okay, you've gotta use picture dictionaries, and you can't do phonics,' without knowing why, then they're just another kid following a pattern. I want them (teachers) to know why because then it's more meaningful. Otherwise it's, *This is the new thing we have to do in education,* and it won't last for long. But if you really understand… This doesn't seem like a theory to me, it's just, *This is how we learn*. At a neurological level. This should be fact. And if you understand it as fact, and if you're a teacher who wants the best for your students – and I hope every teacher does – then why wouldn't you decide to start teaching this way instead? If it's a fad, then you probably won't care. But if you understand the reasoning and theory behind it, you'll probably care a whole lot more and you'll probably do it for longer. And it'll probably help you through the struggles, because there are struggles with implementing it. If you don't believe in it, you're just going to give up early.

As was the case for Rachel, Grace said when she first began her neuroeducation program, it made her question her former practices: "It's funny, after the first class I was like, *Oh no! I've been doing everything wrong!*" Grace said many of her go-to instructional methods, such as using word walls, giving spelling tests, and relying on pattern-based learning, were debunked by her neuroeducation coursework. In Maria's view, educators have a responsibility to adapt to students' needs, and this necessitates a systemic change. She elaborated that if in fact most students are visual learners, then teachers should match their instruction to those needs: "I think we teach all with words in a lecture type of thing. You have to give pictures to people that need images and you need to stop talking as a teacher and let them process. I don't think we give them time to really chew." Similarly, Pamela said neuroeducation is the answer the educational system has sought, but there must be a willingness to abandon former practices – which she claims are ineffective and predominantly rooted in auditory-based curricula – and evolve. According to Pamela, this is schools' duty to the students they serve. She explained:

> For the first time students are receiving a free, appropriate public education. It really makes me question the other types of methods we've been doing since they've been in school; most since three years old in early intervention or younger. And we haven't seen much growth and now we're seeing this level of growth. It makes me question the whole paradigm of what we're doing. I can say for sure that it is due to a lack of instruction in their neurobiological learning system. I mean, we might be giving them the instruction but it's not – it wasn't the right kind of instruction. So it becomes to me a social justice and a civil rights issue.

According to Pamela, "There's a whole systemic change that has to occur with educators and administrators. That whole paradigm shift has to happen." For her, that necessitates redefining

how inclusion is approached. Pamela said meaningful inclusion goes beyond simply putting students with special needs in a general-education classroom, hoping they learn "by exposure." She explained, "There has to be feedback and meaningful assignment of meaning; that whole language theory and language acquisition of how meaning gets assigned. It has to be done in a social way between two agents…and the student has to be engaged." She believes the current inclusive movement fails to integrate applicable research. For Pamela, neuroeducation has the potential to completely recast teaching and learning, but there exists a great deal of resistance:

> I'm hoping there's some way to move it through. To me it would be really sad if it didn't… You're fighting against a huge system at every level, and I think if people just sat down and said, 'Why are we having more students with disabilities? Why are we having such a hard time achieving results?' But it's almost like Occam's razor, where the simplest idea is usually the best. It's so easy! It makes sense!

Table 5 highlights salient quotes from participants regarding the potential for a paradigm shift as a benefit of neuroeducation implementation.

Table 5
Benefit of Neuroeducation: Paradigm Shift

Pamela: "For the first time students are receiving a free, appropriate public education. It really makes me question the other types of methods we've been doing since they've been in school; most since three years old in early intervention or younger. And we haven't seen much growth and now we're seeing this level of growth. It makes me question the whole paradigm of what we're doing. I can say for sure that it is due to a lack of instruction in their neurobiological learning system. I mean, we might be giving them the instruction but it's not – it wasn't the right kind of instruction. So it becomes to me a social justice and a civil rights issue."
Pamela: "There's a whole systemic change that has to occur with educators and administrators. That whole paradigm shift has to happen."
Rachel: "When you go into the neuroeducation program you're presented with this idea that maybe we're not doing everything we need to be doing for the kind of thinking we need for our society. And to be honest, it can be a really tough pill to swallow."
Rachel: "I haven't been in the teaching profession for too long, but what I've seen so far is that it's kind of a one-size-fits-all method of teaching. I think this is a new way of looking at education that

really puts the power back into the student. I think the way that education is right now, it's very focused on the teacher: what the teacher's doing right or wrong, how we can simplify things to make it easier on the teacher, how we should expect students to behave so it's easier on the teacher. We have so many students in one room and we're trying to make this plan that works for all of them, so we've kind of lost sight of what we're looking for."

Sarah: "Neuroeducation has supported the idea that students need to develop a conceptual understanding of things in order to really retain learning."

Established Results. Several participants highlighted that they have seen firsthand student gains, which validates for them the effectiveness of the neuroeducation model (see Table 6). Pamela said there are countless examples of students who have benefitted from the neuroeducation-grounded approaches she utilizes in her classroom. She explained that oftentimes, there are marked changes in students' behavior, in addition to their academics:

> We collect data on increased prosocial behavior and decreased antisocial behavior. We can basically see over time…in some cases it's a drastic change in behavior. For instance, I have a student that came from another school district who bit. The student had two one-on-one assistants that walked 10 feet behind because of the severe aggressive behaviors. Now that student's bitten two or three times in a year, has one assistant, and works for six hours. So a lot of times I'll get students from other districts who had a lot of antisocial behaviors, or were on the iPad for six hours a day, or froze. So we just see… much of it is self-evident because we just see it. So you have a student that was working for five minutes, and now they're working for three hours without a break. You have a student that was engaging in daily antisocial behaviors and now the student is engaging in monthly (behaviors)."

She said she has seen marked changes in students' language, behavior, academics, and problem-solving abilities. Pamela elaborated that she is continually amazed to witness firsthand the impacts of neuroeducation, and to see students' language levels improve:

> Last year I had this student who froze, and literally couldn't do anything without prompting. And now the same student is walking in, doing all of the routines, without being prompted. So much of it you can see from the change in behavior. You can see the language. I have one student who was nonverbal, now I have a student who's speaking. I have a student who you couldn't understand; they couldn't articulate. Now I have a student who's speaking clearly and I can understand what they're saying. So I have seen changes in the language, I'm seeing changes in the behavior, and I'm seeing changes in their academics – in their reading, their writing, their problem solving. You see the changes so drastically. I have students who did not work at all, and now they're doing five, six and seven hours straight. I have students who could not be included in modified classrooms, and now they're being included. Students who had never done gen-ed. [general education] PE who are now working out on the treadmill and doing all the weights. So I mean, it just goes on and on.

In addition to the gains she has witnessed in her own classroom, Pamela has seen the exponential success of neuroeducation. Many of the educational assistants (EAs) she trained are now certified teachers who utilize visual methods in their own classrooms. "I've even gotten calls from some of them, like, 'I tried this method and the principal was shocked when it worked with this student who was having a meltdown!'"

According to Rachel, she has seen significant progress thanks to Viconic Language Methods™ (VLMs). This progress is manifested in her students' literacy abilities:

> What I'm noticing is their writing is tremendous. It is, by far, way more advanced than first grade writing has been for my past students. I have not taught one lesson of phonics this year, and yet my kids can write beautiful stories and they're doing chapter books. I have these kids who supposedly can't read and they're reading."

Maria has also seen drastic improvement in her students' work and their comprehension, which she credits to the neuroeducation-grounded visual methods she utilizes. She said countless students and parents have expressed their appreciation for her practices, because it has increased students' understanding of content and enjoyment of the learning process. Moreover, Maria cited the fact that all students who have learning differences are intentionally placed in her Spanish classes because "the learning specialists have heard from the students that with me and the way I do it, they understand it." Maria said she sees tangible results not just on formal measurements, but through the students' perception of, "*Okay, I'm getting this*." For her, that is what matters most. Table 6 highlights salient quotes from participants regarding established results as a benefit of neuroeducation implementation.

Table 6
Benefit of Neuroeducation: Established Results

Pamela: "Usually we see changes in behavior. We collect data on increased prosocial behavior and decreased antisocial behavior. We can basically see over time…in some cases it's a drastic change in behavior. For instance, I have a student that came from another school district who bit. The student had two one-on-one assistants that walked 10 feet behind because of the severe aggressive behaviors. Now that student's bitten two or three times in a year, has one assistant, and works for six hours. So a lot of times I'll get students from other districts who had a lot of antisocial behaviors or were on the iPad for six hours a day, or froze. So we just see… much of it is self-evident because we just see it. So you have a student that was working for five minutes, and now they're working for three hours without a break. You have a student that was engaging in daily antisocial behaviors and now the student is engaging in monthly (behaviors)."
Pamela: "I have seen changes in the language, I'm seeing changes in the behavior, and I'm seeing changes in their academics (in their reading, their writing) and problem solving."
Pamela: "I have former EAs who became teachers, and they're doing the drawing and writing at their schools. I've even gotten calls from some of them, like, "I tried this method and the principal was shocked when it worked with this student who was having a meltdown!"

Pamela: "Last year I had this student who froze, and literally couldn't do anything without prompting. And now the same student is walking in, doing all of the routines, without being prompted. So much of it you can see from the change in behavior. You can see the language. I have one student who was nonverbal, now I have a student who's speaking. I have a student who you couldn't understand; they couldn't articulate. Now I have a student who's speaking clearly and I can understand what they're saying. You see the changes so drastically. I have students who did not work at all, and now they're doing five, six and seven hours straight. I have students who could not be included in modified classrooms, and now they're being included. Students who had never done gen-ed. [general education] PE who are now working out on the treadmill and doing all the weights. So I mean, it just goes on and on."

Rachel: "What I'm noticing is their writing is tremendous. It is, by far, way more advanced than first grade writing has been for my past students. I have not taught one lesson of phonics this year, and yet my kids can write beautiful stories and they're doing chapter books. I have these kids who supposedly can't read and they're reading."

Maria: "The school has a percentage of students that have learning differences. If they take Spanish in their second year, they put them in my class. Because the learning specialists have heard from the students that with me and the way I do it, they understand it. So it's not just the measuring, and my measuring on a test, it's their perception of, *Okay, I'm getting this*."

Grace: "I was just using it with a certain group of kids and I saw that do amazing things. So then I started with my class this year – and this class is just a little bit lower than my class last year was – so it's worked really well to start out the year doing it. I've noticed the writing is longer, which is one concrete thing I've noticed. They want to write more and I feel like they're more eager to write."

In regard to benefits of neuroeducation, three recurring themes arose across participants: the capacity to meet students' needs, the potential for neuroeducation to result in a paradigm shift, and established results. The next section will address the themes related to participants' application of neuroeducation-grounded approaches.

Theme: Application of Neuroeducation-Grounded Approaches

This section discusses a singular theme that arose in regard to the ways in which educators apply neuroeducation-grounded approaches in the classroom. This theme pertains to the participants' use of visual methods to meet students' needs and promote conceptual thinking. Notably, this was articulated by some participants as formal Viconic Language Methods™ (VLMs), and by others as informal drawing and writing strategies (see Table 7).

Rachel said she incorporates various neuroeducation-grounded approaches into her teaching practice, both for academic and behavior purposes:

> I have been using some Viconic Language Methods™, including some picture dictionaries, flow charts, teaching the kids to draw everything… I've taught them that they're the agent, and the agent is who's in charge, and they always need to include the picture of their agent self in the picture, thinking about whatever they're thinking. My emphasis has changed from, *I'm gonna teach you this* to, *Our job is to think at school, and I want to know what you're thinking*. It's not necessarily, *Are you giving me the right answer?* but, *Are you showing me how you're thinking?* Another thing I've used is social cartooning for classroom routines, for expectations… I use them with my kiddos who are struggling with behaviors as a method to calm them down, but also as a way to help them understand what I expect from them. It is effective when I can do it.

She elaborated on students' use of picture dictionaries, citing it as an effective tool for helping increase their conceptual understanding of key terms and ideas:

> In reading groups we are using picture dictionaries. We do a picture walk and then we scan for words we don't know, and when the kids find a word they don't know and they're like, 'I don't have a picture for this' or 'I don't know what this is' then I tell them what it is, they draw the picture, and then they tag it with the word. What's amazing about that is, once they have the picture with the word connected to it, they know it and they don't often need to reference their picture dictionary again; maybe one or two times after that.

In her classroom, Maria exemplifies content with drawings. Using an iPad and projector, she illustrates stories for students, which she said has been "very helpful" for her students. She further explained:

> I draw and then we make a connection between those images, the words, and what the words and images represent in a grammatical structure. It helps with their conceptual understanding; that's what they convey when I ask them. Another thing I was advised [to do] was the retagging. So I draw a story and I tell the story in Spanish with no words. Then we go back to the story and they tell me the story in English. And then as they tell me the story in English I write the words in Spanish on the story. So I repeat the story in Spanish, I retag orally and retag with words on the board. But the images stay there; they're the same. And then I ask them to do a story that they can tell their neighbor and they can tell me.

Maria said her students use these drawing strategies not only in her class, but in other subjects, as well. For her, the merits of these neuroeducational approaches have been affirmed directly by the students.

Grace said she has begun incorporating visual methods and adapting some of her former instructional methods: "We still have to do spelling tests, so with my littler groups of readers I'm doing storytelling with the words. And so we're starting out with making a big story and then putting in all the words." She said she has also re-envisioned the way she uses parent volunteers: "I used to have them in just for reading…now I have them in for writing. We can go through the process of drawing and then I have them come in and tag." She said the extra help is beneficial for neuroeducation implementation, as many of the drawing and writing methods necessitate

one-on-one assistance. Sarah also relies on drawing techniques, although she acknowledged it is in a less formal manner:

> As I talk to kids I'll draw things out for them. When describing things to children who need understanding, I'll do story form; I'll have them develop their own picture of what's going on. And I don't know if this is really neuroed, but I'll use things like acting it out, I try to use realia whenever possible. I do think the visuals and drawing things out is a good strategy. That is a strategy I use… to have the students talk through things with each other and to process the information, having them draw what they're thinking – I'll use that.

Pamela said she and her support staff rely heavily on Viconic Language Methods™ (VLMs) in the classroom. She said they utilize event-based learning, most of which is derived from the interests of the students. Pamela and the educational assistants (EAs) provide the big picture for students, and then incorporate "a lot of drawing and writing" into lessons. She said there is a continual refining and layering process that occurs. Pamela furthered:

> We talk to them, we use good oral language, we tell them this is what we're doing, we draw out the event with them, and again, we work off their learning system. So no two students' work looks the same. What one EA might do with one student might look different than what one staff might do with another student. So we really work off of their learning system. And we take the concept of the big picture. So any ideas that are not – they haven't yet learned those ideas – we bring it down to a preoperational level, and what they know, and we build it back up. So we do the event-based learning, we do the visual methods, we refine their work and provide feedback in the way they

> neurobiologically learn. In my class it's movement-access, so it's all hand-over-hand drawing, writing, bubbling, picture dictionaries.

Pamela explained how she and the support staff match the students' language: "When the students are out in gen-ed. [general education], we're looking at the language level of the curriculum and translating that auditory language level into the visual thinking." She said they illustrate the students' routines and procedures – such as drawing-out cooking steps and ingredients in a home-economics class – and rely on hand-over-hand drawing and writing. In addition, Pamela said visual methods are used to assist with student behaviors:

> When we do work on behavior, we pull it out, and we draw and write about the behaviors we want to see. Like, 'This is the way you're thinking when you're functioning at this level.' We build the social thinking into the process.

Table 7 highlights salient quotes from participants regarding visual methods as their primary application of neuroeducation-grounded approaches.

Table 7
Application of Neuroeducation: Visual Methods

Rachel: "I have been using some Viconic Language Methods™, including some picture dictionaries, flow charts, teaching the kids to draw everything… I've taught them that they're the agent, and the agent is who's in charge, and they always need to include the picture of their agent self in the picture, thinking about whatever they're thinking. My emphasis has changed from, 'I'm gonna teach you this' to 'Our job is to think at school, and I want to know what you're thinking.' It's not necessarily, 'Are you giving me the right answer?' but 'Are you showing me how you're thinking?' Another thing I've used is social cartooning for classroom routines, for expectations… I use them with my kiddos who are struggling with behaviors as a method to calm them down, but also as a way to help them understand what I expect from them. It is effective when I can do it."
Rachel: "In reading groups we are using picture dictionaries. We do a picture walk and then we scan for words we don't know, and when the kids find a word they don't know and they're like, 'I don't have a picture for this' or 'I don't know what this is' then I tell them what it is, they draw the picture, and then they tag it with the word. What's amazing about that is, once they have the picture with the word connected to it, they know it and they don't often need to reference their picture dictionary again; maybe one or two times after that."
Maria: "Everything I do I exemplify with drawings. I have a projector and an iPad, and I draw on my iPad so the kids can see it. I tell them stories that have to do with what we're learning and the theme that we're learning. That's been very helpful for my students."
Maria: "I draw and then we make a connection between those images, the words, and what the words and images represent in a grammatical structure. It helps with their conceptual understanding; that's what they convey when I ask them. Another thing I was advised [to do] was the retagging. So I draw a story and I tell the story in Spanish with no words. Then we go back to the story and they tell me the story in English. And then as they tell me the story in English I write the words in Spanish on the story. So I repeat the story in Spanish, I retag orally and retag with words on the board. But the images stay there; they're the same. And then I ask them to do a story that they can tell their neighbor and they can tell me."
Maria: "Anecdotally, we had parent-teacher conferences and several parents came to me and said, 'I don't know what you're doing but he's/she's getting it, and he/she likes it!' The only things that's changed is the introduction of the pictures and giving them time to do their own pictures, because that gives me time to go around and work with them if someone is struggling. I've gotten feedback from my students and for many of my students, the drawings help them."
Pamela: "We use event-based learning, so we try and make all of the events about the interests of the students, through some guidance, because of their level of functioning. We provide the big picture, so there's a lot of drawing and writing that we do."
Pamela: "When we do work on behavior, we pull it out, and we draw and write about the behaviors we want to see. Like, 'This is the way you're thinking when you're functioning at this level.' We build the social thinking into the process."

Pamela: "It's individualized to the processes; it depends on what we're doing. So we're doing a lot of refining. We talk to them, we use good oral language, we tell them this is what we're doing, we draw out the event with them, and again, we work off their learning system. So no two students' work looks the same. What one EA might do with one student might look different than what one staff might do with another student. So we really work off of their learning system. And we take the concept of the big picture. So any ideas that are not – they haven't yet learned those ideas – we bring it down to a preoperational level, and what they know, and we build it back up. So we do the event-based learning, we do the visual methods, we refine their work and provide feedback in the way they neurobiologically learn. In my class it's movement-access, so it's all hand-over-hand drawing, writing, bubbling, picture dictionaries."

Pamela: "Basically we match the language. So when the students are out in gen-ed. [general education], we're looking at the language level of the curriculum and translating that auditory language level into the visual thinking. And we do that in the gen-ed. setting, as well as applied work, so we're drawing out their routines, we're drawing out their cooking when they're in home-ec., we're drawing out the ingredients, we're drawing out the process of how to make something using hand-over-hand drawing and writing."

Grace: "We still have to do spelling tests, so with my littler groups of readers I'm doing storytelling with the words. And so we're starting out with making a big story and then putting in all the words. And now I've switched all my writing to be like that, and I've shifted how I use parent volunteers. I used to have them in just for reading and they would read one-on-one with the kids, but now I have them in for writing. We can go through the process of drawing and then I have them come in and tag. So we can use their time for that more instead of just reading."

All five participants rely on various visual techniques to supplement their instruction and promote students' conceptual thinking. Thus, the key theme pertaining to educators' application of neuroeducation-grounded approaches is the utilization of visual methods. For some, this is manifested in a formal manner, such as with Viconic Language Methods™ (VLMs), while for others, this is reflected in the use of informal drawing and writing strategies. The next section addresses the overarching theme pertaining to educators' assessment of the neuroeducation-grounded approaches they utilize.

Theme: Assessment of Neuroeducation-Grounded Approaches

Regarding the ways in which educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize, the cross-cutting theme was the use of informal assessments (see Table 8). The participants discussed the fact that most school and district assessments do

not measure what they want to know, therefore the participants have created their own measurements. Explained Rachel:

> A lot of the traditional assessments that the district gives us that we see in public education are very pattern-based skills like, *If I give you a pattern, can you spit me back the pattern?* And that's not what I'm looking for. I'm looking to see what it is they're thinking and are they able to use that thinking in another context?

She has created her own version of a running record, to determine how frequently students refer to their picture dictionaries and whether they are sounding out words versus looking at whole ideas. In addition, Rachel uses event-based pictures to check students' progress:

> I did this on the first day of school to see what each child could tell me orally. Could they tell me who was in the picture? Could they tell me what they're doing? I have a rubric that I created for that, and my plan is every trimester I will give them a new picture and see what the progress is. I've only done it once, but I'm really excited to see how that's progressed.

For her part, Grace explained that she does not formally assess neuroeducation-attributed progress, due in large part because this is her first year of implementation. However, she said anecdotally, she has seen "amazing things" and has witnessed more eagerness and interest in literacy on her students' part. While she has not seen a discernable difference with spelling, she has noticed gains in the areas of reading and writing. Sarah said she does not formally assess her students in regard to whether the specific drawing methods have proven efficacious. She explained:

> There's nothing that I officially do. I mean, I guess there's observational data, but am I collecting observational data in a formal way? No, I'm not. I'm just responding to what

> I observe, what I hear, what I see. But I can't point to any particular data. Although, I do have checklists of things I observe in the classroom.

On the other hand, Pamela said she incorporates myriad assessment tools into her instruction, as a means of validating her practices and demonstrating student gains. While many of her assessments are "informal and self-evident," she also uses formal measurements:

> We collect data on increased prosocial behavior and decreased antisocial behavior. Sometimes I use that behavior to change my instruction. So if I have a student who's pulling away or this or that, I might be too high; I'm not at their language level, I'm not at their developmental level. Or I might be objectifying them, where I'm giving them too much and not letting them have enough agency over it. So we collect the data on the behavior, and we also look at their drawing and writing, and we look at the level of support needed.

Pamela explained that she began documenting students' progress in part to show others that neuroeducation works. She expounded:

> I was told to collect all this data to prove it, because I'm going against the grain. So I spent the first month of school doing all these charts where I did this communication, behavior, and literacy, as measured in reading and writing. So I just made these charts. I have binders and binders of student work from years; I have more artifacts than anything. I could say, *Okay the student started here* – I looked at their IEP – *and here they are now*. So I looked at where they were and where they are. I rated the severity and then frequency. Because that's how DD – developmental disabilities – that's how they rate need for services for adults. So I kind of modeled it after that, because this would give

someone a picture without them really understanding; you could see the change. So it's constantly just trying to prove it.

Maria said she has incorporated her own methods for gauging student progress, but is still required to conform to her school's expectations regarding assessments: "In a school where parents and students want to see a grade based on something tangible, based on a product, then I have to give them that." While she still utilizes traditional assessments such as exams, she has begun collecting anecdotal evidence that her neuroeducation-based methods are effective. Moreover, she has heard from numerous students that the drawings help them understand and retain content more fully. For Maria, that is all the proof she needs. Table 8 highlights salient quotes from participants regarding utilization of informal assessments as the primary means of gauging the effectiveness of neuroeducation-grounded approaches.

Table 8
Assessment of Neuroeducation: Informal Assessments

Rachel: "A lot of the traditional assessments that the district gives us that we see in public education are very pattern-based skills like, *If I give you a pattern, can you spit me back the pattern?* And that's not what I'm looking for. I'm looking to see what it is they're thinking and are they able to use that thinking in another context?"
Rachel: "I've tried to create my own assessments for running records and things I would use in reading groups, so those assessments look more like, *Does this student use a picture dictionary for the words they're not sure of, and how often do they reference the picture dictionary for words they have in there?* So I'm just monitoring how many times they need to check, and I do have a little spot for, *Are they still trying to sound it out and use the sounds, or are they looking at the whole idea?*"
Rachel: "I am using *Dick and Jane* pictures where kids orally tell me what's going on in the picture. I did this on the first day of school to see what each child could tell me orally. Could they tell me who was in the picture? Could they tell me what they're doing? I have a rubric that I created for that and my plan is every trimester I will give them a new picture and see what the progress is. I've only done it once, but I'm really excited to see how that's progressed."
Sarah: "There's nothing that I officially do. I mean, I guess there's observational data, but am I collecting observational data in a formal way? No, I'm not. I'm just responding to what I observe, what I hear, what I see. But I can't point to any particular data. Although, I do have checklists of things I observe in the classroom."

Maria: "Before, I gave a tremendous amount of fill-in-the-blank worksheets in the form of homework. I stopped giving homework, but the assessments are traditional, because this is kind of a traditional school. So it's not just the measuring, and my measuring on a test, it's [the students'] perception of, *Okay, I'm getting this*."

Maria: "In a school where parents and students want to see a grade based on something tangible, based on a product, then I have to give them that. That's what I have to do as an employee of the school."

Pamela: "We collect data on increased prosocial behavior and decreased antisocial behavior. Sometimes I use that behavior to change my instruction. So if I have a student who's pulling away or this or that, I might be too high; I'm not at their language level, I'm not at their developmental level. Or I might be objectifying them, where I'm giving them too much and not letting them have enough agency over it."

Pamela: "We collect the data on the behavior, and we also look at their drawing and writing, and we look at the level of support needed."

Pamela: "Some of it is formal documentation but much of it is informal and self-evident."

Pamela: "I was told to collect all this data to prove it, because I'm going against the grain. So I spent the first month of school doing all these charts where I did this communication, behavior, and literacy as measured in reading and writing. So I just made these charts. I have binders and binders of student work from years; I have more artifacts than anything. I could say, okay the student started here – I looked at their IEP – and here they are now. So I looked at where they were and where they are. I rated the severity and then frequency. Because that's how DD – developmental disabilities – that's how they rate need for services for adults. So I kind of modeled it after that, because this would give someone a picture without them really understanding; you could see the change. So it's constantly just trying to prove it."

The primary theme that arose in regard to how educators assess the effectiveness of neuroeducation-grounded practices is the utilization of informal assessments. According to several participants, the school system is not set up to measure what they need it to, so they have created their own measurements to validate their practices.

Summary of Chapter

This chapter provided detailed narratives for each of the five participants. It also discussed the various themes that emerged from the research study. These themes pertained to participants' perceptions about the benefits and challenges of neuroeducation implementation,

the means by which they apply neuroeducation-grounded approaches in the classroom, and the assessment methods they utilize in order to gauge the effectiveness of those approaches.

Chapter 5

Discussion

The purpose of this qualitative narrative inquiry was to explore how educators from a language-based neuroeducation program apply and assess neuroeducation-grounded approaches in the classroom, and to investigate their perceptions about the challenges and merits of neuroeducation implementation. The study was premised on a particular model of neuroeducation that overlaps research from neuroscience, cognitive psychology, and language theory. The research sought to provide concrete examples of the ways in which educators connect theory – specifically Neuro-Semantic Language Learning Theory (NLLT) – and classroom practice. Three questions guided the study:

1. How do K-12 educators from a language-based neuroeducation program apply neuroeducation-grounded approaches in their instructional practices?
2. How do these educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize in the classroom?
3. What do these educators perceive as the challenges and merits of neuroeducation implementation?

This chapter provides a discussion and interpretation of the study results, as aligned to the three aforementioned research questions and as compared to the existing body of literature on neuroeducation. Additionally, this chapter discusses inherent limitations of the study, addresses implications for both the neuroeducation discipline and the greater education profession, and highlights suggestions for future research.

Application of Neuroeducation-Grounded Approaches

The first research question asked, *How do K-12 educators from a language-based neuroeducation program apply neuroeducation-grounded approaches in their instructional practices?* Findings from the study reveal that most participants rely on visual methods to promote students' conceptual thinking and increase their language. All five subjects referenced visual strategies, although one qualified that she uses them because they are best practice and not because they are neuroeducation-aligned. Four educators described their utilization of specific Viconic Language Methods™ such as picture dictionaries, bubbling, hand-over-hand writing, and extensive drawing.

Minshew and Williams (2007) pointed to the case of Temple Grandin, a renowned advocate and spokesperson for autism who has discussed her experiences with visual thinking. In order to visualize abstract concepts such as *justice* or *honor*, for instance, Grandin thinks of the television program *Law & Order*. She relies on "already experienced situations or visual pictures (e.g., concrete examples)" for comprehension. According to the researchers, this highlights the compensatory use of visual strategies for tasks usually performed with language.

Arwood, Kaulitz, and Brown (2009) posited that there are four acquisition levels of meaning: (a) sensory receptors take in sights, sounds, smells and touches; (b) the sensory inputs are sorted into recognizable patterns, or perceptions; (c) the perceptual patterns are overlapped to become concepts; and (d) meaning is ascribed to the concepts using language. According to Arwood et al. (2009), educators must know their students' level of meaning and language level in order to provide developmentally appropriate visuals. They further explained that, while all visual materials, pictures, and activities have meaning, the meaning hinges on how the student learns meaning, as well as the level of meaning the visual has for the student.

According to Arwood et al. (2009), in order for visuals to be effective, they must match the language level of the student. Educators who utilize visuals or graphics as an intervention may be unsuccessful if they do not understand the developmental level of the student with whom they are using the intervention. Pictures can be effective for visual learners, which most students in today's schools are, but pictures are subject to interpretation. Therefore, there must be parity between the developmental level of the visual and the developmental level of the learner. When matched to students' individual language levels, pictures can help children learn, both cognitively and socially (Arwood et al., 2009).

In keeping with the research, which posits that language paired with visuals can promote students' conceptual thinking (Arwood et al., 2009), Pamela said the use of drawing in her special education classroom has been an effective method: "We're doing a lot of refining. We talk to them, we use good oral language, we tell them this is what we're doing, we draw out the event with them, and again, we work off their learning system." She further explained that no two students' work looks the same because the visuals are unique to the individual. Rachel also utilizes visual methods, specifically Viconic Language Methods™ within her classroom, both for academic and behavioral reasons. She said she frequently relies on picture dictionaries, flowcharts, hand-over-hand writing, and other approaches that are grounded in neuroeducation. For Rachel, the use of picture dictionaries has helped with students' long-term conceptual understanding:

> In reading groups we are using picture dictionaries. We do a picture walk and then we scan for words we don't know, and when the kids find a word they don't know and they're like, 'I don't have a picture for this' or 'I don't know what this is,' then I tell them what it is, they draw the picture, and then they tag it with the word. What's amazing

about that is, once they have the picture with the word connected to it, they know it and they don't often need to reference their picture dictionary again; maybe one or two times after that.

Similarly, Maria explained that drawing and tagging visual pictures has been key to her students' conceptual understanding. In her Spanish classes, she tells a story aloud in Spanish while simultaneously drawing out the story with only pictures. Next, she asks the students to tell the story back to her in English to gauge their comprehension. As they do, she tags the words in Spanish on the story. Finally, the students tell the story in Spanish using the pictures and tagged words as a reference. Maria said this layering is an effective tool for helping students gain a deeper understanding of the content. The students are often asked to create their own drawings, which is important since visuals are subject to interpretation and also depend on the ascription of meaning by the individual (Arwood et al., 2009).

For Sarah, she incorporates strategies such as drawing into her teaching not because she sees a direct line from NLLT to her practice, but because she believes they are general best practices. While Schmeck et al. (2014) found that drawings, especially learner-generated drawings, are an effective tool for promoting students' understanding of content in a broad sense, Arwood (2011) contended that drawings need to be rooted in NLLT and connected to students' individual language levels and conceptual understanding. According to the latter viewpoint, utilizing drawing in isolation will not promote higher-order thinking. An understanding of students' unique learning systems allows for developmentally appropriate visual methods to be matched to those systems.

Assessment of Neuroeducation-Grounded Approaches

The second research question asked, *How do these educators gauge the effectiveness of the neuroeducation-grounded approaches they utilize in the classroom?* Findings from the study reveal that most participants rely on informal assessments to measure students' progress, both academically and behaviorally. They also use informal assessments to inform them as to whether their neuroeducation-grounded approaches are working. Arwood (2011) posited that educators should assess and intervene based on students' language functions, as opposed to their language structures. This pertains to evaluating students' internal thinking processes as opposed to external, tangible products. In keeping with the research, four of the participants described how they determine students' language levels, utilize visual methods to meet students' needs, and assess changes in language function as a means of documenting students' progress.

According to several participants, the school system is not set up to measure what they need it to, so they have created their own measurements to validate their practices. As Rachel described:

> A lot of the traditional assessments that the district gives us that we see in public education are very pattern-based skills like, *If I give you a pattern, can you spit me back the pattern?* And that's not what I'm looking for. I'm looking to see what it is they're thinking, and are they able to use that thinking in another context?

She has created her own version of a running record to document students' progress in reading, measuring how many times students reference their picture dictionaries. Rachel also created a rubric to document if students can use an event-based picture, such as a picture of a family at a picnic, to tell her what is happening in the picture, including the who, what, where, and why.

Pamela explained that she has binders full of students' work, which she uses to "prove" that the visual methods are effective. She chronicles where the learners are when they come to her and where they are at the end of the year, and she said the progress is staggering. The artifacts document students' academic progress, as well as their social progress. She said as students' language levels improve, so does their level of thinking and their work quality. According to Pamela, this discernable change is chronicled by the examples of students' work. While she has no doubt about the merits of neuroeducation and NLLT, however, she still feels she must prove it to others. Pamela explained that she has kept the binders of student artifacts – including assessments of students who are no longer in her classroom – as a testament to the effectiveness of neuroeducation.

Maria explained that she collects anecdotal evidence that the visual methods work, but she still has a responsibility to utilize traditional assessments that are mandated by her school. For Maria, it is a balancing act between the methods and assessments she finds effective and noteworthy, and the expectations of her administrators and parents, who want to see tangible results. This aligns with Arwood's (2011) assertion that there is often discord between the process approach to versus the product approach.

Challenges and Merits of Neuroeducation Implementation

The third research question asked, *What do these educators perceive as the challenges and merits of neuroeducation implementation?* In regard to challenges, or barriers, participants discussed self-efficacy, isolation, and a perceived mismatch between their mindset and the collective mindset of the educational system. Regarding the perceived benefits of neuroeducation, participants discussed the ability to meet students' needs, the established results they have witnessed in the classroom, and the capacity for neuroeducation to effect a paradigm

shift. These findings are further explored and analyzed in comparison to the body of literature in this section.

Self-Efficacy. Self-efficacy was a prevailing theme in this study. Bandura (1977) defined self-efficacy as people's perceived capacity – whether accurate or not – to produce a desired effect. Four of the five participants discussed their own doubts about their self-confidence in implementing neuroeducation-grounded approaches, as well as translating Neuro-Semantic Language Learning Theory (NLLT) into practice. Sarah said her depth of knowledge is still in its infancy, and she lacks a complete understanding of how the three fields of study – neuroscience, cognitive psychology, and language – inform one another. She said she is "insecure" about implementing neuroeducation in her classroom. Sarah further explained, "I have these separate areas of knowledge, but the knowledge of how they work together I don't feel confident in. It's my own lack of knowledge. I don't feel like I have enough knowledge to speak authoritatively on (neuroeducation)." Similarly, Rachel described her concern as follows: "It's tough when you're not feeling 100% solid in it. I know that if people throw a hard question at me and I can't answer it then I am going to lose the credibility of what I'm doing." For her part, Grace said she does not yet have all the pieces needed to feel confident. "I still don't feel like I totally know how to do [neuroeducation]. And I don't know how you figure it out. Like, is it just me? Am I just stupid?"

Maria said that although she has begun incorporating visual methods into her instruction over the past few years, she is by no means an expert. She heard anecdotally it takes up to five years to feel confident in neuroeducation, and she said she is in the beginning stages. Pamela echoed that it takes several years to feel solidly grounded in the intricacies of neuroeducation and NLLT. She is in her fourth year of implementation and just starting to feel comfortable. She

added that she attends several neuroeducation workshops each year as a way of refining her thinking and honing her skills.

Notably, several participants said they feel unsure about whether they are implementing neuroeducation correctly. Rachel explained, "I'm always second-guessing myself and wondering if I'm doing this correctly, but I figure all I can do is try it out, right?" Similarly, Grace said she wished a neuroeducation expert could visit her classroom to show her the practical aspects of implementation. Grace furthered, "I feel like I need [name redacted] to come to my room for a month and tell me everything I should be doing. And then I could really do it. That's what you'd need. You need people who can describe everything and tell you how it goes, and to get the practical pieces." This aligns with neuroeducation research that highlights the well-documented gap between theory and practice (Edelenbosch et al., 2015). The research underscores that educators, especially those who are new to neuroeducation, need time and refinement in order to translate NLLT into practice.

According to Tschannen-Moran et al., (1998), teachers' self-efficacy is often contingent upon feedback, encouragement, and support from others. However, most of the participants included in this research study are the lone neuroeducators in their buildings, so validation and feedback may be lacking. This may compound their feelings of isolation, a theme which is further explored in the subsequent section. Moreover, if self-efficacy plays a significant role in the successful implementation of an intervention (Turner, Nicholson, and Sanders, 2011), then low teacher-efficacy among neuroeducators may hinder the advancement of neuroeducation.

Despite some participants' hesitation, however, most have decided to move forward with implementing neuroeducation-grounded approaches in their teaching. As Rachel asserted,

"What I've realized is this is a process for me, and this is the first year of this process, where I'm figuring out what's working and what I need to tweak so it can further help my kiddos."

Isolation. Notably, most of the participants involved in the study are the lone neuroeducators within their respective schools. Neuroeducation is a burgeoning discipline, so it is likely that its tenets have not yet received widespread acceptance in the school setting. For most of the participants, they are the sole neuroeducators in their respective schools. Thus, there is often a lack of buy-in and collaboration in regard to neuroeducation and NLLT. Pamela said she is often perceived by others as "going against the grain." Similarly, Rachel said she is the lone neuroeducator at her school, so she fights skepticism from colleagues and feels she must constantly defend her methods. Rachel said she struggles with the lack of collaboration and community within her school: "I don't always get that support, and it's all on me right now."

Furthermore, Rachel described a disconnect between her and her colleagues due to their different teaching approaches. She said the relative newness of neuroeducation, coupled with her youth, contribute to the disconnect. Rachel said she attends special education meetings in which specialists suggest ideas and strategies that she knows are ineffective or misguided, but her contributions are overlooked:

> I'm sitting with this whole panel of people who don't know the theory of this neuroeducation model. It can be really frustrating to listen to what they're saying and to be a younger teacher and to try and give them suggestions for what I know. A lot of times it's shot down right away.

Research suggests that schools are historically insular, and their *egg-crate* architecture (Lortie, 1975) does little to engender collaboration. Teachers typically have few opportunities to collaborate or observe colleagues at work (Davidson & Dwyer, 2014). For the purposes of this

particular study, collegial isolation may be further compounded by the fact that neuroeducators are often scarce, without likeminded coworkers with whom to collaborate. A study by McQuat (2007) found that special education teachers are often isolated and marginalized. Moreover, they may lack social capital, which involves relationships, collaboration with colleagues, and ties to external experts and professional development. Although the McQuat (2007) study was couched in a different context, it may be fair to assume that neuroeducators are similarly isolated and marginalized.

It is possible that the social capital of neuroeducators, many of whom work in isolation, may be diminished if they are unable to collaborate with likeminded individuals or engage in meaningful professional development centered on a topic to which they have devoted their professional lives. In addition to addressing isolation among teachers of students with disabilities, Henley et al. (2010) discussed the separation and lack of collegiality often experienced by teachers of gifted and talented students. They suggested the merits of cooperative efforts, "based on the premise that awareness, knowledge, and cooperation bring about better working relations and less isolation" (p. 206). Again, a similar parallel may be made with neuroeducators who wish to collaborate, share knowledge, and refine their own thinking with colleagues. Pamela explained that in her school, she has encountered resistance from colleagues, which has made it difficult to move neuroeducation forward: "There's almost a fear: a fear of the unknown, a fear of having to be out of your comfort level, a fear of not being able to do it." For Grace, the fact that her grade-level team has disparate mindsets about how to teach literacy, getting buy-in about neuroeducation has proved challenging. Similarly, Maria said there are some educators who are interested in learning more about her neuroeducation-grounded methods, but other who dismiss it as a valid approach to teaching and learning.

Collaboration may in fact combat teachers' feelings of professional isolation and marginalization, and promote better parity among colleagues. It may also help propel the neuroeducation enterprise. Neuroeducation has the potential to be a meritorious and efficacious framework for educational practices, but in order to permeate the school system and receive more widespread acknowledgement, it must move beyond the confines of neuroeducators' individual classrooms. The success and sustainment of the neuroeducation initiative may well depend on fewer silos and greater buy-in.

Mindset Mismatch. Several participants discussed the fact that neuroeducation is contrary to many of the practices found in schools. For many, their methods of teaching, which are grounded in cutting-edge language theory, run counter to the systemic perspective of teaching and learning. According to Pamela, "There's a whole systemic change that has to occur with educators and administrators. Most people right now don't understand the research behind [learning]." Pamela explained that many educators do not understand – or minimize – the role that language plays in learning. In her view, the majority of teachers do not think deeply enough about learning, do not challenge assumptions, and do not question the current dogma on which much of the educational system is based. This has left her incredibly disenchanted. It has also caused Pamela, a lifelong special education teacher, to question the current approach to inclusion of students with disabilities in the general-education setting:

> I really think from a whole systems level, at even a state level, there's so much misinformation about how to include people who have disabilities. I think the whole inclusion movement is a barrier, just because sending a student into a classroom…how inclusion is interpreted…is that really inclusion? If somebody isn't learning, if people aren't really interacting with them socially, is that inclusion? Sitting in the back of the

> classroom? It's that whole, 'I don't really know how learning occurs.' It's a huge barrier. People have good intentions, like, 'Let's just put them in here.' You're just exposing them again. That's just exposure, and they don't learn by just exposing them. There has to be feedback and meaningful assignment of meaning; that whole language theory and language acquisition of how meaning gets assigned. It has to be done in a social way between two agents…and the student has to be engaged. So in some ways the whole inclusive movement is a barrier. The way it's interpreted. I'm not saying inclusion is not good, but it's this all-or-nothing aspect, and it's not based on the research. They're not integrating the fields of research.

For Maria, there is a disparity between her methods of assessing students' progress and the expectations of her traditional-minded school. For her, the challenge is reconciling the approaches she believes are effective with the college preparation and standardized tests mandated by the school. For Rachel, she said she is fighting against systemic misinformation. She explained that she attends special education meetings with teams of specialists who promote phonics and audiobooks for struggling readers, as well as finger fidgets and other strategies to address students who "can't sit still." Rachel elaborated that she wants to share with others that language-based visual methods can ameliorate many of the student issues, but often feels her voice is minimized. This underscores the idea that a cultural mismatch exists between students' learning systems and the prevalent approaches to teaching and learning found in schools. Sarah explained that changing teachers' practices is a lengthy process:

> Unless you have multiple years of teachers stopping the memorization, stopping that type of teaching, then you're always… Even it's just one teacher, they're battling with what

came before and what came after them. To impact any real change, it gets frustrating, and then… that frustration sort of leads to giving up.

The participants' perceptions about mindset mismatch as a barrier to neuroeducation implementation aligns with research. One study alluded to the mismatch between neuroscience knowledge and education practices (Potomac Institute for Policy Studies, 2014), while Arwood (2011) addressed the cultural mismatch between students' learning systems and the prevalent approaches to teaching and learning found in schools. According to Hardiman (2014), education can be transformed by grounding instructional practices on evidence-based research about how students acquire, retain, and apply information.

Several participants suggested that teacher preparation and professional development centered on neuroeducation might help to shift the education paradigm and effect systemic change. According to Grace, "You need the theory but also the practical pieces. You need someone who can describe everything and tell you how it goes." Access to a neuroeducation program, particularly one that includes a consideration for language theory, may in itself be a barrier for advancement of the enterprise. Thus, dissemination of research on language, and Neuro-Semantic Language Learning Theory in particular, may be worthwhile.

Meeting Students' Needs. One benefit of neuroeducation, as discussed by several participants, was the ability to meet students' needs. Rachel said that schools do a disservice to students by expecting them to learn the same way. Citing the fact that "they have different brains and they learn differently," she said the onus is on education to find ways to meet the diverse needs of learners. For her neuroeducation has put the focus back on students, and she appreciates tits holistic approach to learning. Grace echoed this sentiment, explaining that she resonates with the comprehensive, "big picture" approach afforded by neuroeducation. As

Templeton (1991) postulated, the educational system is couched in a pervasive parts-to-whole mindset. For Maria, neuroeducation has illuminated the learning systems and needs of students, which is fundamental to authentic learning: "We need to know how learning occurs in order to maximize the learning capabilities of the students. This idea makes sense to me that there are people who process in different ways." Maria elaborated that the neuroeducation mindset needs to infiltrate the broader school system, in order to enable all students to have rich, meaningful, and lasting learning experiences.

In the case of Pamela, the neuroeducation-grounded approaches she began implementing four years ago have profoundly impacted her students' academic and social abilities. She explained that for the first time in her career, she has witnessed students actually learning and developing in a meaningful way. Pamela said she believes NLLT is the primary reason she has seen such drastic improvement, and this belief is what motivates her to push forward, despite resistance from others:

> When I use this theory it explains every single student I've worked with. Every situation I've ever dealt with can be explained by this theory and through the levels of learning, so that's what keeps me motivated. I only see the progress, I don't see any detriment.

According to Rachel, neuroeducation is the "missing piece" education has sought, and it has the ability to profoundly impact teaching and learning. However, she said the implementation and sustainment of neuroeducation hinge on educators who are willing to change and accept that perhaps the current system does not adequately meet students' needs.

Established Results. In keeping with previous section, several participants discussed the firsthand student gains they have witnessed in their classrooms, which they credit to neuroeducation. These established, documented results both validate the effectiveness of the

neuroeducation model and motivate the educators to push forward with implementation, despite the aforementioned challenges.

For Pamela, there have been drastic results. She said changes in her students' language levels have resulted in tangible changes in their academics, behaviors, and problem-solving abilities. For her thinking and language are inextricably linked. This connects to the research, which demonstrates the interrelationship between thinking and language (Halliday, 1993; Vygotsky, 1962; Mercer, 2013). Pamela explained the strides her students have made, thanks to the visual methods she and her staff utilize in the classroom:

> Last year I had this student who froze, and literally couldn't do anything without prompting. And now the same student is walking in, doing all of the routines, without being prompted. So much of it you can see from the change in behavior. You can see the language. I have one student who was nonverbal, now I have a student who's speaking. I have a student who you couldn't understand; they couldn't articulate. Now I have a student who's speaking clearly and I can understand what they're saying. You see the changes so drastically. I have students who did not work at all, and now they're doing five, six and seven hours straight. I have students who could not be included in modified classrooms, and now they're being included. Students who had never done gen-ed. [general education] PE who are now working out on the treadmill and doing all the weights. So I mean, it just goes on and on."

For Pamela and several other participants, the demonstrable results they have witnessed have affirmed the merits of neuroeducation. The results have also cemented for many of the educators the idea that a larger change is in order. Thus, the next finding pertains to neuroeducation as a lever for systemic change.

Paradigm Shift. In keeping with the findings about the disparity between neuroeducational approaches and the approaches often found in the greater school system, many participants discussed that neuroeducation has the capacity to profoundly and indelibly alter the way teaching and learning are viewed. Rachel explained that in her experience, teaching is rooted in a one-size-fits-all mindset. For her, that mindset was completely debunked by neuroeducation, which has given her "a light at the end of the tunnel" and transformed her ideas about education. Rachel believes that neuroeducation and NLLT have the power to drastically improve students' learning, but educators must be open to change. She conceded that learning about neuroeducation initially can be a "really tough pill to swallow" because it counters many of the strategies and practices on which educators are trained, and it requires a significant change of viewpoint. That said, Rachel believes it is a worthwhile change. Sarah posited, "Neuroeducation has supported the idea that students need to develop a conceptual understanding of things in order to really retain learning."

According to Pamela, a larger systemic paradigm shift is possible, and in order. She admitted that she often feels disempowered and discouraged because she is fighting against "a huge system at every level." Yet, she believes in the power of neuroeducation to transform education:

> For the first time students are receiving a free, appropriate public education. It really makes me question the other types of methods we've been doing since they've been in school; most since three years old in early intervention or younger. And we haven't seen much growth and now we're seeing this level of growth. It makes me question the whole paradigm of what we're doing. I can say for sure that it is due to a lack of instruction in their neurobiological learning system. I mean, we might be giving them the instruction

> but it's not – it wasn't the right kind of instruction. So it becomes to me a social justice and a civil rights issue.

This aligns with the literature, which asserts that neuroeducation has the capacity to help educators understand students' learning systems, in turn meeting their needs and fostering deeper conceptual understanding (Arwood & Kaulitz, 2007; Arwood, 2011).

Neuroeducators as Linchpins

A key premise of the study was the notion of neuroeducators as linchpins in the advancement of the neuroeducation model. They are practitioners and pioneers (Fuller & Glendening, 1985) who bridge the gap between theory and practice by brokering communication between the disciplines. Many of the research participants explained that they are working to propel the neuroeducation enterprise in their own ways. Maria said she is trying to spread the word and convince others to embrace neuroeducation. She discusses it with others "all the time" and has invited several faculty members and administrators to visit her class to observe firsthand her neuroeducation methods. Pamela said she spends significant time working with educational assistants in order to teach them neuroeducational methods. She described, "The beauty of the way I implement it in my classroom is training is done in real-time in the classroom with the students." Although she cited turnover of support staff as an added challenge, she "takes solace" in the fact that many of them go on to become certified teachers who utilize the methods in their own classrooms. She elaborated that despite her disappointment when staff leave, she reminds herself, "Well, at least they're going to have a different perspective going in. Like, maybe they'll take this forward because they've seen it work."

However, some participants shared they lack a deep-enough understanding of neuroeducation and NLLT to share it with others. Grace explained, "I think people are intrigued

by what I'm doing but I can't explain it well enough - how to implement it in their classroom." Rachel echoed this point, saying she would like to see more success in her classroom first before she is "ready to be a solid activist." Importantly, Rachel described that others must be realistic and overcome the misconception she had when she began utilizing neuroeducation-grounded approaches in her classroom. She explained that she believed neuroeducation was a "magic trick" that would solve all of her problems, including behavior issues and academic challenges. She has come to realize, "It's not like I can snap my fingers, start doing neuroeducation, and everything's better." For Sarah, who acknowledged that she feels insecure about implementing neuroeducation, change is incremental.

In keeping with the research, educators may not possess the requisite background knowledge needed to parse research and apply findings appropriately (Hardiman et al, 2011; Sylwester, 1995). Sarah said many teachers coming in to neuroeducation lack the baseline knowledge and experience with neuroscience or cognitive psychology. She elaborated that educators need "enough content knowledge in all the different fields" in order to connect them. According to Sarah, "Your traditional educator in the United States – not that they're not capable – they just don't have that content knowledge in order to know what to do with all these disparate bits of information."

Rachel said neuroeducational practices will only be sustained if educators understand the theory and meaning behind the practices; simply coopting its methods will not suffice. For example, she highlighted teachers who latch onto the idea that *phonics are bad and picture dictionaries are good*, without knowing the theoretical underpinnings that support the idea:

> If you understand the reasoning and theory behind [neuroeducation], you'll probably care a whole lot more and you'll probably do it for longer. And it'll probably help you

> through the struggles, because there are struggles with implementing it. If you don't believe in it, you're just going to give up early.

Conversely, Pamela asserted that it is more important for people to jump in feet-first and begin implementing methods, even if they are less than solid in the theory: "If you were open, I don't think you have to have all the background knowledge. You just have to be open." She explained that educators should embrace the practical aspects of neuroeducation, even if they struggle with the theoretical aspects. That said, Pamela does not negate the importance of the theoretical underpinnings: "You do have to understand some theory to be able to respond to the learner and work off what they need. That takes time."

An important consideration is that learning requires layering and refinement (Arwood, 2011), and this is true for adults learning about neuroeducation. This research study underscores the idea that educators need ongoing professional development, workshops, and opportunities to build upon their knowledge and understanding of neuroeducation. Just as students require layering and refinement of thinking in order to achieve higher-level conceptual learning, so too adults who are seeking to adopt and implement neuroeducation in the classroom.

Implications

This study illuminated findings that, with hope, will inform the teaching profession and the neuroeducation enterprise. It shed light on the promise of neuroeducation, as well as the pitfalls, by focusing on those directly involved in implementation. This study also investigated the ways in which neuroeducators apply and assess neuroeducation-grounded approaches in the classroom. This has practical implications for education. Educators who are interested in understanding neuroeducational theory and utilizing visual methods will benefit from a realistic comprehension of the benefits and the challenges of implementation. Knowing the what and the

why of neuroeducation is essential for propelling it forward. This includes understanding how students' learning systems work and recognizing how to utilize visual methods. Neuroeducators also must understand the challenges of bridging theory and practice, and come to terms with their role as linchpins in the success and longevity of neuroeducation. Furthermore, the literature underscores the need for evidence-based research to inform instructional practices. Studies such as this substantiate the role of language function and highlight neuroeducation as a meritorious framework, in effect adding to a body of research that can serve the education profession well.

The advancement of this particular neuroeducation model and the future trajectories of education would be well served by a consideration for the instrumental role of language in thinking and learning processes. If language function indeed is the missing piece of the puzzle, as one participant postulated, perhaps the education system should focus its efforts on understanding neuroeducation and language theory as a way to ameliorate issues found in schools today. Most importantly, if there is in fact a cultural mismatch between students' learning systems and the prevalent approaches to teaching and learning found in schools, then a paradigm shift is in order. This means moving away from the skills-oriented, parts-to-whole orientation of education, toward a more comprehensive, integrative, whole-to-parts orientation (Templeton, 1991). Language may be the key factor to students' success, both in an academic sense and a social sense.

Another implication of this research study pertains to changing teachers' practices, which takes time and ongoing support (Hall & Hord, 2001; Tunks & Weller, 2009). In regard to adoption and diffusion of an innovation or practice, a successful course of change entails people changing their patterns of behavior, as well as restructuring key beliefs about themselves and their abilities (Prochaska & Di Clemente, 1982). Thus, there is a link between adoption of an

innovation and self-efficacy, and this study further supports that assertion. According to research, there often is a lag in teachers' efficacy beliefs as they attempt to put a new method into practice (Stein & Wang, 1988; Tschannen-Moran et al., 1998). Notably, while self-efficacy was a recurring theme in this research, many participants were new to the teaching profession and new to neuroeducation. As such, careful extrapolation is in order. It is inherently difficult to decouple general new-teacher doubts from the educators' specific doubts about neuroeducation implementation.

According to Tunks and Weller (2009), implementation of an innovation increases significantly when accompanied by continuing, regular support. This dovetails with Arwood and Young's (2000) assertion that conceptual development occurs through layering and scaffolding. As meaning is added to past integrated patterns, a person acquires more depth of understanding. Therefore, just as students undergo a non-linear, recursive process of learning, so too do adults who are engaging in neuroeducation discovery and diffusion. For the novices included in this study, coursework in neuroeducation likely will not be sufficient or exhaustive. Ongoing professional development, workshops, and support are necessary in order to foster refinement of thinking and deeper conceptual understanding of neuroeducation. Adoption of an innovation is an important first step, but sustainment and diffusion necessitate continual layering and, likely, increased teacher self-efficacy.

Future Research

There are three potential areas of future research, based on the findings from this study. The first pertains to the articulation and dissemination of neuroeducational tenets. The second relates to an exploration of teacher isolation using a different lens. The final future direction for research is in regard to the pedagogical and andragogical aspects of neuroeducation.

Articulating and Disseminating the Tenets of Neuroeducation. Neuroeducation programs, especially those that include a focus on language function as a mediating factor, are relatively scarce. For educators who wish to understand and utilize neuroeducational approaches, but who lack access to a neuroeducation program or neuroeducation-centered professional development, delineating the hallmarks would be beneficial. While a key premise within the literature is that neuroscience cannot be prescriptive, and similarly neuroeducation cannot be distilled to a set of strategies or a blueprint for implementation, there may be merit in defining its key tenets. This would necessitate further unpacking and synthesizing the research, articulating the theoretical aspects, and sharing the visual methods that have been shown to tap into students' learning systems. Doing so would prove useful for educators who wish to embed neuroeducation into their pedagogy. Though not a silver bullet, neuroeducation has the capacity to profoundly impact the educational system.

Studying Teacher Isolation with a New Lens. An unexpected finding pertained to teachers' feelings of isolation because they were perceived to be *going against the grain*. While literature on teacher isolation abounds, most focus on isolation in the context of new teachers, rural schools, and general school insularity. Similarly, there is significant research on teachers' beliefs and theories of change, as they pertain to adoption and diffusion of an innovation or practice. However, few studies center on teacher isolation as a barrier for early adopters of an initiative. Research on this topic could serve to provide a better understanding of isolation and marginalization as they pertain to implementation and sustainment of an innovative approach such as neuroeducation. This would be an informative and useful direction for research, and would fill an existing gap in the literature.

Investigating the Andragogical Impacts of Neuroeducation. An unforeseen but telling finding arose from the research study. While neuroeducation has, to varying degrees, informed the participants' practices, it also has prompted them to reflect on their own educational experiences and learning needs. Many of the research subjects discussed how their newfound neuroeducational knowledge has illuminated their own learning systems; this in turn likely imbues their teaching. Therefore, it would seem that neuroeducation has both pedagogical and andragogical impacts. While there is a dearth of literature on the pedagogical implications of language-based neuroeducation approach, there are even fewer studies that pertain to the andragogical implications. An investigation of neuroeducation's impact on adult learning would be a fruitful area of future research.

Conclusion

As someone who intentionally sought out and completed a language-based neuroeducation program, I clearly am a proponent of its merits. However, despite my exposure to a bevy of coursework and theory, I kept returning to one question: "How does this play out in the school setting?" I was eager to discover firsthand how those on the *frontlines* incorporate neuroeducation into their pedagogy, and how they bridged theory with practice. I wished to understand how they utilize drawing and hand-over-hand writing in real time with their students, and to gain a sense of whether neuroeducation has infiltrated the greater school system. It was meaningful to learn from those who have implemented neuroeducation in their classrooms. This study afforded me the opportunity to understand the participants' honest assessments of both the promise and the pitfalls of neuroeducation. The chance to hear and share the personal stories of these five educators in effect refined my own thinking about neuroeducation. Ultimately, this

dissertation process has made me even more resolute to move forward with neuroeducation in my own capacity.

Moreover, because my career entails working closely with preservice educators, I have endeavored to find ways to synthesize the key facets of neuroeducation and share them with teachers entering the field. Though I am a step removed from the K-12 classroom, the educators I am helping to prepare will have a direct impact on students. So I feel a great sense of responsibility to ensure that new teachers are armed with the knowledge, theory, and keen understanding of how to best meet students' needs.

In order to advance neuroeducation, a paradigm shift is in order. The educational system must move beyond insularity and isolation. If teachers implementing cutting-edge, effective neuroeducation-grounded approaches are relegated to their own classrooms, with no opportunities to share their methods with colleagues or engage in further development, neuroeducation will not permeate the greater school system; it will not flourish. Change is difficult, but it is worthwhile. Neuroeducation is a holistic model with the capability to profoundly impact teaching and learning, but a wider audience and more neuroeducators – those key *linchpins* – are needed to propel it. Teachers' practices should be informed by current neuroeducation research and theory; this will further legitimize the profession and, more importantly, it will serve students well.

References

Ablin, J. L. (2008). Learning as problem design versus problem solving: Making the connection between cognitive neuroscience research and educational practice. *Mind, Brain, and Education, 2*(2), 52-54.

Alferink, L. A. & Farmer-Dougan, V. (2010). Brain-(not) based education: Dangers of misunderstanding and misapplication of neuroscience research. *Exceptionality, 18*, 42-52.

American Psychological Association. (2016). *Research in brain function and learning*. Washington, DC: Semrud-Clikeman, M.

Anderson, J. R. (2015). *Cognitive psychology and its implications*. (8th ed.). New York, NY: Worth Publishers.

Ansari, D. & Coch, D. (2006). Bridges over troubled waters: Education and cognitive neuroscience. *Trends in Cognitive Sciences, 10*(4), 146-151.

Ansari, D., Coch, D., & De Smedt, B. (2011). Connecting education and cognitive neuroscience: Where will the journey take us? *Educational Philosophy and Theory, 43*(1), 37-42.

Ansari, D., De Smedt, B., & Grabner, R. H. (2012). Neuroeducation – A critical overview of an emerging field. *Neuroethics, 5*(2), 105-117.

Arnold, C. (2016). Lack of evidence plagues neuroeducation programs. *Nova Next*. Retrieved from http://www.pbs.org/wgbh/nova/next/body/neuroeducation/

Arwood, E., & Kaulitz, C. (2007). *Learning with a visual brain in an auditory world: Visual learning strategies for individuals with autism spectrum disorders*. Shawnee Mission, KS: AAPC.

Arwood, E. L. (2011). *Language function: An introduction to pragmatic assessment and intervention for higher order thinking and better literacy*. London, UK: Jessica Kingsley Publishers.

Arwood, E. L., Kaulitz, C., & Brown, M. (2009). *Visual thinking strategies for individuals with autism spectrum disorders: The language of pictures*. Shawnee Mission, KS: Autism Asperger Publishing Co.

Baars, B. J., & Gage, N. M. (2010). *Cognition, brain, and consciousness: Introduction to cognitive neuroscience*. (2nd ed.). Burlington, MA: Academic Press.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84,* 191-215.

Battro, A. M., Fischer, K. W., & Léna, P. J. (Eds.). (2008). *The educated brain: Essays in neuroeducation*. New York, NY: Cambridge University Press.

Beauchamp, C., & Beauchamp, M. H. (2013). Boundary as bridge: An analysis of the educational neuroscience literature from a boundary perspective. *Educational Psychology Review, 25*(1), 47-67.

Blakemore, S., & Frith, U. (2005). The learning brain: Lessons for education. *Developmental Science, 8*(6), 459-471.

Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher,* 26(8), 4 16.

Bruer, J. T. (2008). Building bridges in neuroeducation. In A. M. Battro, K. W. Fischer, & P. J. Léna (Eds.), *The educated brain: Essays in neuroeducation* (pp. 43-58). Cambridge: Cambridge University Press.

Byrnes, J. B. (2001). *Minds, brains, and learning: Understanding the psychological and educational relevance of neuroscientific research*. New York, NY: The Guilford Press.

Carew, T. J., & Magsamen, S. H. (2010). Neuroscience and education: An ideal partnership for producing evidence-based solutions to guide 21st century learning. *Neuron, 67*, 685-688.

Cheng, T. (2016, January). Same word, different meanings: Common miscommunications between neuroscience and society [Web log post]. Retrieved from https://www.learningandthebrain.com/blog/2016/01/

Christodolou, J. A., & Gaab, N. (2009). Using and misusing neuroscience in education-related research. *Cortex, 45*, 555-557.

Clandinin, D. J., & Connelly, F. M. (2000). *Narrative inquiry: Experience and story in qualitative research*. San Francisco, CA: Jossey-Bass.

Costandi, M. (2015, December 15). Combating neurohype [Web log post]. Retrieved from http://www.theneuroethicsblog.com/2015/12/combating-neurohype.html.

Creswell, C.W. (2007). *Qualitative inquiry & research design: Choosing among five approaches.* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

Creswell, C. W. (2014) *Research design: Qualitative, quantitative, and mixed methods approaches*. (4th ed.). Thousand Oaks, CA: SAGE Publications.

Davidson, J., & Dwyer, R. (2014). The role of professional learning in reducing isolation experienced by classroom music teachers. *Australian Journal of Music Education, 1*, 38-51.

Dekker, S., Lee, N. C., Howard-Jones, P., & Jolles, J. (2012). Neuromyths in education: Prevalence and predictors of misconceptions among teachers. *Frontiers in Psychology, 3*(429), 1-8.

Devonshire, I. M., & Dommett, E. J. (2010). Neuroscience: Viable applications in education? *The Neuroscientist, 16*(4), 349-356.

Edelenbosch, R., Kupper, F., Krabbendam, L., & Broerse, J. E. W. (2015). Brain-based learning and educational neuroscience: Boundary work. *Mind, Brain, and Education, 9*(1), 40-49.

Ferrari, M. (2011). What can neuroscience bring to education? *Educational philosophy and Theory, 43*(1), 31-36.

Ferrari, M. & McBride, H. (2011). Mind, Brain, and Education: The birth of a new science. *Learning Landscapes, 5*(1), 85-100.

Fischer, K. W. (2008). Dynamic cycles of cognitive and brain development: Measuring growth in mind, brain, and education. In A. M. Battro, K. W. Fischer, & P. J. Léna (Eds.), *The educated brain: Essays in neuroeducation* (pp. 127-150). Cambridge, UK: Cambridge University Press.

Fischer, K. W. (2009). Mind, brain, and education: Building a scientific groundwork for learning and teaching. *Mind, Brain, and Education, 3*(1), 3-16.

Fischer, K. W., & Bidell, T. R. (2006). Dynamic development of action, thought, and emotion. In W. Damon & R. M. Lerner (Eds.), *Theoretical models of human development. Handbook of child psychology* (6th ed., Vol. 1, pp. 313-399). New York: Wiley.

Frank, M. J., & Badre, D. (2015). How cognitive theory guides neuroscience. *Cognition, 135*, 14-20.

Frith, C. D., & Frith, U. (2012). Mechanisms of social cognition. *Annual Review of Psychology, 63*, 287-313.

Frith, U. (2013). Neuroscience: Implications for education and lifelong learning. *Integrating Science and Practice, 3*(1), 6-10.

Fuller, J. K., & Glendening, J. G. (1985). The neuroeducator: Professional of the future. *Theory into practice, 24*(2), 135-137.

Galinsky, E. (2010). *Mind in the making: The seven essential life skills every child needs*. New York, NY: HarperCollins Publishers.

García Carrasco, J., Hernández Serrano, M. J., & Martín Garcia, A. V. (2015). Plasticity as a framing concept enabling transdisciplinary understanding and research in neuroscience and education. *Learning Media and Technology, 40*(2), 152-167.

Gardner, H. (2008). Quandaries for neuroeducators. *Mind, Brain, and Education, 2*(4) 165-169.

Gazzaniga, M. S. (2011). *Who's in charge? Free will and the science of the brain*. New York, NY: HarperCollins Publishers.

Geake, J., & Cooper, P. (2003). Cognitive neuroscience: Implications for education. *Westminster Studies in Education, 26*(1), 7-20.

Geake, J. (2008). Neuromythologies in education. *Educational Research, 50*(2), 123-133.

Georgetown University, Department of Neuroscience. (2017). *What is neuroscience?* Retrieved from https://neuro.georgetown.edu/about-neuroscience

Giedd, J. (2014). Effective classroom applications for neuroscience research. In *Neuroscience and education symposium report* (pp. 16-38). Retrieved from http://www.potomacinstitute.org/images/stories/publications/2014-09 17AAASEducationReport.pdf

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Goswami, U. (2006). Neuroscience and education: From research to practice? *Nature Reviews Neuroscience, 7*, 406-413.

Goswami, U. (2008). Principles of learning, implications for teaching: A cognitive neuroscience perspective. *Journal of Philosophy of Education, 42*(3-4), 382-399.

Greene, M. (1995). *Releasing the imagination: Essays on education, the arts, and social change*. San Francisco, CA: Jossey-Bass.

Guest, G., Namey, E. E., & Mitchell, M. A. (2013). *Collecting qualitative data: A field manual for applied research*. Los Angeles, CA: SAGE Publications.

Guy, R., & Byrne, B. (2013). Neuroscience and learning: Implications for teaching practice. *Journal of Experimental Neuroscience, 7*, 39-42.

Hall, G., & Hord, S. (2001). *Implementing change: Patterns, principles and potholes*. Boston, MA: Allyn and Bacon.

Halliday, M. A. K. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5*, 93-116.

Hardiman, M., Rinne, L., Gregory, E., & Yarmolinskaya, J. (2011). Neuroethics, neuroeducation, and classroom teaching: Where the brain sciences meet pedagogy. *Neuroethics, 5*(2), 1-9.

Hardiman, M. (2012). *The brain-targeted teaching model for 21st-century classrooms*. Corwin Press: Thousand Oaks, CA.

Hardiman, M. (2014). Why neuroeducation matters: How the science of learning influences education practices. In *Neuroscience and education symposium report* (pp. 38-48). Retrieved from http://www.potomacinstitute.org/images/stories/publications/2014-09 17AAASEducationReport.pdf

Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of Educational Psychology, 105*(3), 774-786.

Hook, C. J., & Farah, M. J. (2012). Neuroscience for educators: What are they seeking, and what are they finding? *Neuroethics, 6*(2), 331-341.

Horvath, J. C., & Donoghue, G. (2015, September 7). *So much talk about 'the brain' in education is meaningless*. Retrieved from http://theconversation.com/so-much-talk-about-the-brain in-education-is-meaningless 47102

Horvath, J. C., & Donoghue, G. M. (2016). A bridge too far – revisited: Reframing Bruer's neuroeducation argument for modern science of learning practitioners. *Frontiers in Psychology, 7*(377), 1-12.

Howard-Jones, P. (2014). Neuroscience and education: Myths and messages. *Nature Reviews Neuroscience, 15*, 817-824.

Ileris, K. (Ed.). (2009). *Contemporary theories of learning: Learning theorists…in their own words*. London, UK: Routledge.

Immordino-Yang, M. H., & Damasio, A. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. *Mind, Brain, and Education, 1*(1), 3-10.

Immordino-Yang, M. H. (2011). Implications of affective and social neuroscience for educational theory. *Educational Philosophy and Theory, 43*(1), 98-103.

Immordino-Yang, M. H. (2015, May 13). *What cultural differences can reveal about the way we learn/Interviewer: K. Sukel*. GOOD. Retrieved from https://www.good.is/articles/cultural-literacy

Katzir, T., & Pare-Blagoev, J. (2006). Applying cognitive neuroscience research to education: The case of literacy. *Educational Psychologist, 41*(1), 53-74.

Kelly, A. E. (2011). Can cognitive neuroscience ground a science of learning? *Educational Philosophy and Theory*, *43*(1), 17-22.

Kohn, A. (1993). *Punished by rewards: The trouble with gold stars, incentive plans, A's, praise, and other bribes*. Boston, MA: Houghton Mifflin.

Kosaruju, S., Gorman, M. A., & Berry, K. (2014). Conceptualizing the NET: The Neuroeducation Translational (NET) Research Model: A framework for neuroscience research to special education practice. *Journal of Interdisciplinary Studies in Education, 2*(2), 38-49.

Kuhl, P. K. (2011). Early language learning and literacy: Neuroscience implications for education. *Mind, Brain, and Education, 5*(3), 128-142.

Lalancette, H., & Campbell, S. R. (2012). Educational neuroscience: Neuroethical considerations. *International Journal of Environmental and Science Education, 7*(1), 37-52.

L'Ecuyer, C. (2014). The wonder approach to learning. *Frontiers in Human Neuroscience, 8*(764), 1-8.

Limb, C. (2010). Why neuroeducation? *New Horizons for Learning, VIII*(1).

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago, IL: University of Chicago Press.

Mason, L. (2009). Bridging neuroscience and education: A two-way path is possible. *Cortex, 45*(4), 548-549.

Masson, S., & Brault Foisy, L. (2012). Fundamental concepts bridging education and the brain. *McGill Journal of Education, 49*(2) 501-512.

Masson, S. (2014). The brain, learning, and teaching. *Education Canada, 54*(4), 48-50.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach* (2nd ed.). Thousand Oaks, CA: Sage.

McEwen, B. S. (2011). Effects of stress on the developing brain. The Dana Foundation. Retrieved from http://www.dana.org/Publications/ReportDetails.aspx?id=44373

McGrath, V. (2009). Reviewing the evidence on how adult students learn: An examination of Knowles' model of andragogy. *Adult Learner: The Irish Journal of Adult and Community Education*, 99-110.

McQuat, R. C. (2007). An investigation of agency and marginality in special education. *International Journal of Special Education, 22*(3), 37-43.

Mercer, N. (2013). The social brain, language, and goal-directed collective thinking: A social conception of cognition and its implications for understanding how we think, teach, and learn. *Educational Psychologist, 48*(3), 148-168.

Merriam, S.B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. (2nd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook.* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Miller, R. (2016). Neuroeducation: Integrating brain-based psychoeducation into clinical practice. *Journal of Mental Health Counseling, 38*(2), 103-115.

Minshew, N. J., & Williams, D. L. (2007). Brain-behavior connections in autism. In K. D. Buron & P. Wolfberg (Eds.), *Learners on the autism spectrum: Preparing highly qualified educators* (pp. 45-66). Shawnee Mission, KS: Autism Asperger Publishing Co.

Mittelstrass, J. (2008). Mind, brain, and consciousness. In A. M. Battro, K. W. Fischer, & P. J. Léna (Eds.), *The educated brain: Essays in neuroeducation* (pp. 127-150). Cambridge, UK: Cambridge University Press.

Nelson, C. A. (2012). The effects of early life adversity on brain and behavioral development. The Dana Foundation. Retrieved from http://www.dana.org/Publications/ReportOnProgress/The_effects_of_early_life_adversity_on_brain_and_behavioral_development/

O'Connor, C., Rees, G., & Joffe, H. (2012). Neuroscience in the public sphere. *Neuron, 74*, 220-226.

Organisation for Economic Co-Operation and Development. (2007). *Understanding the brain: The birth of a learning science.* Paris, France.

Pasquinelli, E. (2012). Neuromyths: Why do they exist and persist? *Mind, Brain, and Education, 6*(2), 89-96.

Petitto, L. (2008). Cortical images of early language and phonetic development using Near Infrared Spectroscopy. In K. Fisher, A. Battro, & P. J. Léna (Eds.), *The educated brain: Essays in neuroeducation* (pp. 213-232). Cambridge, UK: Cambridge University Press.

Petitto, L. (2014). Effective classroom applications for neuroscience research. In *Neuroscience and education symposium report* (pp. 16-38). Retrieved from http://www.potomacinstitute.org/images/stories/publications/2014-09 17AAASEducationReport.pdf

Prochaska, J. O., & Di Clemente, C. C. (1982). Transtheoretical therapy: Toward a more integrative model of change. *Psychotherapy: Theory, Research and Practice, 19*(3), 276-288.

Purdy, N. (2008). Neuroscience and education: How best to filter out the neurononsense from our classrooms? *Irish Educational Studies, 27*(3), 197-208.

Rose, H., & Rose, S. (2016). The false promise of neuroeducation. *TES: Times Educational Supplement*, 5203, 28-34.

Salomon, G. (Ed.). (1993). *Distributed cognitions: Psychological and educational considerations*. New York, NY: Cambridge University Press.

Samuels, B. M. (2009). Can the differences between education and neuroscience be overcome by Mind, Brain, and Education? *Mind, Brain, and Education, 3*(1), 45-54.

Schenck, J., & Cruickshank, J. (2015). Evolving Kolb: Experiential education in the age of neuroscience. *Journal of Experiential Education, 38*(1), 73-95.

Schmeck, A., Mayer, R. E., Opfermann, M., Pfeiffer, V., & Leutner, D. (2014). Drawing pictures during learning from scientific text: Testing the generative drawing effect and the prognostic drawing effect. *Contemporary Educational Psychology, 39*, 275-286.

Schrag, F. (2013). Can this marriage be saved? The future of 'neuro-education.' *Journal of Philosophy of Education*, 47(1), 20-30.

Serpati, L., & Loughan, A. R. (2012) Teacher perceptions of neuroeducation: A mixed methods survey of teachers in the United States. *Mind, Brain, and Education, 6*(3), 174-176.

Sherman, C. (2013). Connectivity – A primer. The Dana Foundation. Retrieved from http://www.dana.org/Publications/Primers/Connectivity%E2%80%94A_Primer/

Siegel, D. J. (2003). An interpersonal neurobiology of psychotherapy: The developing mind and the resolution of trauma. In M. Solomon & D. J. Siegel (Eds.), *Healing trauma: Attachment, mind, body, and brain* (pp. 1–56). New York: W. W. Norton & Company.

Smeyers, P. (2016). Neurophilia: Guiding educational research and the educational field? *Journal of Philosophy of Education, 50*(1), 62-75.

Sousa, D. (2011). Mind, brain, and education: The impact of educational neuroscience on the science of teaching. *Learning Landscapes, 5*(1), 37-43.

Stein, M. K., & Wang, M. C. (1988). Teacher development and school improvement: The process of teacher change. *Teaching and Teacher Education, 4*(2), 171-187.

Stringer, S., & Tommerdahl, J. (2015). Building bridges between neuroscience, cognition, and education with predictive modeling. *Mind, Brain, and Education, 9*(2), 121-126.

Sylwester, R. (1995). *A celebration of neurons: An educator's guide to the human brain*. Alexandria, VA: ASCD.

Tardif, E., Doudin, P. A., & Meylan, N. (2015). Neuromyths among teachers and student teachers. *Mind, Brain, and Education, 9*(1), 50-60.

Templeton, S. (1991). New trends in historical perspective: The "what" and "why" of skills instruction in literacy. Language Arts, 68, 590-595.

Tokuhama-Espinosa, T. N. (2008). *The scientifically substantiated art of teaching: A study in the development of standards in the new academic field of neuroeducation* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3310716)

Tokuhama-Espinosa, T. N. (2010). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching*. New York, NY: W. W. Norton & Company, Inc.

Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tommerdahl, J. (2010). A model for bridging the gap between neuroscience and education. *Oxford Review of Education, 36*(1), 97-109.

Tschannen-Moran, M., Woolfolk Hoy, A. & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*, 202 - 248.

Tunks, J., & Weller, K. (2009). Changing practice, changing minds, from arithmetical to algebraic thinking: An application of the concerns-based adoption model (CBAM). *Educational Studies in Mathematics, 72*, 161-183.

Turner, K. M. T., Nicholson, J. M., & Sanders, M. R. (2011). The role of practitioner self-efficacy, training, program, and workplace factors on the implementation of an evidence based parenting intervention in primary care. *Journal of Primary Prevention, 32*(2), 95 112.

Varma, S. (2016, September 14). *Lack of evidence plagues neuroeducation programs/Interviewer: C. Arnold.* NOVA Next. Retrieved from http://www.pbs.org/wgbh/nova/next/body/neuroeducation/

Varma, S., McCandliss, B. D., & Schwartz, D. L. (2008). Scientific and pragmatic challenges for bridging education and neuroscience. *Educational Researcher, 37*(3), 140-152.

Vernon, M. (1967). Relationship of language to the thinking process. *Archives of General Psychiatry, 16*(3), 325-333.

Vygotsky, L. S. (2012). *Thought and language*. (Rev. ed.). Cambridge, MA: The MIT Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Whorf, B. (2012). *Language, thought, and reality*. (2nd ed.). J. B. Carroll, S. C. Levinson, & P. Lee (Eds.). Cambridge, MA: The MIT Press.

Willingham, D. T. (2009). Three problems in the marriage of neuroscience and education. *Cortex, 45*, 544-545.

Wolfe, P. (1998) Revisiting effective teaching. *Educational Leadership, 56*(3), 61-64.

Worden, J. M., Hinton, C., & Fischer, K. W. (2011). What does the brain have to do with learning? *Phi Delta Kappan, 92*(8), 8-13.

Appendix A: Pre-Interview Protocol

Demographic Information

1) Including the current academic year, how many years of experience do you have in the teaching profession?

2) What is your current educational position? Which grade levels and subjects do you currently teach?

3) In which UP neuroeducation program are you enrolled, or have you already completed?

4) Have you had additional teacher preparation or professional development centered on neuroeducation or "brain-based learning" apart from your UP coursework? If so, please explain.

Short Answer Questions

1) Why did you choose to pursue neuroeducation, and what did you hope to get from the program?

2) Can you provide examples of former practices you utilized or beliefs you held (e.g. neuromyths) that have changed as a result of your neuroeducation program?

3) Can you describe specific practices you use in the classroom that are based on neuroeducation?

4) How do you measure the effectiveness of your neuroeducation-based practices? In other words, how do you know whether they work?

5) What do you view as benefits of neuroeducation?

6) What do you perceive as the barriers to implementing neuroeducation in the school setting?

7) To what extent do educators need to know HOW learning occurs in the brain? In other words, do they need an understanding of the brain mechanisms (functions, structures) that underlie learning? If so, why?

8) Do you see common practices in the school setting that are potentially based on misinformation or neuromyths? Conversely, are there common practices you see among colleagues that are supported by current brain research? Please explain.

Appendix B: Field Notes Protocol

(Adapted from Portland State University's Classroom Observational Protocol)

Date: _____ Time: _____ Length of Observation: Start time: _____ End time: _____ School: _____ Teacher: _____ Number of Students: _____
Topic of Lesson:

Descriptive Notes:	Reflective Notes:
Physical Setting/Visual Layout	Reflective Comments (e.g., questions to self, observations of nonverbal behavior, my interpretations)

Description of Resources/Activities Used: Description of Teacher Actions: Description of Formative Assessments Used: Specific Quotes: Neuroeducation-Grounded Approaches Used (Highlighted in Advance by Participants):	Reflective Comments (e.g., questions to self, observations of nonverbal behavior, my interpretations

Appendix C: Participant Consent Form

You are invited to participate in a research study conducted by Stephanie Murphy, from the UNIVERSITY OF PORTLAND, School of Education. I hope to learn how educators apply and assess neuroeducation-based practices in the classroom setting. You were selected as a possible participant in this study because you have completed, or are nearing completion of, a neuroeducation program and thus have baseline knowledge and understanding of neuroeducation as a grounding for instructional practices.

If you decide to participate, there are three phases of data collection, all of which will be conducted between October and December, 2016. First, I will conduct a one-hour pre-interview to gather demographic, biographical, and contextual information, as well as glean your perceptions about the merits and challenges of implementing neuroeducation in the classroom. Then I will conduct a half-day observation of your classroom, guided by your responses from the pre-interview, at the time of your choosing. Immediately after the observation (likely at the end of the school day if convenient) I will conduct a 30-minute post-interview to debrief and ask clarifying questions. Each of the three phases of the study will be audio recorded for accuracy.

There are no risks to you if you participate in the study. Your participation will benefit the University of Portland's neuroeducation program and further the neuroeducation enterprise, by shedding light on the promise and pitfalls of neuroeducation as a grounding for instructional practices. However, I cannot guarantee that you personally will receive any benefits from this research.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Subject identities will be kept confidential by omitting your name and identifying information from the data analysis process, and referring to you by pseudonym in the research study. Data will be kept on a password- and firewall-protected computer, and hard copies of paperwork and audio recordings will be secured in a locked safe box.

Your participation is voluntary. Your decision whether or not to participate will not affect your relationship with the UNIVERSITY OF PORTLAND, School of Education. If you decide to participate, you are free to withdraw your consent and discontinue participation at any time without penalty.

If you have any questions about the study, please feel free to contact Stephanie Murphy, researcher, at 858-344-3260 or murphste17@up.edu. If you have questions regarding your rights as a research subject, please contact the IRB (IRB@up.edu). You will be offered a copy of this form to keep.

Your signature indicates that you have read and understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation without penalty, that you will receive a copy of this form, and that you are not waiving any legal claims.

Printed Name

Signature

Date

School of Employment

Appendix D: University of Portland IRB Approval Form

Memorandum

To: Stephanie Murphy
From: Lauretta Frederking, Ph.D.
Date: October 10, 2016

RE: IRB Approval of University of Portland Project # 2016183

Dear Stephanie Murphy:

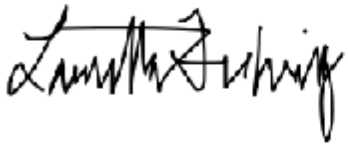
On behalf of the University of Portland's federally registered Institutional Review Board (IRB00006544), a member of the committee has reviewed your research proposal, titled "Promise/Pitfalls of Neuroeducation as a Grounding for Instructional Practices." The IRB concludes that the project satisfies all IRB-related issues involving human subjects research under the "Expedited" classification. A printout of this memorandum should serve as written authorization from IRB to proceed with your research.

The expiration date for this approval is 10/9/2017. If the study is expected to go beyond that date, you must submit a Continued Review Form (located on the IRB website) for continuing review. I recommend that this form be submitted to the IRB at least 30 days prior to the expiration date.

Please note that you are required to abide by all requirements as outlined by the IRB Committee.

A copy of this memorandum, along with your Request for Review and its documentation, will be stored in the IRB Committee files for three years from the completion of your project, as mandated by federal law. Thank you, and good luck with your project.

Yours truly,



Lauretta Frederking, Ph.D.
Associate Provost
Chair, Institutional Review Board
Professor of Political Science