MYTH TO REALITY?

THE PEDAGOGICAL CONNECTION BETWEEN NEUROMYTHS AND
CLASSROOM INSTRUCTION

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ABSTRACT

Previous research indicates that teachers across cultures believe neuromyths, or common misconceptions about brain structure or function. Although cautionary warnings exist about the potential relationship between teachers’ beliefs in neuromyths and his or her instructional practices, there is a dearth of research in this area. This study set out to determine whether there was a relationship between teachers’ beliefs in neuromyths and teachers’ instructional practices related to or rooted in neuromyths. A survey was created that measured teachers’ beliefs in neuromyths, teaching efficacy, neuroscience literacy, and instructional practices related to neuromyths. The survey was piloted with 43 teachers from two schools and 15 teachers participated in two cognitive interviewing focus groups to determine the face validity of the instrument. The survey was adjusted based on that feedback and sent out to a representative sample of 4,519 teachers in Pennsylvania, of which 118 completed the survey.

The results of the survey were analyzed using descriptive and inferential statistics. Both personal teaching efficacy and beliefs in neuromyths had statistically significant relationships with instructional practices related to neuromyths. A linear hierarchical regression model was created that accounted for 27 percent of the variance in instructional practices related to neuromyths. Over and above the control variables, beliefs in neuromyths and personal teaching efficacy accounted for an additional 15.4 percent of the variance in instructional practices related to neuromyths. Personal teaching efficacy accounted for more of the variance in instructional practices related to neuromyths than any of the other variables included in this study.
The results provide support for the goals of neuroeducation, especially in equipping highly-efficacious teachers with tools rooted in findings from the brain sciences instead of those rooted in neuromyths. Implications for future research are included with a focus on how the survey instrument should be adapted for use in the future. The findings also have some implications for practice including a re-thinking of teacher preparation program requirements and the design of professional development for teachers.

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Dedication

To my mother.

To my Sawyer.

To my husband.

All for you three, always.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ONE: OVERVIEW OF THE STUDY</strong></td>
<td>1</td>
</tr>
<tr>
<td>Introduction and Background</td>
<td>1</td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>3</td>
</tr>
<tr>
<td>Purpose</td>
<td>4</td>
</tr>
<tr>
<td>Limitations</td>
<td>4</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>5</td>
</tr>
<tr>
<td>Research Questions</td>
<td>6</td>
</tr>
<tr>
<td>Pilot Questions</td>
<td>6</td>
</tr>
<tr>
<td>Final Survey Administration Questions</td>
<td>6</td>
</tr>
<tr>
<td><strong>TWO: REVIEW OF THE LITERATURE</strong></td>
<td>7</td>
</tr>
<tr>
<td>Introduction</td>
<td>7</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>7</td>
</tr>
<tr>
<td>Social Cognitive Theory</td>
<td>8</td>
</tr>
<tr>
<td>Self-Efficacy Theory</td>
<td>9</td>
</tr>
<tr>
<td>Expectancy Theory</td>
<td>11</td>
</tr>
<tr>
<td>Teacher Efficacy Theory</td>
<td>13</td>
</tr>
<tr>
<td>Neuromyths Research</td>
<td>15</td>
</tr>
<tr>
<td>Roots of Neuromyths</td>
<td>15</td>
</tr>
<tr>
<td>Neuromyths and Instructional Practices</td>
<td>19</td>
</tr>
<tr>
<td>Teacher Efficacy Beliefs and Instructional Practices</td>
<td>25</td>
</tr>
<tr>
<td>Seminal studies of Teacher Efficacy and Instructional Practices</td>
<td>26</td>
</tr>
<tr>
<td>Recent research on Teacher Efficacy and Instructional Practices</td>
<td>27</td>
</tr>
<tr>
<td>Included Neuromyths</td>
<td>31</td>
</tr>
<tr>
<td>Neuromyth 1: Hemispheric Dominance</td>
<td>32</td>
</tr>
<tr>
<td>Neuromyth 1 Definition</td>
<td>32</td>
</tr>
<tr>
<td>Neuromyth 2 Origins and Implications</td>
<td>32</td>
</tr>
<tr>
<td>Neuromyth 2: Learning Styles</td>
<td>33</td>
</tr>
<tr>
<td>Neuromyth 2 Definition</td>
<td>33</td>
</tr>
<tr>
<td>Neuromyth 2 Origins and Implications</td>
<td>34</td>
</tr>
<tr>
<td>Neuromyth 3: Enriched Environments</td>
<td>34</td>
</tr>
<tr>
<td>Neuromyth 3 Definition</td>
<td>34</td>
</tr>
<tr>
<td>Neuromyth 3 Origins and Implications</td>
<td>35</td>
</tr>
<tr>
<td>Neuromyth 4: Exercise and Literacy</td>
<td>35</td>
</tr>
<tr>
<td>Neuromyth 4 Definition</td>
<td>35</td>
</tr>
<tr>
<td>Neuromyth 4 Origins and Implications</td>
<td>36</td>
</tr>
<tr>
<td>Excluded Neuromyths</td>
<td>36</td>
</tr>
<tr>
<td>Needs Assessment</td>
<td>40</td>
</tr>
<tr>
<td>Context of Study</td>
<td>40</td>
</tr>
<tr>
<td>Description of Context</td>
<td>41</td>
</tr>
</tbody>
</table>
FIVE: DISCUSSION

NEUROMYTHS AND INSTRUCTION

Internal consistency correlations..........................................................73
Instructional practices scales..............................................................73
Teacher efficacy scales ........................................................................74
Neuroscience literacy items ..................................................................76
Final Survey Administration Research Question 1 ..................................78
Descriptive Statistics .............................................................................78
Neuromyths Items ..................................................................................79
Final Survey Administration Research Question 2 ..................................81
Pearson’s Correlation .............................................................................81
Linear Regression Model ......................................................................81
Final Survey Administration Research Question 3 ..................................82
Pearson’s Correlation .............................................................................82
Final Survey Administration Research Question 4 ..................................82
Bivariate analyses ..................................................................................82
Independent-samples t-tests .................................................................82
Pearson’s correlations ..........................................................................85
ANOVA .................................................................................................86
Regression model ..................................................................................86
Summary .................................................................................................90

FIVE: DISCUSSION....................................................................................92
Purpose of Study ....................................................................................92
Methodology ..........................................................................................92
Summary of Findings .............................................................................93
Final Survey Research Question 1.........................................................93
Final Survey Research Question 2.........................................................93
Final Survey Research Question 3.........................................................94
Final Survey Research Question 4.........................................................94
Summary of Additional Findings............................................................95
Discussion ..............................................................................................96
Beliefs in Neuromyths ...........................................................................96
Beliefs in Neuromyths and Teacher Instructional Practices ..................97
Neuroscience Literacy and Instructional Practices ..............................98
Instructional Practices and Teacher Efficacy ......................................99
Exposure to Brain Sciences and Instructional Practices ......................100
Use of the Instrument ...........................................................................101
Beliefs in neuromyths subscale ...........................................................101
Neuroscience literacy subscale ..........................................................101
Teacher efficacy subscales .................................................................102
Instructional practices related to neuromyths subscale ......................102
Recommendations for Further Research .............................................103
Results from the Pilot ..........................................................................103
Results from Final Survey .................................................................104
Recommendations for Practice ............................................................106
Final Thoughts ......................................................................................106
REFERENCES .................................................................................................................................................107
Appendix A- Face Validity Survey ..............................................................................................................107
Appendix B- Needs Assessment Survey ...................................................................................................110
Appendix C- Pilot Survey Instrument ........................................................................................................115
Appendix D- Consent Form for Pilot ........................................................................................................125
Appendix E- Cognitive Interviewing Probes ............................................................................................128
Appendix F- Final Survey Instrument .....................................................................................................129
Appendix G- Pennsylvania School Category Breakdown ........................................................................138
Appendix H- Copy of Email Requesting Participation ..............................................................................139
Appendix I- Cognitive Interviewing Memo ..............................................................................................140
Appendix J- Sample Demographics Comparison ......................................................................................144
Appendix K- Literature Review Search Terms and Databases .................................................................145
Bibliography ................................................................................................................................................146
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alekno’s 10 Neuromyths</td>
<td>22</td>
</tr>
<tr>
<td>2. Reasons for Exclusion from Study</td>
<td>37</td>
</tr>
<tr>
<td>3. Face Validity Survey Results</td>
<td>39</td>
</tr>
<tr>
<td>4. Needs Assessment Population Sample Demographics</td>
<td>43</td>
</tr>
<tr>
<td>5. Teacher’s Beliefs in Neuromyths</td>
<td>44</td>
</tr>
<tr>
<td>6. Teacher’s Understandings of Neuroscience</td>
<td>46</td>
</tr>
<tr>
<td>7. Frequencies for Pilot Survey, School 1</td>
<td>53</td>
</tr>
<tr>
<td>8. Frequencies for Pilot Survey, School 2</td>
<td>54</td>
</tr>
<tr>
<td>9. Neuromyths Sample Items</td>
<td>57</td>
</tr>
<tr>
<td>10. Instructional Practices Sample Items</td>
<td>59</td>
</tr>
<tr>
<td>11. Teacher Efficacy Sample Items</td>
<td>60</td>
</tr>
<tr>
<td>12. Sample Descriptive Frequencies</td>
<td>67</td>
</tr>
<tr>
<td>13. Reliability Analysis</td>
<td>73</td>
</tr>
<tr>
<td>14. Correlations between Instructional Practices Measures</td>
<td>73</td>
</tr>
<tr>
<td>15. Correlations between Teacher Efficacy Measures</td>
<td>75</td>
</tr>
<tr>
<td>16. Correlation between Neuroscience Literacy Measures</td>
<td>77</td>
</tr>
<tr>
<td>17. Descriptive Statistics: Neuromyths</td>
<td>78</td>
</tr>
<tr>
<td>18. Correlation between Neuromyths</td>
<td>80</td>
</tr>
<tr>
<td>19. Regression Analysis</td>
<td>82</td>
</tr>
<tr>
<td>20. Independent-Samples t-Tests with Experience with Brain Sciences: Descriptives</td>
<td>83</td>
</tr>
<tr>
<td>21. Independent Samples t-Tests with Experience with Brain Sciences</td>
<td>84</td>
</tr>
</tbody>
</table>
# NEUROMYTHS AND INSTRUCTION

22. Independent Samples t-Tests with Experience with Subject Area Taught .................. 85  
23. ANOVA with School Category .................................................................................. 86  
24. Hierarchical Regression Analysis ............................................................................. 87
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hypothesized Relationship between Variables</td>
<td>30</td>
</tr>
<tr>
<td>2. Relationship between Constructs</td>
<td>100</td>
</tr>
</tbody>
</table>
CHAPTER 1: OVERVIEW

Introduction and Background

Educational literature regarding the role of the brain sciences has increased dramatically in recent years, most notably in the fields of neuroscience and cognitive psychology. While President George Bush, along with the National Institute of Mental Health and Library of Congress, lauded 1990-2000 as “the decade of the brain,” many studies since have brought forth more questions about the practical use of brain research and average citizens’ understanding of brain function and structure (Decade of the Brain Homepage; Herculano-Houzel, 2002).

From this growing and developing interest in the brain came the field of educational neuroscience. Also known as neuroeducation or mind, brain, and education, the field is both young and controversial. Since John Bruer’s iconic 1997 journal article, “A Bridge to Far,” educational neuroscience scholars and researchers have been trying to identify whether or not the bridge between the brain sciences and education is in fact, too far (Bruer, 1997). Yet despite Bruer’s (1997) call to proceed with caution, the field of educational neuroscience has moved forward, and the interest in neuroscience among those in education has expanded considerably in recent years (Ansari, DeSmedt, & Graber, 2012). Not only are there now established mind, brain, and education programs at major universities, such as Harvard University and Johns Hopkins University, but in 2004 the International Mind, Brain, and Education Society (IMBES) was founded (Ansari et al., 2012). Research in the field is currently published in the peer-reviewed journal created by IMBES entitled “Mind, Brain and Education” (Ansari et al., 2012). While those in the field of educational neuroscience are still cautious about translating the material from
neuroscience and cognitive psychology to classroom contexts, the implications of the research are rapidly developing into usable constructs and practices for instruction within brain-based education models (Dubinsky, 2000-2003; Hardiman, 2012; Jensen, 2008).

However, while interest in the brain sciences and neuroscience literacy has grown considerably, misconceptions and misapplications of hastily-applied brain research grew parallel to that interest. Specific misunderstandings and incorrect notions about the brain, either in structure or function, were isolated, identified, and labeled as neuromyths (Organisation for Economic Cooperation and Development, 2002). Particularly within the field of educational neuroscience, or mind, brain, and education, the role of neuromyths has been examined in terms of teachers’ beliefs about what affects and underlies student learning (Dekker, Lee, Howard-Jones, & Jolles, 2012). Examples of some neuromyths include the belief that humans regularly use 10 percent of their brain capacity, that there are visual, auditory, and kinesthetic learners, and that people are either “left-brained” or “right-brained” (OECD, 2012). While there is evidence that teachers do adhere to some of these neuromyths (Alekno, 2012; Dekker et al., 2012; Gleichgerrcht, Luttges, Salvareza, & Campos, 2015; Rato et al., 2013) and that neuroscience research findings can be utilized to transform instructional practice (Dommett, Devonshite, Plateau, Westwell, & Greenfield, 2010), there is currently no validated connection between teacher belief in neuromyths and teacher instructional practices. Though there is research indicating that there is a relationship between teacher beliefs and practices more generally (Allinder, 1994; Anderson, Greene, & Loewen, 1988; Aston & Webb, 1986; Gibson & Dembo, 1984; Guskey, 1988; Knapp, 2013; Stein & Wang, 1988; Youyan, Tan, Liau, Lau, & Chua, 2013), the support for that relationship
NEUROMYTHS AND INSTRUCTION

exists primarily in regard to teacher efficacy. Teacher efficacy, or a teachers’ beliefs regarding his or her teaching abilities or students’ learning abilities, is similar to neuromyths in that they involve core beliefs about students’ learning, but it still needs to be determined if a relationship exists between teacher belief in neuromyths and teacher instructional practices. Further, few studies have examined this relationship in part because no instruments exist that directly measure these discrete variables. Thus, the first step in exploring solutions to this gap in the literature is to pilot a survey instrument that measures the relationship between teacher beliefs in neuromyths and teacher instructional practices and simultaneously provides data on the nature of that relationship.

Statement of Problem

The research problem explored and identified within this dissertation is the lack of any empirically sound connection within neuroeducation, or survey instrument to measure, the relationship between teacher beliefs in neuromyths and teacher instructional practices. Because we know, according to the literature, that neuromyths are prevalent among teachers (Alekno, 2012; Dekker et al., 2012; Gleichgerrcht et al., 2015; Rato et al., 2013) and we know from self-efficacy studies that beliefs can manifest themselves in behaviors (Wood & Bandura, 1989)., it stands to reason that there is potentially a relationship between teacher beliefs in neuromyths and teacher instructional practices. Although the extent and nature of that relationship is currently unknown, it has been hypothesized that teachers may be utilizing instructional practices that are averse to student learning and achievement based on their beliefs in the neuromyths regarding learning (Alekno, 2012; Breen, 2014; Dekker et al., 2012; Gleichgerrcht et al., 2015, Organization for Economic Cooperation and Development; 2002; Rato et al., 2013). If
this is the case and beliefs in neuromyths do lead to misinformed instructional practices, then there is a vested interest in dispelling the neuromyths and integrating neuroscience into teacher preparation curricula and continuing education among those in k-12 education.

**Purpose**

The purpose of the study conducted was to determine whether there was a relationship between teachers’ beliefs in neuromyths and teacher instructional practices and whether neuroscience literacy or teacher efficacy helped to explain any of the variance in teacher instructional practices related to neuromyths.

**Limitations**

Several limitations may have impacted the findings in this study:

1. For the final administration of the survey, the participants were limited to public school teachers in the state of Pennsylvania in districts that did not have an Institutional Review Board.

2. Three of the largest urban districts in the state (Philadelphia School District, Pittsburgh Public Schools, and Allentown School District) were not included in the study.

3. Participation in this study was optional and voluntary.

4. Only the instructional practices that have a clear relationship to neuromyths were examined, though other instructional practices may have a relationship with beliefs in neuromyths.

5. There may be different interpretations of terms used in the survey.
6. Neuroscience literacy was measured utilizing a pre-existing survey from Herculano-Houzel (2002), but there was no information provided on the reliability or validity of the study, though this information was requested.

7. Neuromyths were measured partially using a pre-existing survey from Dekker et al. (2012). The reliability of these neuromyths items was .46, no reliability analysis was conducted, and validity information was not provided (S. Dekker, personal communication, July 5, 2015).

8. Even within the literature, there are different conceptualizations of the term “neuromyths.” Because the field of neuroeducation is so new, what should and should not be included as a neuromyths is still debated. While there were four neuromyths under examination in this study, up to 29 have been identified in the literature.

9. Although 4,519 teachers were invited to participate in the final survey administration of the study, only 118 teachers completed the survey.

Definition of Terms

The following definitions were used to guide this study:

1. Neuromyths are defined as, “common misconceptions about brain mechanisms” (OECD, 2002).

2. Neuroscience literacy is defined as, “the knowledge and understanding of concepts and processes in neuroscience required for understanding issues related to diseases and disorders of the brain, as well as how humans interact with their environment and each other because of their unique nervous system characteristics” (Zardetto-Smith, Mu, Phelps, Houtz, & Royeen, 2002).
3. Personal teaching efficacy is defined as, “a teacher’s… belief that one has the skills and abilities to bring about student learning” (Gibson & Dembo, 1984, p 573).

4. General teaching efficacy is defined as a teacher’s belief that teaching is able to bring about change in learning, regardless of factors external to the teacher (Gibson & Dembo, 1984).

**Research Questions**

**Pilot Questions**

1. As it stands, what is the utility of the survey in assessing teachers’ beliefs in neuromyths?

2. How might the survey be altered to improve the utility in assessing teachers’ beliefs in neuromyths?

**Final Survey Administration Questions**

1. Do teachers report that they believe in neuromyths and to what degree do they believe neuromyths?

2. To what extent do teacher beliefs in neuromyths explain variance in his or her reported instructional practices?

3. What is the relationship between neuroscience literacy and teacher beliefs in neuromyths and teacher instructional practices?

4. What is the relationship between teacher efficacy and teacher beliefs in neuromyths and teacher instructional practices?
CHAPTER 2: LITERATURE REVIEW

Introduction

First, social cognitive theory, self-efficacy theory, expectancy theory, and teacher efficacy theory provide the theoretical framework that conceptualizes a connection between an individual’s beliefs and his or her behavior. Second, the growing body of research about neuromyths identifies four common neuromyths and the potential roots of these misconceptions. Third, neuromyths are looked at specifically in regard to teachers’ beliefs and practices. Fourth, the research from teacher efficacy studies is examined for its potential to shed light on the nature of the relationship between teachers’ beliefs and their behavior in the classroom. Lastly, a needs assessment was conducted in Philadelphia, Pennsylvania to provide additional support for the gap in the literature. The results of this study conclude this review of the literature. The search terms and databases used in this review of the literature are identified in Appendix K.

Theoretical Framework

Educational psychologists have investigated and extensively studied the multiple relationships that exist in the classroom between the teacher, the student, and learning itself. B.F. Skinner’s (1974) behaviorism, Piaget’s (1964) cognitive constructivism, Vygotsky’s (1978) social constructivism are three of the earliest attempts that define and explain the nature of classroom variables. If there is a relationship between teacher beliefs in neuromyths and teacher instructional practices, the theoretical framework that guides it must support the idea that a belief is, or a set of beliefs are, capable of affecting behavior. Social cognitive theory, and specifically Bandura’s (1989) triadic reciprocal determinism, suggests that there is a causal relationship between beliefs, behavior, and
the environment. Both self-efficacy theory and expectancy theory follow from social
cognitive theory and lend additional support to the idea that belief in particular can be a
powerful determinant of behavior. Further, teacher efficacy theory provides a link
between teachers’ beliefs, behaviors, and student outcomes that is analogous to the
relationship between neuromyths and instructional practices explored in this study.

Social Cognitive Theory

Social cognitive theory rests on the notion that there is not a distinct causal
relationship between individual beliefs and behavior, but rather a triadic interplay
between personal factors (such as attitudes, beliefs, thoughts, emotions, and experiences,
as well as the biological structures of the brain), behavioral factors, and environmental
factors (Bandura, 1989). Each of these three factors exerts a causal influence over the
others and different social interactions and conditions can affect how the three factors
interact to cause the individual behaviors (Bandura, 1989). Beliefs in neuromyths can be
categorized in social cognitive theory as a personal factor, whether regarded as an
epistemological belief or an attitude toward learning. Partially by design, social cognitive
theory does not address the distinct relationship between beliefs and behavior, because it
is situated within a sea of additional contributing factors and a complex social
environment. However, social cognitive theory, at its most basic level, supports the core
premise that there is a relationship between beliefs and behavior. The additional variables
explored through the survey instrument created helped to isolate some of the mitigating
social factors and identify the strength of the relationship in regard to this particular belief
and behavior.
Social cognitive theory conceptualizes the uniqueness of human capacity as being derived from the ability to engage in mental representations to test behavioral actions prior to completing them (Bandura, 1989). This means that people process potential actions and behaviors utilizing their beliefs, thoughts, and attitudes to determine their own likelihood of participating in the behaviors (Bandura, 1989). Given that these possible actions are processed through the lens of the individuals’ cognition, Bandura (1989) mentions the possibility of misinterpreting events in ways that lead to incorrect and inaccurate beliefs. Neuromyths could be conceptualized as one of those incorrect or inaccurate beliefs that stem from the individuals’ cognitive lens. Bandura’s (1989) assertion that that which exists entirely in the mental/cognitive sphere can impact individual behaviors is critical to evaluating the practical role of neuromyths.

**Self-Efficacy Theory**

Although personal agency plays a role in behavior and response, the extent to which individuals’ control the interactions between personal, behavioral, and environmental factors in social cognitive theory is largely theoretically unanswered (Bandura, 1989). One piece of that answer comes from Bandura’s work on self-efficacy theory. Self-efficacy is the belief that one has about his or her abilities and capabilities (Bandura, 1989). While not directly attributable to personal agency, self-efficacy is a variable that affects the individuals’ ability to express their agency behaviorally. In this sense, self-efficacy can be thought of as a theory of motivation. Knowledge and skills are necessary to initiate and carry out behaviors or actions. Self-efficacy mediates the relationship between knowledge and related actions or performance (Bandura, 1982). Though self-efficacy would be most readily identified as a personal factor in social
cognitive theory, it not only affects the behavioral factors, but also has a relationship with the other personal factors, such as how the individual processes thought and how they respond emotionally in situations that can be taxing (Bandura, 1982). At its core, self-efficacy theory presumes a relationship between an individuals’ belief in themselves, or their capabilities, and that individuals’ behavior. The gap tying neuromyths and self-efficacy beliefs is the question of whether ones’ belief in themselves and their beliefs more generally are both contributing factors in that individuals’ behavior and, if so, to what extent are each of those relationships causal and predictive.

One study that Wood and Bandura (1989) conducted was done to determine the extent to which induced states of self-efficacy, being told that the task at hand was either a measure of innate ability or acquirable skill, affected the individuals’ performance on a managerial task. Not only were those individuals who were told that the task was a measure of their innate abilities poor performers themselves, but the groups they were managing fared much worse as well (Wood & Bandura, 1989).

In addition to Wood and Bandura’s (1989) study, further studies have been conducted to measure the impact of self-efficacy on all sorts of behaviors, such as anxiety and depression (Endler, Speer, Johnson, & Flett, 2001; Maciejewski, Prigerson, & Mazure, 2000; Muris, 2002; Tahmassian & Moghadam, 2011), motivation (Schunk, 1995), and exercise behavior (Marcus, Selby, Niaura, & Rossi, 1991; McAuley, 1992; Rudolph & Butki, 1998; Sallie, Hovel, Hofstetter, Faucher, Elder, Blachard, Casperen, Powell, & Christenson, 1989). Within the context of education, self-efficacy has been studied in relation with academic achievement (Goulao, 2014; Lent, Brown, & Larkin, 1984; Motlagh, Amrai, Yazdani, Abderahim, & Souri, 2011; Multon, Brown, & Lent,
NEUROMYTHS AND INSTRUCTION


The implications for these studies indicate that perceptions about learning are related to self-efficacy beliefs and that those beliefs affect not only the individual, but also the people being managed. This research lends strong support to the idea that neuromyths, particularly those about the nature of individual learning, could affect the instructional practices a teacher engages in and, ultimately, student success in completing classroom tasks or related measures of academic achievement.

**Expectancy Theory**

Bandura suggests that there are three forms of cognitive motivators: attributions, goals, and outcome expectancies (Bandura, 1992). Attributions and goals and their respective theories, attribution theory and goal theory, are most relevant to the personal factors that affect behavior and less relevant to the connection between beliefs and behaviors. Outcome expectancy, on the other hand, is explicitly related to beliefs because the motivation to behave in a particular manner is related to the belief in the likelihood of a particular outcome of that behavior (Bandura, 1992).

Expectancy theory describes the formularized expression of the relationship between outcome expectancy and behavioral actions (Vroom, 1964). Though theoretically related to both social cognitive theory and self-efficacy theory, expectancy theory finds its roots in industrial and organizational psychology (Vroom, 1964). Expectancy theory was created, in part, as a way to explain the motivation of employees to do their jobs efficiently (Vroom, 1964). In expectancy theory, employee behavior is
determined by three factors: expectancy, instrumentality, and valence (Vroom, 1964). Expectancy is the individual employees’ belief that his or her effort will lead to performance goals (Vroom, 1964). Instrumentality is the individual’s belief that the performance or action will lead to the desired outcome (Vroom, 1964). Valence is the individuals’ assessment of how valuable the outcomes are in terms of his or her own goals (Vroom, 1964). Although only three variables that contribute to behavior, Vroom (1964) determined that if an employee was more likely to believe that his or her actions would bring about the desired outcome, then they would be more inclined to perform that action or behavior as a result.

As he notes, Vroom’s (1964) results cannot necessarily be extrapolated to all situations, but when it comes to teachers, they fit the model of employees that are consistently measured against the desired outcome of student achievement or learning, which fits well within the context of education. Utilizing expectancy theory as a guide, many researchers have studied the effect that teacher expectancy has on student achievement (Brattesani, 1984; Cooper, Findley, & Good, 1982; Good, 1987; Rosenthal & Jacobson, 1963; Rosenthal & Jacobson, 1968). The belief that a teacher has about a particular student’s intellectual ability affects the student’s performance on intellectual tests (Rosenthal & Jacobson, 1968). Rosenthal (1994) suggests that this relationship exists because teacher expectations affect their nonverbal interactions with the students and, in turn, those interactions affect students’ ability to succeed in a classroom. While teacher expectancy beliefs are similar to neuromyths, specifically the neuromyths surrounding learning, there is still some work to determine if teachers’ general beliefs
about student learning are comparable in effect to their specific beliefs about individual student abilities.

**Teacher Efficacy Theory**

From social cognitive theory and self-efficacy theory comes teacher efficacy theory, which looks at the relationship between a teacher’s context-specific beliefs and his or her pedagogical behavior in the classroom. Within teacher efficacy theory there are two constructs that each represent different pieces of self-efficacy theory (Ashton & Webb, 1986). Personal teaching efficacy is a teacher’s belief about his or her ability to affect student achievement. General teaching efficacy is a teacher’s belief about whether or not teaching will impact learning regardless of who does the teaching. Personal teaching efficacy represents a self-efficacy belief, while general teaching efficacy is an outcome expectancy belief. Teacher efficacy theory posits that a teacher’s personal teaching efficacy and general teaching efficacy both have a causal relationship with a teacher’s instructional practices and student achievement. Empirical research supports this relationship (Allinder, 1994; Ashton & Webb, 1986; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Knapp, 2013; Nie, Tan, Liau, Lau, & Chua, 2013; Sandholtz & Ringstaff, 2014; Tracz & Gibson, 1986.)

Recent studies have zeroed in on the types of instructional behaviors that teachers with high teaching efficacy will engage in that presumably cause the student achievement impacts that are seen with these teachers. High efficacious teachers have a stronger sense of responsibility for student achievement, which leads to considerable gains in student success (Lee & Smith, 1996). These teachers are also less disillusioned and frustrated with teaching and are more organized in their pedagogy and fair when dealing with their
NEUROMYTHS AND INSTRUCTION

students (Allinder, 1994). Teachers with high teacher efficacy are more likely to be constructivist in their teaching and therefore implement more innovative pedagogies (Guskey, 1988; Nie et al., 2013). In their interactions with students, highly efficacious teachers are less critical of students when they make errors (Ashton & Webb, 1986) and continue to work with struggling students for a longer period of time (Gibson & Dembo, 1984).

Ashton and Webb (1986) also identified 16 factors that could influence teacher efficacy and among them were both conceptions of the learner and conceptions of the role of education. This is significant to understanding the role of neuromyths and instructional practices, because neuromyths are all conceptions of the learner or the role of education. If beliefs in neuromyths are factors that can affect teacher efficacy beliefs, then this would support a causal relationship with instructional practices. Although this would mean that there is a more indirect relationship between beliefs in neuromyths and instructional practices, with teacher efficacy beliefs serving as the mediating factor through which neuromyths affect instruction, teacher efficacy theory still supports the proposed relationship between neuromyths and instruction. It is also important to note that teacher efficacy is a dynamic factor that changes, and can continue to change as a teacher gains more mastery experiences in the classroom (Hoy & Spero, 2005).

Theoretically, the connection between teacher beliefs in neuromyths and instructional practices finds its roots most strongly in social cognitive theory, because it is a relationship among personal and behavioral factors (Bandura, 1989). Self-efficacy theory, expectancy theory, and teacher efficacy theory all align with the major constructs of social cognitive theory and each individually conceptualize the relationship between
beliefs and behavior somewhat differently. The common thread between these theories is
the notion that there is a relationship between an individual’s beliefs and his or her
behavior. The nature of those beliefs or the extent to which those beliefs are predictive
depends on other mitigating, contributing, and social factors that place the individual in a
wider context. Based on these theories, one can presume a relationship between beliefs in
neuromyths and instructional practices, but that relationship must be solidified in an
empirical context in order to be practically useful.

Neuromyths Research

While the relationship between teachers’ beliefs and teachers’ instructional
practices is validated in the research through social cognitive theory, self-efficacy theory,
and teacher efficacy theory, neuromyths do provide a unique type of belief that is
different from but analogous to efficacy beliefs. Because the study of neuromyths is
relatively new, what is and is not considered a neuromyth is still open to debate.
However, there is some research that points to the source of these beliefs and how they
relate to teachers’ pedagogy. The following section will explore the roots of neuromyths,
the existing research on neuromyths and instructional practices, and the related teacher
efficacy literature.

Roots of Neuromyths

It is important to look holistically at the reasons why teachers might be
susceptible to believing in neuromyths. Although there may be no definitive evidence as
to why teachers believe the neuromyths, there are indications in the research as to where
teachers may encounter the neuromyths and the structural systems in place that may be
allowing neuromyths to prevail uncorrected. Dekker, Lee, Howard-Jones, and Jolles
(2012) investigated the relationship between teachers’ beliefs in neuromyths, their general knowledge of the brain, and whether they read popular science magazines or scientific journals. Teachers across the United Kingdom and the Netherlands were sent an email inquiring about their interest in the brain and its impact on learning (Dekker et al., 2012). If teachers were interested in the topic they followed a link to the survey used in the analysis (Dekker et al., 2012). A total of 242 teachers participated in the survey and the results were mixed (Dekker et al., 2012). The survey asked participants to state their agreement or disagreement with both neuromyths and true statements about the brain’s impact on learning (Dekker et al., 2012).

The results of this study indicated that more than half of the teachers agreed with seven out of the fifteen neuromyths presented (Dekker et al., 2012). Out of the possible predictors of neuromyths, which included country, age, sex, school type, whether or not the individual read popular science magazines or scientific journals, and general knowledge of the brain, only the participants’ general knowledge of the brain was correlated to their beliefs in neuromyths (Dekker et al., 2012). One especially interesting finding was that although whether or not the participant read popular science magazines did not predict beliefs in neuromyths, those who had a higher knowledge of brain sciences were more likely to read popular science magazines (Dekker et al., 2012). This may indicate a relationship between the source of the participants’ information on brain sciences and their contact with neuromyths. Dekker et al. (2012) suggest that these results may be more troubling for classroom instruction, as those who were most interested in brain-based classroom practices were also the most likely to believe in the neuromyths. The major strength of this study is the sample population. Although all of
the participants were teachers, they were from various schools in two different countries. Utilizing an international population of teachers strengthens the results of the study because it indicates that the problem is not limited to particular demographic variables or teacher preparation programs. Yet, while Dekker et al. (2012) suggest that the results may have classroom implications, the study itself does not examine whether or not this speculated relationship exists.

Rato, Abreu, and Caldas (2013) are more specific than Dekker et al. (2012) in identifying some of the reasons that teachers may believe in neuromyths. First, there is a documented information gap between scientists and journalists that lead to journalism that is sometimes incorrect and often oversimplified. Second, teachers do not feel they have the time to focus on developing their understanding of how the brain sciences impact classroom instruction (Rato et al., 2013). Third, and most disturbing, is that educational businesses capitalize upon teachers’ desire to learn about brain structure and function and promote brain-based learning programs that contain some of the neuromyths (Rato et al., 2013). Rato et al. (2013) agree with Dekker et al. (2012) in suggesting that the more a teacher attempts to seek out material from the brain sciences, the more likely they are to fall prey to neuromyths.

In this study, 583 Portuguese teachers answered a survey that measured whether the teacher utilized brain-based techniques in the classroom, whether they had basic knowledge of how the brain sciences affect instruction, and where the teachers were getting their information about the brain sciences. The data showed that out of the six neuromyths presented on the survey, over 50 percent of teachers believed two of the six, although unlike Dekker et al.’s (2012) survey, this allowed for the response of
“uncertain”, which could account for the different results (Rato et al., 2013). When teachers were asked to identify the source of their information regarding the brain sciences and education, 23 percent stated they received their information from television and 21 percent stated they received their information from the internet, while only 17 percent and 19 percent got their information from scientific journals or books, respectively (Rato et al., 2013). The results of this study indicate that teachers do not regularly seek out information from reputable sources, which Rato et al. (2013) speculate is because of the lack of accessibility in how material is presented in scientific journals.

Gleichgerrcht, Luttges, Salvarezza, and Campos (2015) were also interested in exploring whether popular science played a role in the general neuroscience literacy and beliefs in neuromyths. Gleichgerrcht et al. (2015) conducted a study of 3,451 teachers in Latin America, using the Dekker et al. (2012) survey in both a paper and pencil and online version. Results were analyzed using ANOVA tests with Bonferroni post hoc comparisons and Cohen’s $d$ scores. Effect sizes were measured following Cohen’s classification and not statistical significance, due to the large sample size utilized in the study. Knowledge of the brain was generally high among participants (an average of 66.7% correct answers), with those participants who read science texts ($d=.33$) and primary scientific literature ($d=.25$) scoring higher on the portion of the survey measuring general scientific knowledge. Participants who had some access to neuroscience materials were no better at identifying neuromyths than the teachers who had no previous access to those materials. There was a small correlation between beliefs in neuromyths and correct knowledge of the brain ($r=.15$, $p<.001$, $R^2=.045$), which confirmed the results found originally in Dekker et al. (2012).
The Gleigerrcht et al. (2015) study was aligned in both methodology and results with the study conducted by Dekker et al. (2012) and showed that there was a consistent pattern among teachers, regardless of geography. While none of the information gleaned from this study was particularly novel, the patterns observed in Gleigerrcht et al. (2015) are important for two reasons. First, it is the most recent large-scale conducted among teachers about their beliefs in neuromyths and confirms that, despite the proliferation of popular science and brain-based teaching strategies, teachers are still susceptible to the neuromyths. Second, the fact that neuromyths are prevalent among teachers with vastly different economic, educational, and cultural backgrounds points to roots that go far deeper than teacher preparation programs or verbal transmission. Like Rato et al. (2013), Gleigerrcht et al. (2015) suspect and hypothesize that the common thread between these geographically dissimilar teaching populations is popular science and scientific literature.

Neuromyths and Instructional Practices

If teachers believe neuromyths, but do not infuse them into their teaching practices or instructional methods then it would be reasonable to think that there would be no harm to student learning. On the contrary, the research indicates that not only do teacher beliefs impact their instructional methods, but preliminary research also suggests that neuroscience can be used to transform student learning and teacher instructional methods (Kuzborska, 2011). It is worth noting, however, that the research on the relationship between teacher beliefs and practice has yielded mixed results, due in large part to the particular difficulty in defining what a teacher belief is and how it can be adequately measured (Bingimlas & Hanrahan, 2010). Although there is copious research documenting a relationship between teacher beliefs and practice, the strength of that
relationship in light of the nature of the belief (i.e. whether it is about the content being taught, general principles of teaching and learning, or self-efficacy) and the educational context remains a complex grey area (Bingimlas & Hanrahan, 2010).

Kuzborska (2011) conducted a study with 8 teachers teaching a first-year English undergraduate course at a Lithuanian university to determine the relationship between teachers self-identified beliefs about teaching and learning reading to determine if they affected their observed instructional practices. The data were collected from classroom observations, interviews, and document data analysis of classroom materials (Kuzborska, 2011). First, the teachers were observed and recorded for three 90-minute lessons (Kuzborska, 2011). After their lessons were recorded, they watched portions of their lesson on video and were asked to discuss their thought process of why they made particular choices during the lesson (Kuzborska, 2011). The interviews were then coded to discern the teachers’ beliefs in three large categories: process of reading, learning of reading, and teaching of reading (Kuzborska, 2011). The observed practices were compared with the stated beliefs about the reading process and the learning and teaching of reading to determine the relationship between the beliefs and the practices (Kuzborska, 2011). Kuzborska (2011) collected data in the form of teacher interviews, extensive observations, and document analysis. The findings indicated that there was a strong correlation between teacher beliefs, as stated by interviews, and observed teacher practices (Kuzborska, 2011).

There are two notable limitations to this study as it applies to understanding neuromyths. First, the research was conducted with a small sample size of only 8 teachers and the research was primarily qualitative (Kuzborska, 2011). Second, the interviewers
NEUROMYTHS AND INSTRUCTION

asked the teachers their beliefs on the teaching of English, not their beliefs on teaching and learning in a more general sense, so it is difficult to know if these findings would be generalizable. While this would typically not be a limitation, it differs from the author’s suggested intent to study more general views of teaching and learning in reading. This study supports the theoretical relationship between teachers’ beliefs and instructional practices in the classroom, but differs in some fundamental ways from the current study. While the beliefs studied in Kuzborska’s (2011) research were explicit beliefs that had clear relationship with codified instructional approaches, this current study was more exploratory in nature and sought to determine what kind of instructional practices might result from beliefs in neuromyths. Additionally, both the data collection methods and data analysis methods used in the two studies are very different, due to the exploratory nature of the current study.

Alekno (2012) was the first to look at the relationship between beliefs in neuromyths and teaching practices. The research questions that guided Alekno’s (2012) study were focused on the extent that teachers believed neuromyths, the relationship between beliefs in neuromyths and teaching practices, and how external factors affect whether or not teachers’ practice and beliefs in neuromyths align. There were 386 teachers that participated in the study who came from 8 schools across one large Midwestern district (Alekno, 2012). Teachers were asked to fill out a multiple-choice survey for the quantitative portion of the data analysis and those teachers whose responses revealed a pattern were asked to participate in an interview involving open-ended questions (Alekno, 2012). Of the ten neuromyths examined in this study, which can be found in table 1, over 50 percent of respondents agreed with five of the ten
neuromyths studied (Alekno, 2012). These neuromyths were: (1) right-brain/left-brain, (2) ten percent myth, (3) learning styles, (4) multiple intelligences, and (5) male female brain differences (Alekno, 2012). A simple linear regression was used to determine whether or not there was a relationship between each of the neuromyths beliefs and the instructional practices, and ANOVA was used to determine significance. A slightly predictive relationship existed between beliefs in five of the ten neuromyths and classroom practice (Alekno, 2012). These neuromyths were: (1) right-brain/left-brain ($p=.006, p < .01$), (2) learning styles ($p=.001, p<.01$), (3) Brain Gym ($p=.000, p<.01$), (4) synaptogenesis ($p=.000, p<.01$), and (5) male female brain differences ($p=.000, p<.01$) (Alekno, 2012). It is interesting to note that the neuromyths that had a predictive relationship with classroom practice were not the same as the neuromyths that were most believed by the participants, suggesting a complex relationship between neuromyths and classroom practice (Alekno, 2012).

Table 1  
*Alekno’s 10 Neuromyths*

<table>
<thead>
<tr>
<th>Neuromyth Name</th>
<th>Neuromyth Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% Myth</td>
<td>We only use 10% of our brains.</td>
</tr>
<tr>
<td>Right-brain/Left-brain</td>
<td>People are either left-brained or right-brained. People that are left-brained are more analytical, rational, language-oriented, and problem solvers. People that are right-brained are more intuitive, creative, emotional, and imaginative.</td>
</tr>
<tr>
<td>Learning Styles</td>
<td>People have a visual, auditory, or kinesthetic learning style and they learn best when taught to their learning style.</td>
</tr>
</tbody>
</table>
### NEUROMYTHS AND INSTRUCTION

<table>
<thead>
<tr>
<th>Theme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain Gym</td>
<td>Based on a program, student learning can be improved by a specific combination of movement and cognition.</td>
</tr>
<tr>
<td>Multiple Intelligences</td>
<td>Gardner’s theory of multiple intelligences has been verified and supported by neuroscience.</td>
</tr>
<tr>
<td>First Three Years</td>
<td>Everything about the brain is determined by the age of three.</td>
</tr>
<tr>
<td>Synaptogenesis</td>
<td>Periods of synaptogenesis indicate increased capacity for and efficiency of learning.</td>
</tr>
<tr>
<td>Critical Periods</td>
<td>There are critical periods in childhood after which certain things can no longer be learned.</td>
</tr>
<tr>
<td>Enriched Environments</td>
<td>Enriched environments lead to increased learning in young children.</td>
</tr>
<tr>
<td>Male/Female Brain Differences</td>
<td>Male and female brains are biologically different and this leads to differences in learning abilities between the sexes.</td>
</tr>
</tbody>
</table>

Though the sample size was considerably larger in this study than the Kuzborska (2011) study, the results also indicate that, at some level, teacher beliefs do impact classroom practice and instruction, specifically in regard to beliefs about teaching and learning, like neuromyths. Alekno’s (2012) study has often been cited, but has not yet been repeated or the results confirmed. One major limitation of Alekno’s (2012) study is that specific teacher instructional practices were not identified or defined. Alekno (2012) measured whether a teacher utilized a neuromyth to guide his or her teaching by asking them whether or not the belief in the neuromyth affected their classroom practice. Though self-report of instructional practices is often used in educational research, the
way that instructional practices were identified and measured in the Alekno (2012) study does provide much information on the nature of the relationship between teacher beliefs in neuromyths and specific teacher instructional practices that could be related to neuromyths.

Interestingly, while there is little research on the connection between teachers’ beliefs in neuromyths and teachers’ instructional practices, many articles provide warnings about the assumed danger of neuromyths in pedagogy (Ansari, 2008; Bruer, 1997, 2002; Busso & Pollack, 2014; Coch, Michlovitz, Ansari, & Baird, 2009; Della Sala, 2009; Dekker et al., 2012; Gleichgerrcht, Lutgtes, Salvareza, & Campos, 2015; OECD, 2012; Purdy, 2008; Rato et al., 2013). There is a general consensus that there is some value of the brain sciences in education (Ansari & Coch, 2006; Geake & Cooper, 2003; Samuels, 2009; Varma, McCandliss, & Schwartz, 2008), but the extent of that relationship, and the applicability of neuroscience findings remains a controversial issue (Devonshire & Dommett, 2010). Some researchers believe that the existence of neuromyths is directly due to the increased interest in neuroeducation (Alferink & Farmer-Dougan, 2010; Christodoulou & Gaab, 2009; Horvath & Donoghue, 2016), while others point to the value in bringing neuroscience into education (Abiola & Dhindsa, 2012). The goal of most researchers within the field of neuroeducation is to decrease the potential for transmitting neuromyths, while also increasing the potential uses of neuroscience in education (Ansari & Coch, 2006; Byrnes & Fox, 1998; Geake & Cooper, 2003).

In the case of the “Mozart myth” the state of Florida required day-care centers to play classical music and the Georgia governor spent $105,000 so that classical music
could be given to parents of newborns (Pasquinelli, 2012). Most neuromyths, unlike the Mozart myth, have not had that same widespread or egregious outcomes. However, the “brain-based learning” packages that are being offered by some educational companies are not based on solid research and are just as haphazardly implemented (Goswami, 2006). Neuromyths that are not codified into brain-based programs or packages are more akin to teacher efficacy beliefs and may have an indirect or implicit relationship with student achievement. Teachers who are interested in learning about the brain and learning indicate that the brain sciences change their instructional practices by making them more patient, optimistic, and professional with their students, while also making them more credible to their colleagues (Hook & Farah, 2013). With this said, while the existence of neuromyths among teachers is well-established, the roots and instructional extensions of these beliefs remain largely unexplored.

**Teacher Efficacy Beliefs and Instructional Practices**

One of the most well documented relationships between a teacher’s beliefs and his or her instructional practices is in the field of teacher efficacy. Teacher efficacy refers to a teacher’s beliefs on whether he or she can affect a student’s academic achievement or motivation (Gibson & Dembo, 1984; Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998). Some researchers and theorists conceptualize teacher efficacy as a type of self-efficacy, while others believe that it is a separate theoretical and empirical concept (Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998). However, most research on teacher efficacy is guided by Ashton and Webb’s (1986) combined conceptualization of teacher efficacy. This conceptualization includes both a general teaching efficacy (GTE) and personal teaching efficacy (PTE) component. Teacher efficacy has often been examined for its
empirical relationship with student achievement, but there are studies that also examine teachers’ instructional practices as a possible mediating factor in the relationship between teacher efficacy and student achievement (Ashton & Webb, 1986; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Tracz & Gibson, 1986)

**Seminal studies of Teacher Efficacy and Instructional Practices.** Ashton and Webb’s (1986) seminal study on teacher efficacy explored the relationship between teaching efficacy and instructional practices. There were 48 teachers involved in the study and student achievement data, teacher questionnaires measuring teacher efficacy, and classroom observations were all utilized to determine the nature of the relationship. The results indicated that teachers’ sense of efficacy is strongly correlated to academic achievement. Ashton and Webb (1986) also found that teachers with low general efficacy were harsher in their methods of classroom management and had less managed classrooms. In contrast, highly efficacious teachers were warmer to their students, assumed more responsibility for student achievement, praised students more (both verbally and nonverbally), were more likely to assign students work in small groups, developed more positive relationships with students, and provided more individual attention to students. Teachers with high efficacy also provided students with reasons for giving directions instead of giving behavioral rules or demands without their reasoning.

After Asthon and Webb (1986), Allinder (1994) was one of the first to explore the relationship between teacher efficacy and instructional practices by conducting a study among special education teachers. The teachers were asked to fill out a survey that measured their personal efficacy, teaching efficacy, willingness to try new approaches to teaching, organization and “planfulness”, and effective instructional components such as
enthusiasm and clarity in delivering course content (Allinder, 1994). Personal efficacy accounted for a moderately significant 17 percent of the variance in teachers’ willingness to try new approaches and instructional strategies. Personal efficacy accounted for 12 percent of the variance in teacher organization, planning, and fairness with students. Teaching efficacy did not account for a significant portion of the variance in either teacher willingness to try new approaches and strategies or teacher organization, planning, and fairness. Personal efficacy accounted for seven percent of the variance in instructional components, while teaching efficacy accounted for 12 percent of the variance. Allinder’s (1994) results indicate that there is some relationship between efficacy and the instructional methods utilized by special education teachers. This study is unique in that it separates the type of efficacy examined into personal and teaching efficacy, while more current studies utilize a holistic view of teaching efficacy that is inclusive of personal efficacy.

**Recent research on Teacher Efficacy and Instructional Practices.** Sandholtz and Ringstaff (2014) conducted a 3-year longitudinal study to determine the effect of a professional development program on elementary teacher’s self-efficacy and instructional methods, particularly with regard to science instruction. Using a combination of teacher surveys, interviews, and observations, the study explored the changes in teacher’s self-efficacy as a construct separate from their instructional practices, but also utilized statistical analyses to determine the relationship between the two variables (Sandholtz & Ringstaff, 2014). The professional development program, which was not provided by those conducting the study, worked to increase teachers’ understanding of elementary science content and use of instructional methods in science, as well as increase
collaboration amongst teachers in professional learning communities (Sandholtz & Ringstaff, 2014). The self-efficacy assessment was focused on teachers’ beliefs not just about their teaching abilities, but particularly about their ability to teach students science, since that was the focus of the professional development (Sandholtz & Ringstaff, 2014).

Both teachers’ self-efficacy in teaching science and their use of instructional strategies, as measured by two different surveys and supported with classroom observations, increased over the course of the three years (Sandholtz & Ringstaff, 2014). There was also a correlation between teachers’ self-efficacy and five of the instructional strategies studied, indicating a possible relationship between the two variables (Sandholtz & Ringstaff, 2014). The main limitation to this study is that the professional development program attempted to increase elementary teacher’s self-efficacy while simultaneously providing them tools and instructional strategies to teach science, thereby making it difficult to establish whether it was the self-efficacy that then affected the use of instructional strategies or the professional development alone. Regardless, while this study does not lead to a definitive causal relationship between teacher efficacy and instructional strategies, it does provide support for the relationship between teachers’ beliefs toward teaching and their pedagogy.

Knapp (2013) also looked at the relationship between teacher efficacy and instructional practices, particularly constructivist instructional practices. The teachers involved in this study were all secondary science teachers in West Virginia schools and all teachers were surveyed to determine levels of teacher efficacy and use of constructivist instructional practices. Teachers had to volunteer to be interviewed to obtain the qualitative data. The quantitative results indicated that there was a moderate
relationship between total teacher efficacy and use of constructivist instructional practices. There was also a moderate relationship between use of constructivist instructional practices and each of the separated sub-scales of teacher efficacy (efficacy in student engagement \( .523, p<.01 \), efficacy in instructional practices \( .454, p<.01 \), and efficacy in classroom management \( .281, p<.01 \)). The strongest relationship was found between use of instructional practices and efficacy in student engagement. The qualitative data from the teacher interviews did not clarify or add to the understanding of the relationship between teacher efficacy and instructional practices. The only minor limitation to this study was the use of self-report data for measuring the use of constructivist instructional practices without confirming observations, but given the amount of participants involved and their anonymity in the survey reports, it would not have been feasible to do observations.

Nie, Tan, Liau, Lau, and Chua (2013) also examined the relationship between teacher efficacy and constructivist teaching methods, but the purpose of their study was to compare how predictive teacher efficacy was of both constructivist teaching methods and didactic teaching methods. Nie et al. (2013) took the position that constructivist teaching methods should be utilized in classrooms more than the teacher-centered rote memorization that is known as didactic instruction. A total of 2,139 primary teachers from Singapore participated in the study by responding to a questionnaire that identified their levels of teaching efficacy and their use of constructivist and didactic teaching methods (Nie, Tan, Liau, Lau, & Chua, 2013). Teachers were selected from low, middle, and high performing schools (Nie et al., 2013). The results structural equation modeling indicated that there was a significant predictive relationship between teacher efficacy and
constructivist instruction and accounted for 39 percent of the variance of constructivist instruction \((\beta = 0.62, p < .01)\) (Nie et al., 2013). On the other hand, while teacher efficacy was also a significant predictor of didactic instruction, it only accounted for 4.6 percent of the variance and the relationship was much weaker (Nie et al., 2013). This study not only supports the general relationship between teacher efficacy and instructional methods, but also indicates that the type of instruction utilized by the teacher can be affected by a teachers’ beliefs, particularly his or her beliefs in their capabilities as a teacher.

As seen in figure 1, the exploratory study sets out to determine the relationship between beliefs in neuromyths, teacher efficacy, and instructional practices related to neuromyths. Teacher efficacy is included to determine whether beliefs in neuromyths are a type of teacher efficacy belief and would be more accurately embedded within this construct.

![Diagram](image.png)

*Figure 1: Hypothesized relationship between variables.*
Included Neuromyths

The term neuromyths was originally coined by a doctor who used it to describe misleading information about medical symptoms and causes that were prevalent in medical circles (Crockard, 1996). In 2002, the OECD used the same term to describe a misconception of facts from the learning sciences for use in education. Although some neuromyths are bound within cultural context, most neuromyths identified by those in educational neuroscience have been identified across western countries (Dekker et al., 2012; Gleichgerrcht et al., 2015; Rato et al., 2013). Some researchers have identified up to 29 neuromyths, but neuromyths included in this study had to meet three qualifications (Dekker et al., 2012; OECD, 2002; Tokuhama-Espinosa, 2010). First, there has to be existing research from multiple studies that indicate that more than 30 percent of teachers believe the neuromyths. Second, the neuromyths must be easily operationalized into an instructional practice. Third, there must be a general consensus that the idea is a neuromyth. Using the 15 neuromyths included in the Dekker et al. (2012) survey, gender-based neuromyths from the Alekno (2012) study, and multiple intelligences neuromyths from the Rato et al. (2013) study, a total of 17 neuromyths were considered for inclusion in the study. There were four neuromyths that met these three qualifications. There were 13 neuromyths that met some, but not all, of these qualifications and were therefore excluded from the study.

Neuromyth 1: Hemispheric Dominance

Neuromyth 1 definition. The first neuromyth is that people are dominant on one side of their brains, which is described as left-brained or right-brained (Geake, 2008). The idea is that those who are “right-brained” are right hemisphere dominant have more
creative personalities, while those who are “left-brained” are left hemisphere dominant and tend to excel at logical tasks (Geake, 2008). This neuromyth can be divided into three separate neuromyths. First, that people show a dominance in one of their brain hemispheres (Tokuhama-Espinosa, 2010). This is how the neuromyth is most often identified in the literature on neuromyths. Second, that learning occurs separately in the two brain hemispheres (Tokuhama-Espinosa, 2010). Third, that language and spatial abilities occur in the left and right hemispheres, respectively (Tokuhama-Espinosa, 2010).

**Neuromyth 1 origins and implications.** This neuromyth originates either from the phrenology of the early 1900s, or from a misapplication of neuroscience research that indicates that some processes of the brain are carried out in localized brain regions, such as language and emotional processing (Geake, 2008; Hardyck & Haapanen, 1979; Worden, Hinton, & Fischer, 2011). However, studies in patients who have a severed corpus callosum have shown that the two hemispheres work together and not in isolation (Geake, 2008). These patients are also not a representative group upon which to base educational programs (Hardyck & Haapanen, 1979). Additionally, although people might have differences in whether they think creatively or analytically, these differences cannot be isolated to one portion of the brain (Geake, 2008). It is more accurate to describe brain processes as complex interactions between sets of neural networks that exist in both the right and left brain hemispheres (Walsh & Pascual-Leone, 2003). Furthermore, brain research has also indicated that aspects of an individual’s personality, particularly impulse control and emotional response, can be greatly impacted by damage to the frontal
lobe of the brain, leading neuroscientists to believe that personality is not founded in hemispheric dominance (Helding, 2014).

Studies on beliefs in neuromyths among teachers have confirmed that teachers do believe this neuromyth (Alekno, 2012; Dekker et al., 2012; Rato et al., 2013). Although creating classroom activities that involve logic, language, and emotion can create a more cohesive and engaged classroom environment, teachers who believe this neuromyth could try to differentiate their lessons for students’ hemispheric dominance instead of creating integrated activities. Similar to the learning styles myth discussed below, this could put students into boxes that they do not rightfully belong in.

**Neuromyth 2: Learning Styles**

**Neuromyth 2 definition.** The second neuromyth suggests that students should be taught to their preferred method of receiving information, whether visual, auditory, or kinesthetic (Geake, 2008). Like the multiple intelligences myth, the learning styles myth is a misappropriated psychological theory. The undergirding truth in this neuromyth is that students are bound to have different strengths and preferences that can affect their academic outcomes (Riener & Willingham, 2010).

**Neuromyth 2 origins and implications.** However, instructional practices should not be centered around teaching to these particular learning preferences, because when students are taught to their preferred style, it does not increase their learning outcomes (Geake, 2008; Riener & Willingham, 2010). While research supports the use of multiple approaches to teaching material, it is because learning is strengthened when students see the material represented in multiple ways concurrently (i.e. seeing it while hearing it) (Geake, 2008). Multi-modal teaching induces a supra-additive effect for learning,
because multisensory stimuli causes increased neuronal activity in comparison to unimodal stimuli (Calvert, Campbell, & Brammer, 2000; Geake, 2008). Therefore, this neuromyth could encourage teachers to utilize multiple modalities in their teaching, which would have positive student outcome consequences, or it could encourage teachers to teach students to their particular learning style, as is suggested by the neuromyth’s proponents, which would have either no impact or an adverse impact on student learning (Doyle & Jacobs, 2013). Studies on beliefs in neuromyths among teachers have indicated that teachers do believe this neuromyth (Alekn, 2012; Dekker et al., 2012; Rato et al., 2013).

Neuromyth 3: Enriched Environments

Neuromyth 3 definition The third neuromyth includes the notion that children should be in enriched environments to stimulate their brain development (Hall, 2005). Although it is not clear what exactly enriched environments are, most believers in this neuromyth take it to mean an environment that is highly visually stimulating. Teachers often use this neuromyth as justification for decorating classrooms.

Neuromyth 3 origins and implications. This neuromyth came from rat studies that showed that rats kept in enriched environments had denser connections between their neurons than rats raised in deprived environments (Hall, 2005). The original research did not clearly clarify the difference between “enriched” and “deprived” environments, and the results of the study showed that this difference in neural density existed regardless of the rat’s age (Greenough, Black & Wallace, 1987; Hall, 2005). Additionally, as Hall (2005) points out, there are no studies linking neural density to improved learning outcomes. What this neuromyth points to is a lack of understanding of brain sciences and
how learning actually occurs in the brain. The enriched environments neuromyth has taken hold most strongly in preschool education, where it is believed that creating visually stimulating environments for preschool students will encourage their brain development. Studies on beliefs in neuromyths among teachers have indicated that teachers do believe this neuromyth, especially with regard to stimulating preschool environments (Alekno, 2012; Dekker et al., 2012).

Neuromyth 4: Exercise and Literacy

**Neuromyth 4 definition.** The fourth neuromyth, that exercise can lead to increased literacy skills, is sometimes known as the “Brain Gym” myth. This is the belief that particular coordination exercises and movements will help students become better readers. The education program Brain Gym was marketed to educators as a way to improve the particular exercises, and thereby improve student literacy.

**Neuromyth 4 origins and implications.** While the source of this myth is largely unknown, it has been speculated that this neuromyth originates from Brain Gym (Howard-Jones, Franey, Mash-moushi, and Liao, 2009; Hyatt, 2007). Brain Gym is a fairly popular program that is offered in more than 80 countries and uses physical exercise to increase student learning (Hyatt, 2007). The Brain Gym program is associated with many of the neuromyths including that physical exercise increases literacy skills, that exercise leads to increased integration between the two brain hemispheres, and that there is a left-brain/right-brain dichotomy in learning (Alekno, 2012; Hyatt, 2007).

While exercise has been shown to impact certain learning processes, its connection with literacy has not been documented or supported by research (Hillman, Erickson, and Kramer, 2008). Additionally, most of the studies promoting the effects of
exercise on mental health and cognition refer to exercise generally and not to exercise done within a classroom context. Two studies on beliefs in neuromyths among teachers have indicated that teachers do believe that exercise can improve students’ literacy (Dekker et al., 2012, Howard-Jones, Franey, Mash-moushi, and Liao, 2009). Teachers that believe this particular neuromyth may be integrating exercise or movement into their classroom instruction in a haphazard way that does not increase student literacy, but does occupy considerably instructional time.

**Excluded Neuromyths**

Table 1 includes the rationale for all of the neuromyths that were considered to be part of this study, but were not included because they did not meet at least one of the three requirements for inclusion. Table 2 includes the results from a short survey that was conducted to determine the face validity of whether or not the neuromyth could be operationalized into an instructional practice. The 14 participants in this survey were all education doctoral students at Johns Hopkins University, ranging in age from 28 to 50. These students were all formally employed within the education sector, although the level of education varied between the participants. The neuromyth was included if at least 70 percent of respondents agreed that it could be operationalized into an instructional practice. The survey questions that were used are included in Appendix A.

<table>
<thead>
<tr>
<th>Neuromyth</th>
<th>There is not research from multiple studies that support teachers’ belief in the neuromyth.</th>
<th>It cannot be operationalized into instructional practices.</th>
<th>There is not general consensus that it is a neuromyth.</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are significant differences between the male and the female brain</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Brain development has finished by the time children reach secondary school. | X | X

Learning is due to the addition of new cells to the brain. | X

We only use 10% of our brain (Rato et al., 2013) | X

Regular drinking of caffeinated drinks reduces alertness (Dekker et al., 2012) | X

Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain (Dekker et al., 2012) | X

If students do not drink enough water (6-8 glasses) their brains will shrink. | X

It has been scientifically proven that fatty acid supplements (omega-3s and 6s) have a positive effect on academic achievement. | X

Children must acquire their native language before a second language is learned. If they do not do so, neither language will be fully acquired. | X
When we sleep the brain shuts down. X X

Children are less attentive after consuming sugar snacks/drinks. X X

Learning problems associated with developmental differences in brain function cannot be remediated by education. X

Mental capacity is hereditary and cannot be changed by the environment or experience. X X

Multiple intelligences correspond with strengths in different brain regions. X

### Table 3
*Face Validity Survey Results*

<table>
<thead>
<tr>
<th>Neuromyth</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Individuals learn better when they receive information in their preferred learning style (i.e. visual, auditory, or kinesthetic)</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>2. Environments that are rich in stimulus improve the brains of preschool children.</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>3. Exercises that rehearse coordination of motor perception skills can improve literacy.</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>4. Differences in hemispheric dominance (left brain/right brain) can help explain individual differences among learners.</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>5. Short bouts of coordination exercises can improve integration of left and right brain hemispheres.</td>
<td>11</td>
<td>3</td>
</tr>
</tbody>
</table>
6. Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.

7. Children are less attentive after consuming sugary snacks/drinks.

8. There are critical periods in childhood after which certain things can no longer be learned.

9. It has been scientifically proven that fatty acid supplements (Omega-3s and Omega-6s) have a positive effect on academic achievement.

10. We only use 10% of our brain.

11. Brain development has finished by the time children reach secondary school.

12. If pupils do not drink sufficient amounts of water, their brains will shrink.

13. Mental capacity is hereditary and cannot be changed by environment or experience.

14. Learning problems associated with developmental differences in brain function cannot be remediated by education.

15. When we sleep, the brain shuts down.

** Respondents were asked to select “yes” or “no” to whether the neuromyth could be operationalized into a practice for k-12 teachers of any subject.

This review of the literature indicates that there is a theoretical connection between beliefs and behavior, as supported by social cognitive theory, that there are four common neuromyths believed by a substantial number of teachers, and that there is a relationship between a teacher’s beliefs and his or her instructional practices. Because only the Dekker et al. (2012) and Alekno (2012) studies evaluated whether or not teachers believed in neuromyths, a needs assessment was conducted at a school in
NEUROMYTHS AND INSTRUCTION

Philadelphia, Pennsylvania to gain some additional information on teacher beliefs in neuromyths.

Needs Assessment

A needs assessment study was conducted in June 2014 to determine the extent to which teachers believed in neuromyths. The results of this needs assessment study confirmed results from existing studies that indicate that teachers do believe in neuromyths (Dekker et al., 2012). The results also indicated that there was a need for more information regarding the nature of those beliefs and how they affected instructional practices and, ultimately, student learning.

Context of Study

Utilizing a shortened version of the survey created by Dekker, et al. (2012), a needs assessment study was conducted at a magnet school in Philadelphia, Pennsylvania. Although Dekker et al. (2012) and Alekno (2012) both evaluated teacher belief in neuromyths, the context of this study was unique in that it studied teachers in an urban context.

Description of Context

The high school was a 9-12 public charter school in Philadelphia, Pennsylvania. This school began in 1999 with one 9-12 campus in center city, Philadelphia. The school expanded to a second 9-12 campus in 2012 in West Philadelphia. The West Philadelphia campus is where the needs assessment was conducted. Although the school is a public school and part of the School District of Philadelphia, it does not serve as a neighborhood school. Students have to apply and interview for positions in the 9th grade class. For this
NEUROMYTHS AND INSTRUCTION

reason, the population of students at the school are incredibly diverse in academic background, ethnicity, and interests. Both campuses receive title 1 federal funding.

Target Audience

The stakeholders are public school teachers, students, parents, and community members. In addition, those designing and implementing teacher preparation programs at colleges and universities may be interested in identifying the sources of education neuromyths.

Goals and Objectives

The purpose of this needs assessment was to determine the extent to which teachers believe in neuromyths and whether or not they have a functional understanding of brain structure and function as it guides student learning. The research was guided by the following research questions:

1) Do teachers believe neuromyths?

2) Do teachers understand brain structure and function to the extent that it affects student learning?

Methodology

Participants

The school where the study was conducted has 12 teachers and 3 administrators. The survey was sent to a total of 14 possible respondents, which included 11 teachers and 3 administrators. Since this particular campus of the school has only been in existence for two academic school years, teachers have only been teaching at the school for a maximum of two years, although some of the teachers have prior teaching experience outside of the high school involved in the study.
Instruments

The instrument utilized in this needs assessment was a survey designed to measure the strength of teachers’ beliefs in neuromyths and teachers’ understanding of neuroeducation research that would impact student learning and teacher instruction. The survey was adapted, with permission, from the survey used by Dekker et al. (2012). The survey can be found in its entirety in Appendix A. The survey assessed demographic variables, beliefs in neuromyths, and background knowledge of brain sciences. The three demographic variables studied were: role in the school, age, and gender. The survey was adapted from the survey used by Dekker et al. (2012), but it used a Likert-type scale instead of asking respondents whether they agree or disagree. A Likert-type scale was chosen to better identify the degree to which teachers and administrators agreed with particular ideas about neuroscience.

Table 4
Needs Assessment Population Sample Demographics

<table>
<thead>
<tr>
<th>Sample Population</th>
<th>Pennsylvania Population*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 30 years old</td>
<td>40%</td>
</tr>
<tr>
<td>30-49 years old</td>
<td>60%</td>
</tr>
<tr>
<td>50 + years old</td>
<td>0%</td>
</tr>
<tr>
<td>Male</td>
<td>50%</td>
</tr>
<tr>
<td>Female</td>
<td>50%</td>
</tr>
</tbody>
</table>


Procedure
**Data collection.** On June 20, 2014, all of the potential respondents were sent an introductory email and a link to the survey on Surveymonkey.com. The consent form was included on the introductory page of the survey and respondents were only allowed to take the survey if they accepted the terms of the consent form. Each of their responses was kept anonymous and evaluated in the aggregate. Of those that were sent the email, 10 of them responded for a response rate of 71.4 percent. The demographic breakdown of age and gender is included in table 3, along with a comparison of teachers in the state of Pennsylvania.

**Data analysis.** There were five variables used in the analysis of data. The data were analyzed using frequency statistics to determine the percentage of participants responding positively to the neuromyths questions and the neuroscience literacy questions. Because there were so few participants in the needs assessment, additional statistical analyses were not employed.

**Needs Assessment Findings**

Although the sample size utilized for this needs assessment was small, the findings confirmed Dekker et al.’s (2012) research that teachers do believe in some of the neuromyths. Additionally, the results regarding understanding of the brain sciences indicated that teachers had a fairly good understanding of basic neuroscience. While these results seem contradictory, the relationship between the two variables was not analyzed in this study.

**Beliefs in Neuromyths**

This study included a total of 15 neuromyths. Of the 15 neuromyth items, 11 items received responses in agreement with the neuromyth. This means that 4 of the
neuromyths studied had no impact on the participants at the school or their classroom instruction because they did not believe them to be true. The 4 neuromyths that did not impact teachers at this particular school were (1) the brains of boys and girls develop at the same rate, (2) mental capacity is hereditary and cannot be changed by the environment or experience, (3) learning problems associated with developmental differences in brain function cannot be remediated by education and, (4) when we sleep the brain shuts down.

Table 5
*Teacher’s Beliefs in Neuromyths*

<table>
<thead>
<tr>
<th>Neuromyth</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environments that are rich in stimuli improve the brains of preschool children.</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Short bouts of coordination exercises can improve integration of left and right hemispheric brain function.</td>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Individuals learn better when they receive information in their preferred learning style (e.g. auditory, visual, or kinesthetic)</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Children are less attentive after consuming sugary drinks and/or snacks.</td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Differences in hemispheric dominance (left-brain, right-brain) can help explain individual differences amongst learners.</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Exercises that rehearse coordination of motor-perception skills can improve literacy skills.</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>It has been scientifically proven that fatty acid supplements (omega-6 and omega-3) have positive effect on academic performance.</td>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>If students do not drink sufficient amounts of water (~6-8 glasses per day) their brains will shrink.</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>
NEUROMYTHS AND INSTRUCTION

There are critical periods in childhood after which certain things can no longer be learned.  

We only use 10% of our brains.  

Children must acquire their native language before a second language is learned. If they do not do so, neither language will be acquired.  

The brains of boys and girls develop at the same rate.  

Mental Capacity is hereditary and cannot be changed by the environment or experience.  

Learning problems associated with developmental differences in brain function cannot be remediated by education.  

When we sleep, the brain shuts down.  

In addition to teacher beliefs in neuromyths, respondents were also asked to rate their level of belief in true statements about neuroscience and education. There were 14 total questions assessing teacher understanding of brain sciences and frequency statistics was utilized to analyze the data.

Table 6  
Teacher’s Understanding of Neuroscience

<table>
<thead>
<tr>
<th>Neuroscience Statement</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>We use our brains 24 hours a day.</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Academic achievement can be affected by skipping breakfast.</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Production of new connections in the brain can continue into old age.</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Learning occurs through the modification of the brains’ neural connections.</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain. 9 1 0

Individual learners show preferences for the mode in which they learn (e.g. visual, auditory, kinesthetic) 9 1 0

There are sensitive periods in childhood when it’s easier to learn things. 9 1 0

Vigorous exercise can improve mental function. 9 1 0

Circadian rhythms shift during adolescence, causing pupils to be tired during the first lessons of the school day. 9 0 1

When a brain region is damaged, other parts of the brain can take up its function. 7 2 1

Normal development of the human brain involves the birth and death of brain cells. Learning is not due to the addition of new cells to the brain. 7 1 2

The left and right hemispheres of the brain always work together. 6 2 2

Regular drinking of caffeinated drinks reduces alertness. 4 1 5

Boys have bigger brains than girls. 2 3 5

**Discussion**

The research in the needs assessment shows two somewhat conflicting results. First, a majority of the teachers believe 7 of the neuromyths. Second, teachers that responded to the survey have an overall understanding of basic neuroscience as it relates to education and instruction. These results are consistent with the results found by Dekker, Lee, Howard-Jones, and Jolles (2012). What this means for classroom
NEUROMYTHS AND INSTRUCTION

instruction is somewhat unclear, because teachers did not indicate the extent to which these beliefs shaped their practice. Research from Kuzborska (2011) and Alekno (2012) and teacher efficacy studies (Allinder, 1994; Ashton & Webb, 1986; Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Knapp, 2013; Nie, Tan, Liau, Lau, & Chua, 2013; Sandholtz & Ringstaff, 2014; Tracz & Gibson, 1986) indicate that teacher beliefs are not isolated from teacher practice and that beliefs in neuromyths likely affect classroom instruction.

The results of the study imply that teachers in this particular Philadelphia magnet school have a wide range of disparity when it comes to their understanding of neuroscience and their adherence to neuromyths. It would be presumptive to assume that all of the teachers in the study who believed any neuromyths are also consistently and uniformly implementing those neuromyths in their classroom methods and instruction. However, the literature does support the implication that teachers’ beliefs do impact their instruction and decision-making process in the classroom. Due to the large number of teachers that believed 7 of the neuromyths, it becomes a larger problem for the school to address teachers enacting incorrect beliefs about student learning.

Although the results do appear to be conflicting because teachers believe both incorrect and correct statements about neuroscience and education, this supports the research in two different ways. Teachers clearly have an interest in utilizing neuroscience in their classrooms, or otherwise the beliefs in correct statements about neuroscience would not have been as high. This supports the use of professional development time for increasing teacher understanding of neuroscience. Also, the sources of the correct and incorrect beliefs may be the same namely, as Rato, Abreu, and Castro-Caldas (2012)
identified, popular science magazines, the internet, and television. Thus, where teachers are encountering neuroeducation, they may also be encountering neuromyths.

Conclusion

Good teaching that moves students’ achievement forward does not always look the same from classroom to classroom, but when teachers are implementing practices based on misconceptions about the science of learning, student success may be sacrificed. While the research on neuromyths and the use of neuroscience in the classroom is still developing, there is a lot of work to be done within schools to determine the extent that the brain sciences can be brought safely and effectively into the classroom. The most common neuromyths, as discussed above, are multiple intelligence, 10 percent usage, left and right-brained thinking, learning styles, and critical periods of development (Alekno, 2012; Geake, 2008; Hall, 2005; Pasquinelli, 2012; Riener & Willingham, 2010; Waterhouse, 2006; Worden, Hinton, & Fischer, 2011). The reasons for teachers’ susceptibility to believing in neuromyths are still somewhat unknown, but preliminary research indicates that educational businesses, popular science magazines, television programs, and the lack of accessibility of scientific research to the educational community may all play a part in teachers’ adherence to false beliefs about the brain sciences and learning (Dekker et al., 2012; Pasquinelli, 2012; Rato et al., 2013).

While it is notably difficult to define what a belief is, both Kuzborska (2011) and Alekno (2012) show that teachers’ beliefs about teaching and learning do play a role in shaping their classroom practices. Additionally, the research from teacher efficacy studies supports a relationship between teachers’ beliefs in their ability to affect student achievement and instructional practice (Allinder, 1994; Knapp, 2013; Nie et al., 2013;
NEUROMYTHS AND INSTRUCTION

Sandholtz & Ringstaff, 2014). This research collectively tasks the next generation of educational professionals to both dispel the neuromyths and increase the extent to which educational neuroscience is used to inform classroom instruction, but only if a definitive relationship can be empirically defined between teacher beliefs in neuromyths and teacher instructional practices. In addition to the evidence in the literature, the findings from the needs assessment suggest that teachers from a small sample believe in neuromyths. In order to determine whether these beliefs exist within the larger population of teachers and whether or not these beliefs are related to instructional practices, a broader study should be conducted.
CHAPTER 3: RESEARCH METHODS

The purpose of this mixed methods study was to explore the relationship between teachers’ beliefs in neuromyths and their instructional practices. There were two stages to this study. First, the instrument was piloted with teachers from two different schools to establish face validity of the survey items prior to the final survey administration. During this pilot, teachers from each school were asked to participate in cognitive interviewing focus groups after the survey was administered to discuss the process of taking the survey. Because the instrument created for this study was unique in measuring teacher beliefs regarding neuromyths and the practices that may result from those beliefs, a pilot was necessary. Second, after the survey was adjusted based on the data from the pilot, the survey link was sent to 4,807 teachers in the state of Pennsylvania along with a request for participation. The pilot survey is included in Appendix A and the final survey is included in Appendix C. The cognitive interviewing probes used are included in Appendix D.

In this chapter, the research methodology will be explained. First, the research design of the study is described followed by a description of the population and sample. Then, the survey instrument and all its subscales are explained and sample items included. Lastly, the data collection and data analysis that occurred during this study are described.

**Research Design**

There were two parts to this mixed-method research design, each correlating with a different type of data. Qualitative data was obtained through the pilot study for the purpose of establishing face validity for the instrument and adjusting the instrument to
better reflect the experiences of teachers (Creswell & Plano Clark, 2011). Quantitative data was obtained through the final survey administration and analyzed using correlational statistics. A mixed-method study was best suited to solve this research problem; qualitative methods are necessary to evaluate participants’ understanding of survey items, while quantitative methods are best used when attempting to generalize to an entire population (Creswell & Plano Clark, 2011).

Cognitive interviewing is a tool used to improve the quality of surveys by more closely examining the subjects’ thought process while taking a survey (Collins, 2003; Willis, 1999). The verbal probing technique was utilized over the think aloud technique, because the think aloud technique can place an undue burden on the subjects involved (Willis, 1999). Verbal probing is easier for the subjects and allows the interviewer to control the interview and ask targeted questions (Willis, 1999). The cognitive interviewing focused on the questions that were created for the purpose of this study, which are questions that measured teachers’ instructional practices that might follow from beliefs in neuromyths and also additional neuromyths questions.

Population and Sample

All participants involved in the pilot and the final survey administration were teachers from the state of Pennsylvania. Administrators, teaching assistants, school counselors, and other school personnel that were not full-time teachers were not a part of the pilot or final survey administration because, while they may have an impact on instruction, they do not have defined instructional practices. Teachers selected were all full-time k-12 teachers from various subject matters and grade levels. All teachers from
the one hundred randomly selected schools were invited to participate in the final survey administration.

**Pilot Survey Participants**

For the pilot of the instrument teachers from two schools were invited to participate. These two schools were selected because they were a convenience sample. Teachers from these two schools were demographically distinct and the schools were characteristically different from each other in their organizational structure, student population, and location. The first school involved was a public charter school, grades 5-12, located in center city, Philadelphia. There were a total of 98 teachers invited from the first school to participate and 15 took the survey, for a response rate of 15 percent. All of the teachers that took the survey were invited to participate in a follow-up cognitive interview focus group. Six teachers participated in the cognitive interviews.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>20-24</td>
<td>20%</td>
</tr>
<tr>
<td>25-29</td>
<td>40%</td>
</tr>
<tr>
<td>30-34</td>
<td>20%</td>
</tr>
<tr>
<td>35-39</td>
<td>20%</td>
</tr>
<tr>
<td>40-44</td>
<td>0%</td>
</tr>
<tr>
<td>45-49</td>
<td>0%</td>
</tr>
<tr>
<td>50-54</td>
<td>0%</td>
</tr>
<tr>
<td>55-59</td>
<td>0%</td>
</tr>
<tr>
<td>60-64</td>
<td>0%</td>
</tr>
<tr>
<td>65-70</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Level of Education**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelors Degree</td>
<td>53.3%</td>
</tr>
<tr>
<td>Masters Degree</td>
<td>46.7%</td>
</tr>
<tr>
<td>Doctorate</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Have Attended Professional Conference on the Brain or Education*
The second school involved was an independent high school located in Bucks County, outside of Philadelphia. From the second school 41 teachers were invited to participate and 29 took the survey for a response rate of 70 percent. All of the teachers that took the survey were invited to participate in a follow-up cognitive interview focus
group. Volunteers were used because of the additional time commitment outside of school hours. Nine teachers participated in the cognitive interviews. These focus groups were held in two sessions, one at each participating school. The pilot sample data for this school can be found in table 8 below.

Table 8
*Frequencies for Pilot Survey, School 2*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
</tr>
<tr>
<td>20-24</td>
<td>0%</td>
</tr>
<tr>
<td>25-29</td>
<td>13.8%</td>
</tr>
<tr>
<td>30-34</td>
<td>20.7%</td>
</tr>
<tr>
<td>35-39</td>
<td>10.3%</td>
</tr>
<tr>
<td>40-44</td>
<td>3.4%</td>
</tr>
<tr>
<td>45-49</td>
<td>13.8%</td>
</tr>
<tr>
<td>50-54</td>
<td>3.4%</td>
</tr>
<tr>
<td>55-59</td>
<td>6.9%</td>
</tr>
<tr>
<td>60-64</td>
<td>10.3%</td>
</tr>
<tr>
<td>65-70</td>
<td>17.2%</td>
</tr>
</tbody>
</table>

| **Level of Education**                           |         |
| Bachelors Degree                                 | 13.8%   |
| Masters Degree                                   | 72%     |
| Doctorate                                        | 13.8%   |

| **Have Attended Professional Conference on the Brain or Education** |         |
| Yes                                                            | 44.8%   |
| No                                                             | 51.7%   |

| **Required to take a course in biology, neuroscience, psychology, or biological basis of behavior as it relates to learning?** |         |
| Yes                                                            | 51.7%   |
| No                                                             | 34.5%   |

| **Do you have an undergraduate degree in any of the following fields: biology, neuroscience, psychology or biological basis of behavior?** |         |
| |   |
Do you have a graduate degree in any of the following fields: biology, neuroscience, psychology, or biological basis of behavior?

<table>
<thead>
<tr>
<th>Option</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6.9%</td>
</tr>
<tr>
<td>No</td>
<td>93.1%</td>
</tr>
</tbody>
</table>

Years of Teaching Experience

<table>
<thead>
<tr>
<th>Experience Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>13.8%</td>
</tr>
<tr>
<td>5-10</td>
<td>24.1%</td>
</tr>
<tr>
<td>11-19</td>
<td>27.6%</td>
</tr>
<tr>
<td>20+</td>
<td>34.5%</td>
</tr>
</tbody>
</table>

Final Survey Participants

For the administration of the survey in its final form, a representative sample of school districts in the state of Pennsylvania were selected. The Pennsylvania Department of Education classifies public schools into nine demographic categories: small suburb, mid-size suburb, large suburb, fringe rural, distant rural, remote rural, small city, mid-size city, large city, fringe town, distant town, and remote town. The breakdown of the 3,242 schools in Pennsylvania is included in appendix F. A total of 100 schools were selected for participation and the breakdown of the sample matched the demographic breakdown of schools in Pennsylvania. A pre-determined number of schools were randomly selected from each of the demographic categories so the sample was more representative of teachers across the state. The selected schools were all schools that do not have an
institutional review board. Because Philadelphia School District and Pittsburgh City Schools both had an institutional review board, charter schools were oversampled in Philadelphia and Pittsburgh. This helped to ensure that the sample matched the demographic distribution of schools in the state.

The teachers were asked to participate in an email. Approximately 4,807 teachers’ email addresses were collected and sent the link to the survey. Out of those emails, 289 email addresses listed on school websites were incorrect or disabled by the time the email was sent, meaning only 4,519 teachers received the email. The email sent to the participants on September 15, 2015 is included in Appendix G. Participants were sent one reminder email 2 weeks after the original email requesting their participation in the survey. The survey remained open for one month, until October 15, 2015, at which time the survey was closed and the data was uploaded into SPSS.

**Instrumentation**

An online survey link was sent to each participant’s email to obtain data on teachers’ beliefs in neuromyths, neuroscience literacy, teacher efficacy, and instructional practices. The survey included five sections: demographics, beliefs in neuromyths, instructional practices, teacher efficacy, and neuroscience literacy. The demographics section will ask for the following information from the teachers: age, highest level of education, where in their education they received their teacher training, experience with brain sciences, years of teaching experience, grade level taught, subject area taught, and type of school system. Beliefs in neuromyths will be measured partially utilizing the survey items taken from Dekker, Lee, Howard-Jones, and Jolles (2012). Neuroscience literacy were measured using a scale created by Herculano-Houzel (2002). Teacher
efficacy were with a shortened 14-item version of Gibson and Dembo’s (1986) teacher efficacy scale. Survey items on instructional practices potentially related to neuromyths were created for the purpose of this study, as were additional questions measuring beliefs in the neuromyths. Face validity of these survey items were measured during and after the pilot.

**Belief in Neuromyths**

Dekker et al. (2012) created a survey that measured beliefs in neuromyths as well as understanding of brain sciences. The original survey included 17 items that measured teachers’ beliefs in neuromyths, but only four of these items were included, as only four of the neuromyths met the qualifications for inclusion in the study. The reliability of the instrument was measured using Cronbach’s alpha and the reliability of the neuromyth items was .46 (S. Dekker, personal communication, July 1, 2015). A reliability analysis was not conducted because the researchers were primarily concerned with the variability between the beliefs in neuromyths (S. Dekker, personal communication, July 1, 2015). The researchers did not include any information about the validity of the items in their study. Although this information was requested several times, no validity information was provided. Because of this, there were two additional neuromyths questions added for each of the four included neuromyths. Participants were asked to select “yes”, “no”, or “I don’t know” on whether or not they believed the statement to be true. Table 9 outlines the neuromyths questions taken from Dekker et al. (2012) and the additional questions that were created for each neuromyth.
Table 9

*Neuromyths Sample Items*

<table>
<thead>
<tr>
<th>Neuromyths Question (From Dekker et al., 2012)</th>
<th>Neuromyths Question (Created for Study)</th>
</tr>
</thead>
</table>
| Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners. | 1. Some students are left-brained (i.e. more rational, logical, and analytical), while other students are right-brained (i.e. more emotional, artistic, and creative).  
2. Every person favors either their left brain hemisphere or their right brain hemisphere, and which hemisphere a person favors can be determined by his or her personality traits. |
| Individuals learn better when they receive information in their preferred learning style (e.g. auditory, visual, kinesthetic). | 1. Students can be roughly categorized into three groups—auditory, visual, or kinesthetic—based on how they best receive knowledge in a classroom.  
2. It is important for students to determine their learning style (e.g. visual, auditory, or kinesthetic) so that they can adjust their study skills to match their learning style. |
| Environments that are rich in stimulus improve the brains of pre-school children. | 1. An environment that is enriched is going to improve learning conditions.  
2. Science has proven that having an environment with a lot of external stimuli can improve learning conditions. |
| Exercises that rehearse coordination of motor-perceptual skills can improve literacy skills. | 1. Physical activities should be done in a classroom because it can improve student learning and reading comprehension.  
2. There is research that indicates that students are better readers when given the opportunity to move around the classroom during a lesson. |
Neuromyths and Instructional Practices

For the four neuromyths that met the criteria for inclusion in this study, potential instructional practices were identified that might naturally stem from a belief in the neuromyth. Because these instructional practices were created newly for the purposes of this study, two or three questions were created for each of the four included neuromyths. The instructional practices survey items that were included in the study can be found in table 10 along with their corresponding neuromyth belief from the Dekker et al. (2012) study.

Table 10

<table>
<thead>
<tr>
<th>Neuromyths Question (From Dekker et al., 2012)</th>
<th>Instructional Practices Question(s) (Created for Study)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.</td>
<td>1. I try to adapt my lesson materials to whether there are more “right-brained” or “left-brained” students in my classroom. 2. When planning my lessons, I consider whether or not my students are more “right-brained” or “left-brained”.</td>
</tr>
<tr>
<td>Individuals learn better when they receive information in their preferred learning style (e.g. auditory, visual, kinesthetic).</td>
<td>3. I give students different activities to suit their learning style (auditory, visual, or kinesthetic) so that they are more capable of meeting the objectives. 4. I disregard students’ learning styles (auditory, visual, or kinesthetic) when planning my lessons. 5. I provide my students with a quiz during the school year so that I can determine their learning styles and adjust my teaching accordingly.</td>
</tr>
<tr>
<td>Environments that are rich in stimulus improve the brains of pre-school children.</td>
<td>3. I make my classroom as visually stimulating as possible to improve my students’ ability to think</td>
</tr>
</tbody>
</table>
Exercises that rehearse coordination of motor-perceptual skills can improve literacy skills.

3. I integrate physical activity into my course for the purpose of stimulating student literacy.
4. I provide my students with breaks from instructional time for movement so that they are better able to read.

Teacher Efficacy Scale

Both general teaching efficacy and personal teaching efficacy were measured using an adapted version of Gibson and Dembo’s (1984) teacher efficacy scale. The original 6-point Likert scale used in the Gibson and Dembo (1984) study was used for this study. Their original survey instrument had 30 items, but the survey used in this study was shortened to 16 of those items. JohnBull (2010) evaluated all 30 items and kept only the items that had a factor loading greater than or equal to .45. For the 16 included items, reliability was high for both of the subscales (Cronbach’s alpha= .79) (JohnBull, 2010). Some sample items are included in table 11.

<table>
<thead>
<tr>
<th>Table 11 Teacher Efficacy Sample Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Teaching Efficacy</strong></td>
</tr>
<tr>
<td>1. When the grades of my students improve, it is usually because I found more effective teaching approaches.</td>
</tr>
<tr>
<td>2. When I really try, I can get through to the most difficult students.</td>
</tr>
<tr>
<td>3. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him or her quickly</td>
</tr>
<tr>
<td><strong>General Teaching Efficacy</strong></td>
</tr>
<tr>
<td>1. If students aren’t disciplined at home, they aren’t likely to accept</td>
</tr>
</tbody>
</table>
any discipline.
2. If parents would do more with their children, I could do more.
3. Even a teacher with good teaching abilities may not reach many students.

Data Collection

Data were collected for both the pilot and the final survey administration. The pilot data were collected through an online medium from a convenience sample, and the final survey administration was sent out to over 4,000 public school teachers selected randomly from a representative sample of 100 schools.

Pilot

For the pilot, data was collected using an online survey format through Google Forms. For both schools involved in the pilot, the survey was conducted during the first week of professional development prior to the beginning of the 2015-2016 academic school year. The survey link was forwarded to the participants from a teacher within the school. The data was then uploaded from Google Forms to Excel and SPSS for analysis. Pilot cognitive interviews were held in two sessions. At the small independent high school, the cognitive interviewing focus group was conducted over Google Hangouts and recorded. At the public charter school, the cognitive interviewing focus group was held in person and also recorded on audio. These cognitive interviews were summarized into a memo and analyzed to determine face validity of the survey questions. That memo is included in Appendix I.

Final Survey Administration
The Pennsylvania Department of Education (PDE) categorizes all of the public school districts and schools in the state of Pennsylvania into nine “urban-centric locale” codes based on their location in the state. The school names and codes are all published on the PDE website in a downloadable spreadsheet. For the pilot, teacher emails were not needed, as the survey was sent out to them from someone employed within the school. A random number generator was utilized to select the 100 schools that were a part of the final survey administration. All of the teacher emails were then obtained from the public school websites.

For the final survey administration, data was collected using an online survey format through Google Forms. Each potential participant received a link to the survey on September 15, 2015 and they had 30 days to complete the survey. Once that date arrived, the data was uploaded from Google Forms to SPSS for analysis and the survey was no longer accepting responses.

**Data Analysis**

Data was analyzed in two stages; during the pilot and during the final survey administration. The following section discusses the analysis plan for both the pilot and the final survey administration. Validity was evaluated during the pilot of the study, and the survey was adjusted to ensure validity through the final survey administration. Reliability was analyzed along with the correlational data at the conclusion of the final survey administration.

**Validity**

To establish the face validity of the newly created survey items and the instrument as a whole, the pilot study utilized cognitive interviewing. The probes being used for the
cognitive interviewing are found in Appendix D. Content validity of the neuroscience literacy items can be found in the original study in which these survey items were utilized (Herculano-Houzel, 2012). In that study, a representative sample of both the general population and neuroscientists evaluated these items and only items that had 95 percent agreement among neuroscientists were included in this study (Herculano-Houzel, 2012).

**Analysis Plan- Pilot**

Once the survey was completed, teachers were invited to participate in one of two cognitive interviewing focus groups. The cognitive interviewing focus groups were recorded and then analyzed to create a memo of the challenges, recommendations, final decision, and rationale. This memo is included in Appendix I. The final changes were then made to the survey based on the results of the cognitive interviewing.

**Reliability**

To establish the reliability of the survey items, Cronbach’s coefficient alpha was used to measure internal consistency. The reliability of the survey items was measured during the final survey administration. During the final survey administration, the reliability of the neuromyths items, the instructional practices items, the neuroscience literacy items, the personal and general teaching efficacy items, and the entire scale was measured.

**Analysis Plan- Final Survey Administration**

Once the survey was completed, the results were uploaded into SPSS computer software. The results of the survey were analyzed using both descriptive and correlational statistics. To establish internal consistency, Chronbach’s alpha was used on the whole survey and each of the five subscales (beliefs in neuromyths, neuroscience literacy,
NEUROMYTHS AND INSTRUCTION

personal teaching efficacy, general teaching efficacy, instructional practices related to
neuromyths). Bivariate analyses were conducted to determine which of the independent
variables had a significant relationship with instructional practices related to neuromyths.
Independent-samples t-tests were conducted between teacher’s experience with brain
sciences measures and instructional practices. ANOVAs were conducted on age level,
subject area, school category, and education level. Results from the bivariate analyses
were used to build a linear hierarchical regression model to determine the nature of a
relationship between beliefs in neuromyths and instructional practices related to
neuromyths.

The dependent variable is:

Y1: Instructional Practices Related to Neuromyths

The independent variables are:

X1: Age
X2: Educational Level
X3: Experience with Brain Sciences
X4: Years of Teaching Experience
X5: Age Level Taught
X6: Subject Area
X7: School Category
X8: Beliefs in Neuromyths
X9: Neuroscience Literacy
X10: Personal Teaching Efficacy
X11: General Teaching Efficacy
NEUROMYTHS AND INSTRUCTION

Summary

To explore the relationship between teacher beliefs in neuromyths and teacher instructional practices, the researcher conducted a mixed-method exploratory study utilizing a qualitative cognitive interviewing pilot and a quantitative survey administration design. For the pilot, two high schools were selected, approximately 43 teachers were surveyed, and 15 teachers took part in the follow-up cognitive interviewing. The cognitive interviewing recordings were used to create a memo and the survey was adjusted accordingly. For the final survey administration, one hundred schools were selected and 4,519 teachers were invited to participate in the survey. The quantitative data were analyzed using bivariate analyses and linear hierarchical regression analysis. Using this analysis, the researcher hoped to glean more information about the relationship between neuromyths and instructional practices.
CHAPTER 4: RESULTS/FINDINGS

The following chapter reviews the findings of the survey administered to determine the nature of the relationship between a teacher’s beliefs in neuromyths, teacher efficacy, and his or her instructional practices. This chapter is organized into three parts. First, descriptive statistics are utilized to describe the teachers that participated in the study. Second, the results of the pilot study are shared as they relate to the first two research questions and the utility of the survey instrument created for this study. Third, inferential statistics are employed to answer the remaining four research questions.

Sample

A random sample of 4,519 Pennsylvania teachers were sent the link to participate in the finalized survey. These teachers were chosen from a representative sample of schools that matched the Pennsylvania breakdown of school demographics, as described in chapter three. Of these teachers, 118 people completed the survey for a response rate of 2.61 percent. Because the response rate was so low, there is the possibility of non-response bias. However, given the sample’s parity with both the Pennsylvania population and United States population of teachers, this is not likely to be a concern. Several variables were collected from the 118 teachers that took the survey, including age, level of education, teacher training, exposure to neuroeducation through coursework, school category, subject taught, grade level taught, and years of teaching experience. The following table presents the descriptive statistics conducted on the categorical measures of interest included within this study. Sample sizes are presented, along with percentages
and valid percentages of response. In discussing these results, the valid percentages, ignoring missing data, will be focused upon.

Table 12

Sample Descriptive Frequencies

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 30</td>
<td>18</td>
<td>15.3</td>
<td>16.3</td>
<td>15.3</td>
</tr>
<tr>
<td>30-39</td>
<td>37</td>
<td>31.4</td>
<td>57.7</td>
<td>28.9</td>
</tr>
<tr>
<td>40-49</td>
<td>22</td>
<td>18.7</td>
<td>10.8</td>
<td>25.1</td>
</tr>
<tr>
<td>50-59</td>
<td>31</td>
<td>16.3</td>
<td>15.3*</td>
<td>23.1</td>
</tr>
<tr>
<td>Over 60</td>
<td>8</td>
<td>6.7</td>
<td>-</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>116</td>
<td>98.3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Level of Education***

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelors Degree</td>
<td>27</td>
<td>22.9</td>
<td>32.9</td>
<td>39.9</td>
</tr>
<tr>
<td>Masters Degree</td>
<td>80</td>
<td>67.8</td>
<td>53.9</td>
<td>47.7</td>
</tr>
<tr>
<td>Doctorate</td>
<td>8</td>
<td>6.8</td>
<td>8.7</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>115</td>
<td>97.5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**School Category***

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>24</td>
<td>20.3</td>
<td>8.23</td>
<td>26</td>
</tr>
<tr>
<td>Rural</td>
<td>41</td>
<td>34.7</td>
<td>26.13</td>
<td>32</td>
</tr>
<tr>
<td>Suburban</td>
<td>40</td>
<td>33.9</td>
<td>38.16</td>
<td>27</td>
</tr>
<tr>
<td>Town</td>
<td>10</td>
<td>8.7</td>
<td>13.11</td>
<td>14</td>
</tr>
</tbody>
</table>

**Years of Teach Exp.***

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 3</td>
<td>8</td>
<td>0.7</td>
<td>6.2</td>
<td>9</td>
</tr>
<tr>
<td>3 to 9</td>
<td>29</td>
<td>25.4</td>
<td>37</td>
<td>33.3</td>
</tr>
<tr>
<td>10 to 20</td>
<td>47</td>
<td>41.2</td>
<td>35.7</td>
<td>36.4</td>
</tr>
<tr>
<td>Over 20</td>
<td>30</td>
<td>26.3</td>
<td>21</td>
<td>21.3</td>
</tr>
</tbody>
</table>

**Current age/grade level of the students taught***

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary</td>
<td>38</td>
<td>32.2</td>
<td>-</td>
<td>51</td>
</tr>
<tr>
<td>Secondary</td>
<td>74</td>
<td>62.8</td>
<td>-</td>
<td>49</td>
</tr>
<tr>
<td>K-12</td>
<td>3</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Attended Professional Conferences on the Brain or Education***

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>% Valid</th>
<th>PA Population</th>
<th>US Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>69</td>
<td>39.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>46</td>
<td>58.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>115</td>
<td>97.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**NEUROMYTHS AND INSTRUCTION**

*Required to take a course in biology, neuroscience, psychology, or biological basis of behavior as it relates to learning*

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>78</td>
<td>37</td>
<td>115</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>97.5</td>
</tr>
</tbody>
</table>

*Undergraduate degree in: biology, neuroscience, psychology or biological basis of behavior*

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>13</td>
<td>102</td>
<td>115</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>97.5</td>
</tr>
</tbody>
</table>

*Graduate degree in: biology, neuroscience, psychology, or biological basis of behavior*

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
<td>112</td>
<td>113</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td>96.4</td>
</tr>
</tbody>
</table>


* Age category by state ended with “55 and over”


**Age**

First, with regard to respondent age, the sample was more closely aligned with the United States’ population of teachers than the Pennsylvania population. Of the teachers in Pennsylvania, the largest percentage, 57.7 percent, fall between ages 30 and 39, which makes the sample in this study slightly older than the Pennsylvania population of teachers. The sample did have a slightly higher percentage of teachers in the 30-39 age range and slightly fewer teachers in each of the older age categories than the United States population. Overall, the sample was situated between the United States population and the Pennsylvania population, though it had more parity with the United States population of teachers.
Education Level

In terms of the highest level of education received, of the teachers surveyed, 6.8 percent had received doctorates, 67.8 percent had received masters degrees, and 22.9 had only bachelors degrees. However, of these teachers, 52.5 percent of them received their teacher training in their bachelors degree programs, 15.8 percent of them received their teacher training in their masters degree programs, 26.3 received teacher training at both the bachelors and masters level, and 2.6 percent of them received teacher training at the bachelors, masters, and doctoral levels. Only one respondent did a teacher certification program that yielded no degree in education. The education level was slightly higher than both the Pennsylvania population and the United States population of teachers.

School Categories

The school categories for the final survey administration were collapsed into urban, rural, suburban, and town. The sample was closer to the population of teachers in the United States than teachers in Pennsylvania. This could be partially attributed to the fact that the school categories were not defined and, therefore there may be some lack of clarity. There were slightly more urban and rural teachers than in the Pennsylvania sample, but slightly less suburban and town teachers. In contrast, there were slightly less urban and town teachers in the sample and slightly more suburban and rural teachers than the United States population of teachers.

Teaching Experience

Teacher’s experience in education ranged from new teachers with no teaching experience to teachers with 41 years of teaching experience. The mean years of teaching experience was 15.17 years and the standard deviation was 9.56. Compared to both the
Pennsylvania and United States population of teachers, the sample involved in this study had a higher number of teachers with more years of teaching experience.

**Experience with Brain Sciences**

Respondents were also asked whether they were required to take a course in biology, neuroscience, psychology, or a course on the biological basis of behavior as it relates to learning. Slightly over 66.1 percent of respondents indicated they had not, with the remainder, close to 31.4 percent, indicating that they had. Following this, individuals were asked whether they have an undergraduate degree in the fields of biology, neuroscience, psychology, or on the biological basis of behavior. Of these respondents, 86.1 percent of individuals indicated that they did not, with the remainder, 11 percent, indicating that they did. Respondents were also asked whether they have a graduate degree in the fields of biology, neuroscience, psychology, or the biological basis of behavior. Nearly 99 percent of individuals indicated they did not, with the remainder, slightly over 1 percent, indicating that they did. Information about the United States population of teachers and Pennsylvania population of teachers in regards to the brain sciences measures was not available.

**Subject Area Taught**

Teachers in the sample represented many different subject areas. Subject areas included elementary education, computer, business education, social studies, physical education, English, special education specialties (ELL, autistic support, life skills, multiple disabilities), gifted education, reading, art, science, music, elementary specialties (math, reading, early intervention, library), and language. For the purposes of this study, teachers were divided into two categories by whether they primarily taught a science or
non-science subject. Of the sample, 79.7 percent of the teachers taught a non-science subject, while 18.3 percent primarily taught science. This was significantly different than the United States population, where only 6.7 percent of total teachers, and 12 percent of secondary teachers, teach a science subject (U.S. Department of Education, 2011).

Research Questions and Statistical Analyses

The following section will detail the findings and results for each of the seven research questions outlined in this study. The research questions and findings from the pilot will come first, followed by the data from the final survey administration.

Pilot Research Question 1: As it stands, what is the utility of the survey in assessing teachers’ beliefs in neuromyths?

According to the cognitive interviews conducted in the pilot, the survey has strong face validity and measures what it intends to measure. Teachers were not able to identify the terms “neuromyths” or “instructional practices” when referring to what the survey was measuring, but provided the following topics when asked what they thought the survey was asking:

“How teachers adapt their teaching to left brain/right brain students” (1 teacher said this)
“Learning styles” (3 teachers said this)
“Measuring teacher’s knowledge of brain processes” (1 teacher said this)
“Brain use as it relates to learning” (1 teacher said this)
“What you understand about the brain, how it applies to learning styles, and whether these ideas are true” (1 teacher said this)
“How the brain [interprets] information” (1 teachers aid this)

These answers indicate that the teachers involved in the pilot study knew that the survey was measuring their knowledge of the neuromyths, specifically hemispheric dominance and learning styles, instructional practices, and whether the teachers were applying their knowledge to what they were doing in their classrooms. Interestingly,
Teachers from both cognitive interviewing focus groups indicated that taking the survey made them feel like they should be doing more in their classrooms or were not adjusting their instruction enough to the neuromyths.

**Pilot Research Question 2: How might the survey be altered to improve the utility in assessing teachers’ beliefs in neuromyths?**

The final survey needed to be altered in one way. School categories were changed from 12 possibilities to four possibilities. The new options were, “town”, “suburban”, “rural” and “city.” These still aligned with the Pennsylvania Department of Education categories, but were less specific than the demographic categories utilized. This adjustment was made to help teachers more accurately identify their school category.

**Preliminary Analyses**

A series of preliminary analyses were conducted prior to analyzing the data obtained from the final survey administration. These analyses were conducted to evaluate the validity and reliability of the survey instrument.

**Reliability.** Cronbach’s alpha is used as a measurement of reliability to determine whether the items are homogenous and are measuring the same construct (Cronbach, 1951). Reliability analyses were conducted on all scale items in this study in order to determine their level of internal consistency. These results are presented in Table 13. As shown, reliability was found to be slightly below the standard of 0.7 with regard to instructional practices associated with neuromyths and general teaching efficacy, was substantially lower with regard to the personal teaching efficacy subscale, and was found to be above 0.7 with regard to the scales of neuroscience literacy as well as beliefs in
neuromyths. High reliability indicates internal consistency of the scale, or that each of the individual items in a subscale were all measuring the same construct. The results from the reliability analysis indicate that high reliability was not found in all cases, though reliability was also not found to be very low with regard to any of these scales.

Table 13

Reliability Analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>N Items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Practices associated with Neuromyths</td>
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</tr>
<tr>
<td>Neuroscience Literacy</td>
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<td>.767</td>
</tr>
<tr>
<td>Beliefs in Neuromyths</td>
<td>12</td>
<td>.713</td>
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</table>

Teacher Efficacy

General                          | 7       | .670            |
Personal                         | 7       | .592            |

Internal consistency correlations. A series of correlations were conducted between the items constituting each of the four scales included within this study in order to further test for internal consistency.

Instructional practices scale. First, the following table presents a summary of the correlations between all of the Instructional Practices measures. As shown, correlations were generally found to be approximately moderate in strength, with a substantial set of significant correlations indicated. This would suggest internal consistency with regard to this scale.

Table 14

---

1 The standard acceptable range for Cronbach’s alpha is 0.7-0.9 (George & Mallery, 2003).
Correlations between Instructional Practices Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>HD1</th>
<th>HD2</th>
<th>VAK1</th>
<th>VAK2</th>
<th>VAK3</th>
<th>EE1</th>
<th>EE2</th>
<th>BG1</th>
</tr>
</thead>
<tbody>
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<td>.37**</td>
<td>.35***</td>
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<td>.54**</td>
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</tbody>
</table>

Note. *p<.05, **p<.01, ***p<.001.

Note. HD= Hemispheric dominance, VAK= Learning Styles, EE=Enriched Environments, BG= Brain Gym

Teacher efficacy scales. Table 18 presents the results of the correlations between the items relating to teacher efficacy. Weak to moderate correlations were found, with a substantial set of significant correlations indicated within this set of analyses (-0.31-0.44). These results also suggest internal consistency for this scale.
Table 15

<table>
<thead>
<tr>
<th>Meas.</th>
<th>PTE1</th>
<th>PTE2</th>
<th>PTE3</th>
<th>PTE4</th>
<th>PTE5</th>
<th>PTE6</th>
<th>PTE7</th>
<th>GTE1</th>
<th>GTE2</th>
<th>GTE3</th>
<th>GTE4</th>
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</table>

*Note. PTE = Personal Teaching Efficacy, GTE = General Teaching Efficacy*

*Note. *p<.05, **p<.01, ***p<.001.*
**Neuroscience literacy items.** The final set of correlations focused upon the relationships between the neuroscience literacy items. These analyses were conducted using the phi coefficient, as respondents either answered correctly or incorrectly with regard to these items, making these measures dichotomous. As shown in Table 19, no correlation is presented in a number of these cases due to the lack of variation in a number of these items. However, as shown, several significant correlations were indicated (0.19-0.34). These results, taking into consideration the results of the Cronbach’s alpha reliability analyses conducted, suggest internal consistency with regard to this scale.
Table 16

*Correlation between Neuroscience Literacy Measures*

<table>
<thead>
<tr>
<th>Meas.</th>
<th>NL 1</th>
<th>NL 2</th>
<th>NL 3</th>
<th>NL 4</th>
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</tr>
</tbody>
</table>

*Note.* NL= Neuroscience Literacy
Final Survey Administration Question 1: Do teachers report that they believe in neuromyths and to what degree do they believe neuromyths?

**Descriptive statistics.** The following table presents descriptive statistics conducted on the beliefs in neuromyths items. Slightly more than 98 percent (98.28) of teachers answered yes to at least one of the neuromyths beliefs questions. It should be noted here that, for the purposes of analysis beyond the descriptive level that a response of “I don’t know” was coded in the same way as a response of “no”.

Table 17

*Descriptive Statistics: Neuromyths*

<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>No</th>
<th>I don’t know</th>
<th>Yes</th>
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<td>1</td>
<td>17</td>
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<td>63</td>
</tr>
<tr>
<td>VAK1</td>
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<td>5</td>
<td>108</td>
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<td>VAK2</td>
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<td>8</td>
<td>7</td>
<td>101</td>
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<td>42</td>
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</table>

*Note.* HD= Hemispheric Dominance, VAK= Learning Styles, EE= Enriched Environments, BG= Brain Gym

Some of the neuromyths items showed variability among responses, while others showed stronger adherence. For example, the third hemispheric dominance question showed a more even split between no (n=29), I don’t know (n=22) and yes (63). Similarly, the third enriched environments question showed variability between no
(n=13), I don’t know (n=45), and yes (57) responses. For several of the questions, there was a lot of adherence. These include the first two hemispheric dominance questions, all three of the learning styles questions, and two of the enriched environments questions. Of the four neuromyths measured, there were less “yes” answers for the questions about the connection between literacy and exercise, though there were also very few responses indicating that teachers knew the neuromyths statements to be false.

**Neuromyths items.** Next, the following table presents the correlations conducted between the neuromyths. Approximately weak to moderate correlations were commonly found (0.04-0.56), with a large set of correlations between these measures found to achieve statistical significance (0.20-0.56). These results also suggest internal consistency for this scale.
Table 18

**Correlation between Neuromyths**

<table>
<thead>
<tr>
<th>Meas.</th>
<th>HD1</th>
<th>HD2</th>
<th>HD3</th>
<th>VAK1</th>
<th>VAK2</th>
<th>VAK3</th>
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<td>.04</td>
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<td>.18</td>
<td>.18</td>
<td>.41**</td>
<td>.52**</td>
</tr>
</tbody>
</table>

**Note.** *p<.05, **p<.01, ***p<.001.

**Note.** HD= Hemispheric dominance, VAK= Learning Styles, EE=Enriched Environments, BG= Brain Gym
Final Survey Administration Question 2: To what extent do teacher beliefs in neuromyths explain variance in his or her reported instructional practices?

**Pearson’s correlation.** A series of four Pearson’s correlations were conducted in order to determine the relationship between neuromyths instructional practices and neuromyths beliefs, neuroscience literacy, general teaching efficacy, and personal teaching efficacy. Statistical significance was indicated with respect to the relationship between instructional practices related to neuromyths and neuromyths beliefs, $r(106) = .367, p < .01$. This result indicates that a positive and significant association of moderate size exists between these two measures.

**Linear regression model.** The results of bivariate analyses were used in order to build a linear regression model. The independent variables found to achieve statistical significance in the bivariate analyses conducted were incorporated within this regression model, which consisted of beliefs in neuromyths and personal teaching efficacy. The results of this regression model are presented in Table 16. As shown, both variables retain their statistical significance within this regression model.

The overall regression model was found to achieve statistical significance on the basis of the $F$-test conducted, with the $R$-squared indicating that 9.3% of the variation in instructional practices is explained on the basis of this regression model. Furthermore, substantial multicollinearity was not indicated on the basis of the measures of tolerance and variance inflation factors found within this model. Additional diagnostics indicated normally distributed residuals, no substantial homoscedasticity, and no non-linearity or substantial outliers.
Table 1

Regression Analysis

<table>
<thead>
<tr>
<th>Measure</th>
<th>B</th>
<th>SE</th>
<th>Beta</th>
<th>F</th>
<th>p</th>
<th>$R^2$ Change</th>
<th>Cum $R^2$</th>
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</thead>
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<td>GTE</td>
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<td>0.08</td>
<td>0.08</td>
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<td>0.41</td>
<td>0.01</td>
<td>0.01</td>
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<td>9.24</td>
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<td>0.08</td>
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</table>

Note. $F(2, 100) = 11.56, p < .001; R^2 = .188$. No variance inflation factor (VIF) was found to meet the threshold of concern for multicollinearity, PTE = Personal teaching efficacy, Beliefs = Neuromyths beliefs

Final Survey Administration Question 3: What is the relationship between neuroscience literacy and teacher instructional practices?

Pearson’s correlation. A series of four Pearson’s correlations were conducted in order to determine the relationship between instructional practices and neuromyths beliefs, neuroscience literacy, general teaching efficacy, and personal teaching efficacy. A significant correlation was not indicated with respect to neuroscience literacy and neuromyths instructional practices, $r(106) = .118, p = .228$. However, a significant correlation was indicated with respect to neuroscience literacy and beliefs in neuromyths, $r(103) = .448, p < .01$. This indicates a positive, moderate relationship between neuroscience literacy and beliefs in neuromyths.

Final Survey Administration Question 4: What is the relationship between teacher efficacy and teacher beliefs in neuromyths and teacher instructional practices?

Bivariate analyses. First, a series of bivariate analyses were conducted for the purposes of building the regression model which served to determine the nature of the relationship between the predictors of interest and instructional practices related to
neuromyths. Spearman’s correlations were conducted between the dependent variable, instructional practices, and the independent variables of years of teaching experience and level of education. A significant association was not indicated with years of teaching experience, $\rho(111) = .096, p = .315$, with significance found with regard to respondent education, $\rho(112) = .220, p < .05$. Additionally, an ANOVA was also conducted between instructional practices and level of education. This analysis indicated a significant mean difference in instructional practices on the basis of category of level of education, $F(2, 112) = 4.727, p < .05$.

**Independent-samples t-tests.** A series of independent-samples $t$-tests were also conducted in order to determine the relationship between instructional practices and the measures focusing upon experience with brain sciences. Table 20 presents the descriptive statistics associated with these analyses. As shown, mean differences in instructional practices related to neuromyths on the basis of these measures were found to be small.

Table 20

<table>
<thead>
<tr>
<th>Measure</th>
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<th>Mean</th>
<th>SD</th>
</tr>
</thead>
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<tr>
<td>Conferences</td>
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</tr>
<tr>
<td>No</td>
<td>45</td>
<td>3.27</td>
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<tr>
<td>Yes</td>
<td>67</td>
<td>3.42</td>
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<td>MBT Exposure 1</td>
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<tr>
<td>No</td>
<td>37</td>
<td>3.19</td>
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<td>75</td>
<td>3.44</td>
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<td>3.27</td>
<td>0.57</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Yes</td>
<td>109</td>
<td>3.89</td>
<td>0.58</td>
</tr>
</tbody>
</table>
Note. MBT Exposure 1 refers to whether the respondent was required to take a course in brain sciences in their teacher preparation program, MBT Exposure 2 refers to whether the respondent had an undergraduate degree in brain sciences, MBT Exposure 3 refers to whether the respondent had a graduate degree in brain sciences.

Next, table 21 summarizes the results of these independent-samples t-tests.

Levene’s tests, conducted to test the assumption of the homogeneity of variances, was not found to achieve statistical significance in any case. These results indicate that the assumption of the homogeneity of variances was not violated with regard to these analyses. With respect to the independent-samples t-tests conducted, statistical significance was not indicated with the exception of the t-test conducted with MBT Exposure 1, or whether or not the teacher was required to take a course in the brain sciences during their teacher preparation program.

Table 21

<table>
<thead>
<tr>
<th>Measure</th>
<th>Levene’s Test</th>
<th>t-Test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
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<td>$E$</td>
<td>$p$</td>
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<tr>
<td>Difference</td>
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<tr>
<td>Conferences</td>
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<td>.24</td>
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<td>MBT Exposure 1</td>
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<td>.46</td>
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<td>MBT Exposure 2</td>
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<td>MBT Exposure 3</td>
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<td>.92</td>
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</table>

Note. MBT Exposure 1 refers to whether the respondent was required to take a course in brain sciences in their teacher preparation program, MBT Exposure 2 refers to whether the respondent had an undergraduate degree in brain sciences, MBT Exposure 3 refers to whether the respondent had a graduate degree in brain sciences.

An additional independent samples t-test was conducted to determine the relationship between instructional practices and whether or not the teacher taught a science or non-science subject. Table 22 presents the descriptive statistics associated with
these analyses. As shown, mean differences in instructional practices related to neuromyths on the basis of these subject area taught were found to be small.

Table 22

*Independent-Samples t-Tests with Experience with Subject Area Taught*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Levene’s Test</th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>$E$</td>
<td>$p$</td>
<td>$t$</td>
<td>$df$</td>
<td>$p$</td>
<td>Mean Difference</td>
<td>$SE$</td>
<td>Difference</td>
<td>$SE$</td>
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<td>0.17</td>
<td>0.14</td>
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</table>

**Pearson’s correlation.** A Pearson’s correlation was conducted between instructional practices and years of teaching experience, which was treated as a continuous variable for the purposes of this analysis. This analysis indicated no significant correlation between these two measures, $r(111) = .138$, $p = .150$.

A series of additional Pearson’s correlations were conducted in order to determine the relationship between instructional practices and neuromyths beliefs, neuroscience literacy, general teaching efficacy, and personal teaching efficacy. A significant correlation was not found with respect to general teaching efficacy and instructional practices, $r(110) = .123$, $p = .202$. A significant, positive, and moderate relationship was found with respect to general teaching efficacy and beliefs in neuromyths, $r(105)=2.58$, $p<.01$. A significant correlation was also found between instructional practices related to neuromyths and personal teaching efficacy, $r(110) = .314$, $p < .01$. This latter result indicates a positive, moderate, and significant association between instructional practices and personal teaching efficacy. A significant correlation was not found with respect to personal teaching efficacy and beliefs in neuromyths.
ANOVAs. A one-way ANOVA focused upon school category. As shown in Table 24, no significance was indicated in instructional practices on the basis of school category.

Table 23

**ANOVA with School Category**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
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<td>Between Groups</td>
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<td>.50</td>
<td>1.53</td>
<td>.219</td>
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<tr>
<td>Within Groups</td>
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<td>110</td>
<td>.33</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>36.39</td>
<td>111</td>
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</table>

Regression model. A linear regression analysis was also conducted on these data. A one standard deviation increase in personal teacher efficacy was found to be associated with a .314 standard deviation increase in neuromyths instructional practices. The overall regression model was found to achieve statistical significance on the basis of the F-test conducted, with the $R^2$ indicating that 27% of the variation in instructional practices is explained on the basis of this regression model. The linear regression analysis consisted of a hierarchical model to determine the relationship between the variables and the amount of variance that could be attributed to personal teacher efficacy and beliefs in neuromyths over and above the control variables. The analysis, the results of which are summarized in Table 25, consists of a series of five linear regression analyses in total. The initial model contained the control variables of teaching experience, level of education, all three brain sciences exposure measures, and subject area taught (whether science or non-science), as factors accounting for variance. All of these variables are reflected in the regression model to represent the teachers more holistically and to accurately identify the amount of variance attributable to beliefs in neuromyths.
and personal teaching efficacy over and above all the other variables. The second model added neuroscience literacy. The third model included all the previous predictors and added general teaching efficacy. The fourth and fifth models added in personal teaching efficacy and beliefs in neuromyths, respectively. The results of first two models indicate that none of the variables achieved significance. In the third model, only the requirement of a brain sciences course (MBT Exposure 1) was found to account for statistically significant variance (F(1, 83)= 1.41, p=.05). variance in the first, second, and third models conducted. In the fourth linear regression model, only the predictor of personal teaching efficacy was found to explain statistically significant variance (F(1,82)=2.71, p<.01). In the fifth linear regression model, both personal teaching efficacy (F(1,81)=3.05, p<.01) and beliefs in neuromyths (F(1,81)=3.05, p=.03) were found to explain statistically significant variance. Over and above all the other control variables, both personal teaching efficacy and beliefs in neuromyths explained a significant amount of variance in instructional practices associated with neuromyths. The regression equation for the fifth model is:

\[ IP' = 1.32 + 1.23(\text{Level of Ed}) + .06(\text{Teaching Exp.}) - 1.97(\text{Subject Taught}) - 1.09(\text{MBT Exposure 1}) - 1.49(\text{MBT Exposure 2}) + 1.62(\text{MBT Exposure 3}) + .12(\text{Neuroscience Literacy}) + .1(\text{General Teaching Efficacy}) + .39(\text{Personal Teaching Efficacy}) + .21(\text{Beliefs in Neuromyths}) \]
Table 24
Hierarchical Regression Analysis

<table>
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<th>Measure</th>
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<th>Beta</th>
<th>p</th>
<th>R</th>
<th>( \text{cum } R^2 )</th>
<th>( R^2 )</th>
<th>Change</th>
<th>F</th>
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### NEUROMYTHS AND INSTRUCTION

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*Note:* No variance inflation factor (VIF) was found to meet the threshold of concern for multicollinearity.
With respect to these five models, statistical significance for the overall regression model was found in the fourth (F(1,82)=2.71, \( p<.01 \)) and fifth models (F(1,81)=3.05, \( p=.00 \)). R-squared measures were found to range from a minimum of 0.05 in the second and third regression models to a maximum of 0.184 in the fifth regression model. Within this fifth model, this result indicates that 18.4 percent of the variance in instructional practices related to neuromyths is explained on the basis of the set of predictors included within this analysis which are level of education, teaching experience, subject area taught, experience with brain sciences, general teaching efficacy, personal teaching efficacy, and beliefs in neuromyths. Cohen’s \( d \) calculations equal 1.22 indicating a large effect size (Cohen, 1988). The control variables accounted for 5 percent of the variance in instructional practices related to neuromyths. Over and above the control variables, personal teaching efficacy and beliefs in neuromyths accounted for an additional 13.4 percent of the variance.

Summary

Within this chapter, the results of the analyses conducted for this study were presented and discussed. These analyses indicated a reasonable level of internal consistency reliability with regard to the scale items included within this study, while the bivariate analyses conducted indicated beliefs in neuromyths, personal teaching efficacy, level of education, and MBT Exposure 1 to significantly predict the dependent variable, neuromyths instructional practices. A series of five linear regression analyses confirmed the significance of level of education, beliefs in neuromyths, and the personal teaching
efficacy. The following chapter will discuss these results in relation to previous literature as well as the limitations of the present study and possibilities for future research.
CHAPTER 5: DISCUSSION

Purpose of Study

The purpose of this study was to examine the potential relationship between teacher beliefs in neuromyths and teacher instructional practices associated with neuromyths. To explore the nature of that relationship, a pilot survey was created and sent to a small group of teachers at two Pennsylvania schools. Two research questions guided the pilot:

1. As it stands, what is the utility of the survey in assessing teachers’ beliefs in neuromyths?
2. How might the survey be altered to improve the utility in assessing teachers’ beliefs in neuromyths?

Once refined, the survey was sent to a large sample of Pennsylvania and data was collected over the course of a month. The following research questions were used to guide the final survey administration and resulting analysis:

1. Do teachers report that they believe in neuromyths and to what degree do they believe neuromyths?
2. To what extent do teacher beliefs in neuromyths explain variance in his or her reported instructional practices?
3. What is the relationship between neuroscience literacy and teacher beliefs in neuromyths and teacher instructional practices?
4. What is the relationship between teacher efficacy and teacher beliefs in neuromyths and teacher instructional practices?

Methodology
NEUROMYTHS AND INSTRUCTION

The study conducted was a mixed-methods exploratory study whose purpose was to determine the nature of the relationship between teachers’ beliefs in neuromyths and their instructional practices. Cognitive interviewing was utilized in the pilot to determine the face validity of the instrument created for the purpose of the study and to answer the two pilot research questions. Once the survey was changed based on the results of the pilot, descriptive statistics and hierarchical linear regression analyses were used to answer the remaining four research questions. The population in the sample was public teachers in Pennsylvania. One hundred schools were included in the sample and 4,519 teachers were sent the link to the survey. Of these teachers, 118 completed the survey.

Summary of Findings

Results from the statistical analyses are presented in the following section to address each of the four research questions involved in the final survey administration.

Final Survey Research Question 1: Do teachers report that they believe in neuromyths and to what degree do they believe neuromyths?

According to item frequencies, slightly more than 98 percent (98.28) of teachers answered yes to at least one of the neuromyths beliefs questions, so the results indicated that teachers had a very high level of beliefs in neuromyths. Of the four neuromyths tested in this study, the most teachers believed in learning styles (n= 99-108) and hemispheric dominance (n= 63-104). While both literacy and exercise, or brain gym, (n=71-93) and enriched environments (n=57-100) were a bit weaker, there were still many teachers who believed in these neuromyths.

Final Survey Research Question 2: To what extent do teacher beliefs in neuromyths explain variance in his or her reported instructional practices?
The results of a Pearson’s correlation indicated that a one standard deviation increase in teachers’ beliefs in neuromyths was found to be associated with a 0.367 standard deviation increase in instructional practices related to neuromyths. The relationship between these two variables was significant, positive, and moderate. This indicates a Cohen’s effect size of 0.79, a medium effect size (Cohen, 1988). The results of a hierarchical regression model indicated that beliefs in neuromyths, when combined with personal teaching efficacy, accounted for 18.4 percent of the variance in instructional practices related to neuromyths.

**Final Survey Research Question 3: What is the relationship between neuroscience literacy and teacher beliefs in neuromyths and teacher instructional practices?**

There was no statistically significant relationship found between teachers’ neuroscience literacy and their instructional practices related to neuromyths. There was a statistically significant relationship between beliefs in neuromyths and neuroscience literacy. A one standard deviation increase in neuroscience literacy was associated with a 0.448 standard deviation increase in beliefs in neuromyths. It should be noted, however, that there was little variability in responses on the neuroscience literacy scale and most respondents did not answer the questions correctly.

**Final Survey Research Question 4: What is the relationship between teacher efficacy and teacher beliefs in neuromyths and teacher instructional practices?**

There was no statistically significant relationship between general teaching efficacy and instructional practices related to neuromyths. There was a positive, moderate, and significant relationship between general teacher efficacy and beliefs in neuromyths. One standard deviation increase in general teaching efficacy was associated
with a 0.258 standard deviation increase in instructional practices related to neuromyths. There was also a significant, moderate, and positive relationship between personal teaching efficacy and instructional practices related to neuromyths. A one standard deviation increase in personal teacher efficacy was associated with a 0.314 standard deviation increase in instructional practices related to neuromyths.

When combined with beliefs in neuromyths, personal teaching efficacy accounts for 17 percent of the variance in instructional practices. Beliefs in neuromyths and personal teaching efficacy explained the most variance in instructional practices. General teaching efficacy did not explain any of the variance in instructional practices.

**Summary of Additional Findings**

There were several other findings of interest and additional analyses in the study that did not directly relate to the research questions. These findings are explained below. Analyses of variance and independent samples t-tests were used to explore whether any of the additional variables measured were related to instructional practices related to neuromyths. No significant difference was found in instructional practices on the basis of age level taught, subject area taught (science versus non-science subjects), type of school, years of teaching experience, and all of the experiences with brain sciences measures except one. Although level of education, and MBT Exposure 1 (or whether the teacher was required to take a brain sciences course as part of their teacher preparation programs) were both found to have a statistically significant relationship with instructional practices related to neuromyths, these did not have significance when entered into 4 of the 5 regression models which included subject area taught, years of teaching experience, the additional experiences with brain sciences measures, general
teaching efficacy, personal teaching efficacy, neuroscience literacy, and beliefs in neuromyths. Although in the third regression model, which included level of education, years of teaching experience, subject area taught, exposure to brain sciences, neuroscience literacy, and general teaching efficacy, MBT Exposure 1 (whether or not the teacher had been required to take a brain sciences course in their teacher preparation program) did achieve significance, it accounted for a very small part of the variance. Personal teaching efficacy and beliefs in neuromyths explained far more of the variance in instructional practices related to neuromyths than did level of education or whether or not the teacher participant was required to take a brain sciences course as part of their teacher preparation program.

Discussion

The research and findings have important implications for the fields of neuroeducation, teacher efficacy, and teacher preparation. Additionally, should this study be repeated, there are some important considerations and changes that should be made to the instrument.

Beliefs in Neuromyths

The findings from the first research question indicated that teachers do still believe in neuromyths, despite the proliferation of neuroeducation programs and brain-based education models (Dubinsky, 2000-2003; Hardiman, 2012; Jensen, 2008). These results confirm the findings of other researchers (Alecko, 2012; Dekker et al., 2012; Gleichgerrcht et al., 2015; Rato et al., 2012). What this might indicate is a communication problem in the field of education between scholars and practitioners. So, while the field of neuroeducation continues to grow, the research does not seem to be
NEUROMYTHS AND INSTRUCTION

translating quickly to accurate understandings of brain structure and function related to student learning. While Daniel (2012) makes the case that we should be cautious about integrating findings from neuroscience and cognitive psychology into teachers’ classroom practice, this study indicates that even correct background information, information that some would call essential, is not even being accessed by teachers.

Beliefs in Neuromyths and Teacher Instructional Practices

The findings from the item frequencies, Pearson’s correlations, and hierarchical regression analyses from the first two research questions indicate that teachers’ beliefs in neuromyths are impacting what they do in the classroom. Only the study by Alekno (2012) explored whether neuromyths impacted classroom practices, but their study indicated that teachers’ beliefs in neuromyths only slightly impacted their pedagogy. This study found a stronger relationship between the beliefs in neuromyths and reported instructional practices related to neuromyths. There are two differences between the study conducted here and Alekno’s (2012) study. Alekno’s (2012) study only involved teachers at one school district in the Midwest, while this study involved teachers across the entire state of Pennsylvania. Second, the questions in each study were worded differently. In relation to beliefs in neuromyths, teachers in Alekno’s (2012) study were asked to rate their beliefs on a Likert scale, whereas this study used a forced choice scale of “yes”, “no”, or “I don’t know.” Teachers in Alekno’s (2012) study were also asked whether or not they believed in a particular neuromyth and then asked immediately following whether they adjust their instruction on the basis of that belief. This study used different language to ask questions about instructional practices related to neuromyths. The difference in the strength of the relationship found between this study and Alekno’s
(2012) study may reflect a change in the field of education over the 4 years between the studies, the difference in the wording of the questions, or the different populations evaluated. Regardless, the results of this study do confirm the relationship identified in Alekno (2012).

**Neuroscience Literacy and Instructional Practices**

The findings from the Pearson’s correlation for the third research question indicate that there is no significant relationship between neuroscience literacy and instructional practices related to neuromyths. An interesting finding, however, is that there was a significant, positive, and moderate relationship between beliefs in neuromyths and neuroscience literacy. These results should be accepted cautiously due to both the small sample size and the small number of respondents who answered correctly to any of the neuroscience literacy questions. This does, however, confirm the findings in Dekker et al. (2012) that indicated that an increase in neuroscience literacy was related to an increase in beliefs in neuromyths. This is not surprising, considering the origin of the neuromyths, because most neuromyths are rooted in a misapplication or a misunderstanding of research findings. Knowing a little bit about the brain appears to be more dangerous than knowing nothing. Yet, more research should be done to determine whether having a comprehensive understanding of brain sciences as it relates to student learning changes these results. Neuroscience literate teachers were not part of the study.

The difference between this study and the Dekker et al. (2012) study, in terms of neuroscience literacy, was the scale used to measure general knowledge and the scale used to measure neuroscience literacy. The scale used in this study was taken from Herculano-Houzel (2002) and was considerably more complex than the scale used in the
NEUROMYTHS AND INSTRUCTION

Dekker et al. (2012) study. The questions in the Dekker et al. (2012) study also focused more on general neuroscience knowledge as it relates to learning, not just in general. Further research needs to be conducted to tease out the relationship between neuroscience literacy and neuromyths, specifically to determine the extent to which neuroeducation professional development programs, brain-based teaching programs, psychology courses, or neuroscience courses in teacher preparation programs could be utilized to dispel neuromyths.

**Instructional Practices and Teacher Efficacy**

The findings from Pearson’s correlations and the hierarchical regression analyses regarding the fourth research question indicated that there was a moderate statistically significant relationship between personal teaching efficacy and instructional practices related to neuromyths. No relationship was found between general teaching efficacy and instructional practices related to neuromyths. Over and above the other control variables, personal teaching efficacy accounts for an additional 11 percent of the variance in instructional practices related to neuromyths, more than any of the other variables measured in this study. This study indicates that beliefs in neuromyths are related to instructional practices and personal teaching efficacy is related to instructional practices, but that the two are not significantly related to each other. Yet, there is a significant relationship between general teaching efficacy and beliefs in neuromyths, which may indicate that beliefs in neuromyths is a type of general teaching efficacy belief.
The teacher efficacy literature indicates that personal teaching efficacy is related to teacher behaviors such as planning and organization, classroom management, interactions with students, and enthusiasm for teaching (Allinder, 1994; Ashton & Webb, 1986; Gibson & Dembo, 1984), but no study prior to this one has explored the relationship between teacher efficacy and beliefs in neuromyths or instructional practices related to neuromyths.

![Diagram showing relationships between constructs]

*Figure 2: Relationship between constructs*

**Exposure to Brain Sciences and Instructional Practices**

ANOVA s and Independent samples t-tests were conducted to determine the extent to which the following four questions were related to instructional practices related to neuromyths:

1. Have you attended any professional conferences focusing on the brain or education?
2. Were you required, in your teacher preparation program(s) to take any course in biology, neuroscience, psychology, or biological basis of behavior as it relates to learning?
NEUROMYTHS AND INSTRUCTION

3. Do you have an undergraduate degree in any of the following fields: biology, neuroscience, psychology or biological basis of behavior?

4. Do you have a graduate degree in any of the following fields: biology, neuroscience, psychology, or biological basis of behavior?

The findings indicated that there was no significant relationship between the first, third, and fourth of these factors and instructional practices related to neuromyths. The second question, or whether the teacher was required to take a brain sciences course in their teacher preparation program, was found to be related to a change in teacher instructional practices related to neuromyths. However, when entered into the regression models, this no longer retained its significance. This indicates that neuromyths can permeate teachers’ belief systems regardless of their background courses or engagement with education at the professional level. This either represents the notion that neuromyths are being transmitted in some of these courses or that neuromyths are being transmitted in subtle ways while in the field of K-12 education.

Use of the Instrument

Findings from the internal consistency and correlational analyses indicated that several parts of the instrument had high reliability. These were the beliefs in neuromyths ($\alpha = 0.713$), instructional practices related to neuromyths ($\alpha = 0.694$), and neuroscience literacy subscales ($\alpha = 0.812$). The personal teaching efficacy subscale had substandard reliability ($\alpha = 0.592$). For the future use of this instrument, several changes should be made.

Beliefs in neuromyths subscale. There are three changes that should be made in the future to the beliefs in neuromyths subscale. First, beliefs in neuromyths should be measured using a Likert scale like the one used in Dekker et al. (2012), so that the strength of the belief can be evaluated and correlated with instructional practices. Second,
some of the questions that were added for the purposes of this study should be removed if they continue to show low correlations with other questions measuring the same neuromyth. In particular, the third hemispheric dominance question (“Every person favors either their left brain hemisphere or right brain hemisphere, and which hemisphere a person favors can be determined by his or her personality traits”) and the third enriched environments question (“Science has proven that having an environment with a lot of external stimuli can improve learning outcomes”) should be evaluated. Third, additional neuromyths should be added to see if this still holds true for neuromyths that did not meet the qualifications for inclusion within this study.

**Neuroscience literacy subscale.** Additionally, very few responses on the neuroscience literacy scale were correct, indicating very low levels of neuroscience literacy. For this reason, that subscale should be revised to include questions that are more appropriately leveled and also measure neuroscience literacy specific to student learning and teaching. This subscale should also be moved to the end of the survey, before the demographic questions, so that participants who find these questions difficult are not discouraged.

**Teaching efficacy subscales.** Although the general teaching efficacy subscale was close to the standard for reliability, both the general teaching efficacy and personal teaching efficacy subscale could have improved reliability. Additional analyses indicated that the removal of none of the items in the personal teaching efficacy scale or the general teaching efficacy scale would substantially improve reliability for either of the subscales. Other studies have also indicated low reliability for each of these subscales and, therefore, they should remain unchanged in future studies.
Instructional practices related to neuromyths subscale. For future use of the instrument, the second enriched environment question should be changed or removed. Doing so would substantially increase the reliability of the subscale ($\alpha = 0.718$). Additional instructional practices that are potentially related to neuromyths could be added to further understand the relationship between the variables.

Recommendations for Further Research

Results from both the pilot study and the final survey administration lead to many new areas of inquiry and possibilities for future research.

Results from Pilot

There were two findings discovered in the pilot that could be expanded upon in future research. First, several teachers cited psychology courses as the source of their knowledge about the neuromyths. It was the most often cited source in the cognitive interviews. While Rato et al. (2012) hypothesized that teachers were encountering this information in popular media, the pilot cognitive interviewing indicated otherwise. This finding requires further exploration to examine if psychology courses do, in fact, have a role in transmitting neuromyths to teachers, or if teachers are incorrectly attributing the knowledge of the neuromyths to psychology courses because it aligns with the content typically found in those courses. Are psychology courses making the distinction between psychological theories and research-based constructs clear? Are psychology courses really teaching neuromyths? Or are teachers mistaken in their attribution? What is the value of psychology courses for pre-service teachers and are these courses positively contributing to teachers’ understanding of student learning?
Second, the results of the cognitive interviews and pilot survey both indicated that there were differences between the private school and the public school teachers. It appeared that the public school teachers had a much greater exposure to the neuromyths than the private school teachers. It would be an interesting extension to conduct this survey among a sample of only private school teachers to determine if there are statistically significant differences between private school teachers’ and public school teachers’ beliefs in the neuromyths.

**Results from Final Survey**

There were also some unexpected findings in the final survey administration. First, neuroscience literacy did not have a statistically significant relationship with instructional practices, but did have a relationship with beliefs in neuromyths. Since Dekker et al. (2012) found similar results, this study should be conducted again, looking more closely at the items on the neuroscience literacy subscale and including questions that reflect neuroscience literacy as it relates to learning and the brain specifically, instead of general neuroscience knowledge. Additional research should also be done to determine where teachers are obtaining this neuroscience literacy, because none of the experiences with brain science measures were found to be significant, with the exception of the requirement of a single course.

Second, the relationship between personal teaching efficacy and instructional practices related to neuromyths needs to be explored. This study indicated that, while there is a statistically significant relationship between personal teaching efficacy and instructional practices related to neuromyths, there is no relationship between personal teaching efficacy and beliefs in neuromyths. It was originally hypothesized that there
NEUROMYTHS AND INSTRUCTION

would be a relationship between beliefs in neuromyths and both personal and general teacher efficacy, since the two are not entirely separate constructs. However, because teachers with high personal teaching efficacy take more personal responsibility for student academic achievement (Ashton & Webb, 1986), it could be that instructional practices associated with neuromyths are seen as teacher best practices, so the highly efficacious teachers are engaging in these instructional practices without adopting the related neuromyth belief or evaluating the root of the practice. Ideally, a study would be conducted that uses a larger teacher efficacy scale with higher reliability than the subscale used in this study, as well as a larger sample size.

The purpose of this study was to determine whether or not a relationship existed between teachers’ beliefs in neuromyths and instructional practices. The results indicate that there is a relationship between these two constructs, although the nature of this relationship is still not explicitly clear. This study also explored whether beliefs in neuromyths was really a type of teacher efficacy belief and therefore should be embedded into the teacher efficacy model. Results indicate that beliefs in neuromyths are related to teacher efficacy beliefs, but still a separate construct that accounts for some of the variance in teachers’ instructional practices. It is more likely that beliefs in neuromyths is actually a type of general teaching efficacy belief. Further research should determine the relationship between personal teacher efficacy, general teaching efficacy, and beliefs in neuromyths. Additionally, this study should be replicated with a larger sample size, and further studies should be conducted to elucidate some of the underlying factors of this relationship and the effects of the identified instructional practices on students’ academic achievement.
Recommendations for Practice

The results of this study, which indicate that there is a relationship between a teacher’s beliefs in neuromyths and his or her reported instructional practices, should be taken into consideration for practice with caution until further research is done to determine whether or not the identified instructional practices affect student learning in the classroom. While Rato et al. (2012) and Dekker et al. (2012) both recommend neuroscience courses be integrated into teacher preparation programs, the finding that there is no relationship between neuroscience literacy and instructional practices related to neuromyths lead to more questions regarding that recommendation. Integrating neuroscience into teacher preparation programs may prevent the transmission of neuromyths, but that would not address the millions of teachers already teaching who do believe in some, or all, of the neuromyths. Although it is possible to work on changing these beliefs, it might be more effective is to target practices relating to neuromyths in professional development for existing teachers and replace them with practices that better align with research on student learning from neuroscience and cognitive psychology. Yet, the hesitation in offering this suggestion comes from the relationship between neuroscience literacy and beliefs in neuromyths as found in this study and the Dekker et al. (2012) study. If neuroeducation is to be embraced and promoted, then the goal is to encourage a comprehensive understanding of the brain and learning, as opposed to a partial understanding which leads to the adoption of neuromyths.

Final Thoughts

This exploratory, mixed-methods study conducted revealed that there is a statistically significant relationship between teachers’ beliefs in neuromyths and their
NEUROMYTHS AND INSTRUCTION

Instructional practices. This study opens up many different avenues of research, particularly to determine whether the instructional practices identified here have any relationship with student achievement in K-12 classrooms. What this study also confirms is that what teachers believe about their abilities as educators and what they believe their students to be capable of, affects what they do in the classroom, whether they know it or not (Allinder, 1994; Anderson, Greene, & Loewen, 1988; Aston & Webb, 1986; Gibson & Dembo, 1984; Guskey, 1988; Knapp, 2013; Stein & Wang, 1988; Youyan, Tan, Liau, Lau, & Chua, 2013). Even subtle parts of teachers’ belief systems that may not be firmly rooted in their identities as teachers can still impact the type of instruction they are providing to students. While neuroeducation may not be the ultimate solution for teachers and students, what it does offer is a way to address and dispel neuromyths among teachers so they are not utilizing ill-informed instructional practices. It is the researchers’ hopes that, moving forward, the brain sciences can be integrated into both teacher preparation programs and professional development in a way that allows all teachers, and especially highly efficacious ones, to bring research-based best practices into their classrooms to promote student learning.
REFERENCES
APPENDIX A: Face Validity Survey

1. Children must acquire their native language before a second language is learned. If they do not do so neither language will be fully acquired.
   a. Yes
   b. No

2. If pupils do not drink sufficient amounts of water, their brains will shrink.
   a. Yes
   b. No

3. It has been scientifically proven that fatty acid supplements (Omega-3s and Omega-6s) have a positive effect on academic achievement.
   a. Yes
   b. No

4. We only use 10% of our brain.
   a. Yes
   b. No

5. Differences in hemispheric dominance (left brain/right brain) can help explain individual differences among learners.
   a. Yes
   b. No

6. Brain development has finished by the time children reach secondary school.
   a. Yes
   b. No

7. There are critical periods in childhood after which certain things can no longer be learned.
   a. Yes
   b. No

8. Individuals learn better when they receive information in their preferred learning style (i.e. visual, auditory, or kinesthetic)
   a. Yes
   b. No

9. Mental capacity is hereditary and cannot be changed by environment or experience.
   a. Yes
   b. No

10. Environments that are rich in stimulus improve the brains of preschool children.
    a. Yes
    b. No

11. Children are less attentive after consuming sugary snacks/drinks.
    a. Yes
    b. No

12. Exercises that rehearse coordination of motor perception skills can improve literacy.
    a. Yes
    b. No
13. Learning problems associated with developmental differences in brain function cannot be remediated by education.
   a. Yes
   b. No

14. Short bouts of coordination exercises can improve integration of left and right brain hemispheres.
   a. Yes
   b. No

15. When we sleep, the brain shuts down.
   a. Yes
   b. No
APPENDIX B: Needs Assessment Survey

1. Which of the following best describes you?
   a. Teacher
   b. Student
   c. Parent
   d. Administrator
   e. Other

2. Which of the following best describes your age?
   a. 22-30
   b. 31-40
   c. 41-50
   d. 51-60
   e. 61-70

3. Which of the following best describes your gender?
   a. Male
   b. Female
   c. Choose not to respond

DIRECTIONS: For questions 4-33, rate the following on how much you agree with the statement presented.

4. Children must acquire their native language before a second language is learned. If they do not do so, neither language will be acquired.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

5. If students do not drink sufficient amounts of water (≈6-8 glasses per day) their brains will shrink.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

6. It has been scientifically proven that fatty acid supplements (omega-6 and omega-3) have a positive effect on academic achievement.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

7. We only use 10% of our brains.
   a. Strongly Agree
   b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

8. Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

9. The brains of boys and girls develop at the same rate.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

10. There are critical periods in childhood after which certain things can no longer be learned.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

11. Individuals learn better when they receive information in their preferred learning style (e.g. auditory, visual, kinesthetic).
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

12. Mental capacity is hereditary and cannot be changed by the environment or experience.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

13. Environments that are rich in stimuli improve the brains of pre-school children.
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
14. Children are less attentive after consuming sugary drinks and/or snacks.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

15. Exercises that rehearse coordination of motor-perception skills can improve literacy skills.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

16. Learning problems associated with developmental differences in brain function cannot be remediated by education.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

17. Short bouts of coordination exercises can improve integration of left and right hemispheric brain function.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

18. When we sleep, the brain shuts down.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

19. We use our brains 24 hours a day.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

20. Boys have bigger brains than girls.
   a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

21. When a brain region is damaged other parts of the brain can take up its function.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

22. The left and right hemisphere of the brain always work together.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

23. Learning is not due to the addition of new cells to the brain.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

24. Learning occurs through modification of the brains’ neural connections.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

25. Academic achievement can be affected by skipping breakfast.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

27. Vigorous exercise can improve mental function.
a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

28. Circadian rhythms (body clock) shift during adolescence, causing pupils to be tired during the first lessons of the school day.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

29. Regular drinking of caffeinated drinks reduces alertness.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

30. Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

31. Individual learners show preferences for the mode in which they receive information (e.g. visual, auditory, kinesthetic)
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

32. Production of new connections in the brain can continue into old age.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
   e. Strongly disagree

33. There are sensitive periods in childhood when it’s easier to learn things.
   a. Strongly Agree
   b. Agree
   c. Neutral
   d. Disagree
e. Strongly disagree

* Adapted from Dekker, Lee, Howard-Jones, and Jolles (2012).
APPENDIX C: Pilot Survey Instrument

Survey Items

Pilot Survey

1. By continuing this survey, you agree to have your confidential results included as part of this research study.
   a. Accept
   b. Decline

2. I try to adapt my lesson materials to whether there are more “right-brained” or “left-brained” students in my classroom.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

3. When planning my lessons, I consider whether or not my students are more “right-brained” or “left-brained”.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

4. I give students different activities to suit their learning style (auditory, visual, or kinesthetic) so that they are more capable of meeting the objectives.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

5. I disregard students’ learning styles (auditory, visual, or kinesthetic) when planning my lessons.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

6. I provide my students with a quiz during the school year so that I can determine their learning styles and adjust my teaching accordingly.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

7. I make my classroom as visually stimulating as possible to improve my students’ ability to think creatively.
   a. Never
8. I avoid classroom decorations because they serve as a distraction from the lessons.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

9. I integrate physical activity into my course for the purpose of stimulating student literacy.
   a. Never
   b. Rarely
   c. Sometimes
   d. Often
   e. Always

10. I provide my students with breaks from instructional time for movement so that they are better able to read.
    a. Never
    b. Rarely
    c. Sometimes
    d. Often
    e. Always

11. We use our brain 24 hours a day.
    a. Yes
    b. No
    c. I don’t know

12. Communication between different parts of the brain happens through electrical impulses and chemical substances.
    a. Yes
    b. No
    c. I don’t know

13. The electroencephalogram gives a measure of the development of each brain region.
    a. Yes
    b. No
    c. I don’t know

14. Learning is due to modifications in the brain.
    a. Yes
    b. No
    c. I don’t know

15. Brain activity can be measured by the incorporation of radioactive molecules administered to the blood.
    a. Yes
16. Brain activity can be studied through the oxygen consumption of specific brain areas.
   a. Yes
   b. No
   c. I don’t know

17. Our brain has maps of the surface of the body and of the visual field.
   a. Yes
   b. No
   c. I don’t know

18. Any brain region can perform any function.
   a. Yes
   b. No
   c. I don’t know

19. Varied sensory experience is necessary to the normal maturation of the brain functions.
   a. Yes
   b. No
   c. I don’t know

20. Normal development of the human brain involves birth but also death of brain cells.
   a. Yes
   b. No
   c. I don’t know

21. All body parts are equally sensitive.
   a. Yes
   b. No
   c. I don’t know

22. The brain has areas specialized at certain functions, such as mathematics; the development of these brain areas can be identified through the shape of the skull.
   a. Yes
   b. No
   c. I don’t know

23. Body function regulation through hunger, thirst, and temperature control are functions of a certain brain area.
   a. Yes
   b. No
   c. I don’t know

24. Learning occurs through the modification of the brain’s nervous connections
   a. Yes
   b. No
   c. I don’t know

25. Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.
a. Yes
b. No
c. I don’t know

26. Some students are left-brained (i.e. more rational, logical, and analytical), while other students are right-brained (i.e. more emotional, artistic, and creative).
   a. Yes
   b. No
   c. I don’t know

27. Every person favors either their left brain hemisphere or right brain hemisphere, and which hemisphere a person favors can be determined by his or her personality traits.
   a. Yes
   b. No
   c. I don’t know

28. Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).
   a. Yes
   b. No
   c. I don’t know

29. Students can be roughly categorized into three groups—auditory, visual, or kinesthetic—based on how they best receive knowledge in a classroom.
   a. Yes
   b. No
   c. I don’t know

30. It is important for students to determine their learning style (e.g. visual, auditory, or kinesthetic) so that they can adjust their study skills to match their learning style.
   a. Yes
   b. No
   c. I don’t know

31. Environments that are rich in stimulus improve the brains of pre-school children.
   a. Yes
   b. No
   c. I don’t know

32. An environment that is enriched is going to improve learning conditions.
   a. Yes
   b. No
   c. I don’t know

33. Science has proven that having an environment with a lot of external stimuli can improve learning outcomes.
   a. Yes
   b. No
   c. I don’t know

34. Exercises that rehearse coordination of motor-perception skills can improve literacy skills.
   a. Yes
b. No
c. I don’t know

35. Physical activities should be done in a classroom because it can improve student learning and reading comprehension.
   a. Yes
   b. No
   c. I don’t know

36. There is research that indicates that students are better readers when given the opportunity to move around the classroom during a lesson.
   a. Yes
   b. No
   c. I don’t know

37. When a student does better than usual, many times it is because I exerted a little extra effort.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

38. The hours in my class have little influence on students compared to the influence of their home environment.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

39. The amount that a student can learn is primarily related to family background.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

40. When a student is having difficulty with an assignment, I am usually able to adjust to his or her level.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

41. If students aren’t disciplined at home, they aren’t likely to accept any discipline.
   a. Strongly disagree
b. Disagree
  c. Slightly disagree
  d. Slightly agree
  e. Agree
  f. Strongly agree

42. When I really try, I can get through to the most difficult students.
    a. Strongly disagree
    b. Disagree
    c. Slightly disagree
    d. Slightly agree
    e. Agree
    f. Strongly agree

43. A teacher is very limited in what he/she can achieve because a student’s home environment is a large influence on his or her achievement.
    a. Strongly disagree
    b. Disagree
    c. Slightly disagree
    d. Slightly agree
    e. Agree
    f. Strongly agree

44. When the grades of my students improve, it is usually because I found more effective teaching approaches.
    a. Strongly disagree
    b. Disagree
    c. Slightly disagree
    d. Slightly agree
    e. Agree
    f. Strongly agree

45. If a student masters a new concept quickly, this might be because I knew the necessary steps in teaching that concept.
    a. Strongly disagree
    b. Disagree
    c. Slightly disagree
    d. Slightly agree
    e. Agree
    f. Strongly agree

46. If parents would do more with their children, I could do more.
    a. Strongly disagree
    b. Disagree
    c. Slightly disagree
    d. Slightly agree
    e. Agree
    f. Strongly agree

47. If a student did not remember information I gave in a previous lesson, I would know how to increase his or her retention in the next lesson.
    a. Strongly disagree
b. Disagree  
c. Slightly disagree  
d. Slightly agree  
e. Agree  
f. Strongly agree  

48. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him or her quickly.  
a. Strongly disagree  
b. Disagree  
c. Slightly disagree  
d. Slightly agree  
e. Agree  
f. Strongly agree  

49. The influences of a student’s home experience can be overcome by good teaching.  
a. Strongly disagree  
b. Disagree  
c. Slightly disagree  
d. Slightly agree  
e. Agree  
f. Strongly agree  

50. Even a teacher with good teaching abilities may not reach many students.  
a. Strongly disagree  
b. Disagree  
c. Slightly disagree  
d. Slightly agree  
e. Agree  
f. Strongly agree  

51. Which of the following best describes your age at the time of this survey?  
a. Under 20  
b. 20-24  
c. 25-39  
d. 30-34  
e. 35-39  
f. 40-44  
g. 45-49  
h. 50-54  
i. 55-59  
j. 60-64  
k. 64-70  
l. Over 70  

52. What is the highest level of education you have competed?  
a. Bachelor’s Degree  
b. Master’s Degree  
c. Doctoral Degree
53. At what point in your education did you receive your teacher training?
   a. Bachelor’s degree in Education
   b. Master’s degree in Education
   c. Doctoral degree in Education
   d. Certification Program in Education (no degree)
   e. Both Bachelor’s and Master’s degrees in Education
   f. Bachelor’s, Master’s, and Doctoral degrees in Education
   g. Both Master’s and Doctoral degrees in Education

54. Have you attended any professional conferences focusing on the brain or education?
   a. Yes
   b. No
   c. If yes, please share which conference(s) and how many you have attended.

55. Were you required, in your teacher preparation program(s) to take any course in biology, neuroscience, psychology, or biological basis of behavior as it relates to learning?
   a. Yes
   b. No

56. Do you have an undergraduate degree in any of the following fields: biology, neuroscience, psychology or biological basis of behavior?
   a. Yes
   b. No

57. Do you have a graduate degree in any of the following fields: biology, neuroscience, psychology, or biological basis of behavior?
   a. Yes
   b. No

58. How many years of teaching experience in your own classroom do you have at the k-12 level?

59. What is the current age/grade level of the students you teach?
   a. 4-10 years of age (kindergarten-4th grade)
   b. 11-14 (5th-8th grade)
   c. 14-19 (9th-12th grade)

60. What subject area do you primarily teach?
   a. All areas (elementary school classroom teacher)
   b. Elementary (k-6) mathematics/science
   c. Elementary (k-6) English/social studies
   d. Physical Education/Health
   e. Secondary (7-12) mathematics
   f. Secondary (7-12) science
   g. Secondary (7-12) English language arts
h. Secondary (7-12) Social studies/social sciences
i. Secondary (7-12) language
j. Secondary (7-12) art or music education
k. Other (If other, please describe your teaching position)

61. Which of the following best describes the school in which you are currently employed?
   a. Small suburban school
   b. Mid-size suburban school
   c. Large suburban school
   d. Fringe rural school
   e. Distant rural school
   f. Remote rural school
   g. Small city school
   h. Mid-size city school
   i. Large city school
APPENDIX D- Consent Form for Pilot

Consent Form- Pilot

Johns Hopkins University Homewood
Institutional Review Board (HIRB) Consent

Title: Examining Neuromyths and Instructional Practice--Philadelphia, PA
Principal Investigator: Alexandra Murtaugh, Ed.D. Candidate, Johns Hopkins University
Date: August 20, 2015

PURPOSE OF RESEARCH STUDY:
The purpose of this study is to pilot an online survey with the intention of developing a sound instrument that measures teachers attitudes and practices concerning research from the learning sciences. The research will be conducted among approximately 40 teachers at a suburban independent 9-12 school and 40 teachers at an urban 9-12 charter school to determine the extent to which teachers and administrators believe in neuromyths and to what extent that affects their instructional practices. We anticipate that approximately 100 teachers will be invited to participate in this portion of the pilot. In addition, 15 teachers from the suburban independent 9-12 school and 15 teachers from the urban 9-12 charter school will be asked to participate in a follow-up group interview.

PROCEDURES:
There will be two components for this pilot study:

1. You will be asked to complete the following survey, taking approximately 30 minutes.
2. You may be asked to be part of an interview to discuss your understanding of the survey questions. These scores will remain anonymous.

Time required: You will be asked to complete this survey one time, taking an estimated 30 minutes. You may be asked to participate in a 30-minute group interview

RISKS/DISCOMFORTS:
There are no anticipated risks to participants.

BENEFITS:
All participants will have the chance to win a $20 gift card to Dunkin Donuts.

VOLUNTARY PARTICIPATION AND RIGHT TO WITHDRAW:
Your participation in this study is entirely voluntary. You choose to participate and you will indicate below whether you agree to take part in the study. If you decide not to participate there are no penalties, and you will not lose any benefits that you would otherwise be entitled. You can stop participation in the study at any time, without any penalty or lost benefits. If you want to withdraw yourself from the study, please contact Alexandra Murtaugh via phone or email: (484) 695-6162,
Alexandra.Murtaugh@gmail.com
CONFIDENTIALITY:
Any study records that identify you will be kept confidential to the extent possible by law. The records from your participation may be reviewed by people responsible for making sure that research is done properly, including members of the Johns Hopkins University Homewood Institutional Review Board and officials from government agencies, such as the office for Human Research Protections. (All of these people are required to keep your identity confidential.) Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. All measures will be examined by the Principal investigator and research affiliates only (including those entities described above). No identifiable information will be included in any reports of the research published or provided to school administration. A participant number will be assigned to all surveys. Surveys will be collected in online format. All research data including paper surveys and observation results will be kept in a locked office. Electronic data will be stored on the PI’s personal computer, which is password protected. Any paper files will be shredded, five years after collected. Only group data will be included in publication; no individual achievement data will ever be published.

COMPENSATION:
You will be entered in a drawing to win a $20 Dunkin Donuts gift card. No additional compensation will be offered.

IF YOU HAVE QUESTIONS OR CONCERNS:
You can ask questions about this research study at any time during the study by contacting Alexandra Murtaugh via phone or email: (484) 695-6162, Alexandra.Murtaugh@gmail.com.

If you have questions about your rights as a research participant or feel that you have not been treated fairly, please call the Homewood Institutional Review Board at Johns Hopkins University at (410) 516-6580.

SIGNATURES
WHAT YOUR SIGNATURE MEANS:
Your signature below means that you understand the information in this consent form.
Your signature also means that you agree to participate in the study.

By signing this consent form, you have not waived any legal rights you have as a participant in a research study.

<table>
<thead>
<tr>
<th>PARTICIPANT NAME</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of Participant</td>
<td>DATE</td>
</tr>
</tbody>
</table>
SIGNATURE OF PERSON OBTAINING CONSENT  
(Investigator or HIRB-Approved Designee)
APPENDIX E: Cognitive Interviewing Probes

1. First, what is your impression of the survey?

2. Let’s look at question number _____. What does it mean to you?

3. Can you put question ______ in your own words?

4. What did you think question ____ was asking?

5. What do you think this survey was measuring?

6. What is your experience and how has it affected your answers to this survey?

* Adapted from National Survey of Student Engagement (NSSE), 2010
APPENDIX F: Final Survey Instrument

Survey Items

1. By continuing this survey, you agree to have your confidential results included as part of this research study.
   a. Accept
   b. Decline

2. I try to adapt my lesson materials to whether there are more “right-brained” or “left-brained” students in my classroom.
   f. Never
   g. Rarely
   h. Sometimes
   i. Often
   j. Always

3. When planning my lessons, I consider whether or not my students are more “right-brained” or “left-brained”.
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4. I give students different activities to suit their learning style (auditory, visual, or kinesthetic) so that they are more capable of meeting the objectives.
   f. Never
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   h. Sometimes
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7. I make my classroom as visually stimulating as possible to improve my students’ ability to think creatively.
   f. Never
   g. Rarely
   h. Sometimes
8. I avoid classroom decorations because they serve as a distraction from the lessons.
   f. Never
   g. Rarely
   h. Sometimes
   i. Often
   j. Always

9. I integrate physical activity into my course for the purpose of stimulating student literacy.
   f. Never
   g. Rarely
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   i. Often
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10. I provide my students with breaks from instructional time for movement so that they are better able to read.
    f. Never
    g. Rarely
    h. Sometimes
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11. We use our brain 24 hours a day.
    a. Yes
    b. No
    c. I don’t know

12. Communication between different parts of the brain happens through electrical impulses and chemical substances.
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13. The electroencephalogram gives a measure of the development of each brain region.
    a. Yes
    b. No
    c. I don’t know

14. Learning is due to modifications in the brain.
    a. Yes
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    c. I don’t know

15. Brain activity can be measured by the incorporation of radioactive molecules administered to the blood.
    a. Yes
    b. No
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16. Brain activity can be studied through the oxygen consumption of specific brain areas.
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17. Our brain has maps of the surface of the body and of the visual field.
   a. Yes
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18. Any brain region can perform any function.
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19. Varied sensory experience is necessary to the normal maturation of the brain functions.
   a. Yes
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20. Normal development of the human brain involves birth but also death of brain cells.
   a. Yes
   b. No
   c. I don’t know

21. All body parts are equally sensitive.
   a. Yes
   b. No
   c. I don’t know

22. The brain has areas specialized at certain functions, such as mathematics; the development of these brain areas can be identified through the shape of the skull.
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   b. No
   c. I don’t know

23. Body function regulation through hunger, thirst, and temperature control are functions of a certain brain area.
   a. Yes
   b. No
   c. I don’t know

24. Learning occurs through the modification of the brain’s nervous connections
   a. Yes
   b. No
   c. I don’t know

25. Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.
   a. Yes
   b. No
c. I don’t know
26. Some students are left-brained (i.e. more rational, logical, and analytical), while other students are right-brained (i.e. more emotional, artistic, and creative).
   a. Yes
   b. No
   c. I don’t know
27. Every person favors either their left brain hemisphere or right brain hemisphere, and which hemisphere a person favors can be determined by his or her personality traits.
   a. Yes
   b. No
   c. I don’t know
28. Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).
   a. Yes
   b. No
   c. I don’t know
29. Students can be roughly categorized into three groups—auditory, visual, or kinesthetic—based on how they best receive knowledge in a classroom.
   a. Yes
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   c. I don’t know
30. It is important for students to determine their learning style (e.g. visual, auditory, or kinesthetic) so that they can adjust their study skills to match their learning style.
   a. Yes
   b. No
   c. I don’t know
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   a. Yes
   b. No
   c. I don’t know
32. An environment that is enriched is going to improve learning conditions.
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   a. Yes
   b. No
   c. I don’t know
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   a. Yes
   b. No
   c. I don’t know
37. When a student does better than usual, many times it is because I exerted a little extra effort.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree
38. The hours in my class have little influence on students compared to the influence of their home environment.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree
39. The amount that a student can learn is primarily related to family background.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree
40. When a student is having difficulty with an assignment, I am usually able to adjust to his or her level.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree
41. If students aren’t disciplined at home, they aren’t likely to accept any discipline.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
42. When I really try, I can get through to the most difficult students.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

43. A teacher is very limited in what he/she can achieve because a student’s home environment is a large influence on his or her achievement.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

44. When the grades of my students improve, it is usually because I found more effective teaching approaches.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

45. If a student masters a new concept quickly, this might be because I knew the necessary steps in teaching that concept.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

46. If parents would do more with their children, I could do more.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

47. If a student did not remember information I gave in a previous lesson, I would know how to increase his or her retention in the next lesson.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
48. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him or her quickly.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

49. The influences of a student’s home experience can be overcome by good teaching.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

50. Even a teacher with good teaching abilities may not reach many students.
   a. Strongly disagree
   b. Disagree
   c. Slightly disagree
   d. Slightly agree
   e. Agree
   f. Strongly agree

51. Which of the following best describes your age at the time of this survey?
   a. Under 20
   b. 20-24
   c. 25-39
   d. 30-34
   e. 35-39
   f. 40-44
   g. 45-49
   h. 50-54
   i. 55-59
   j. 60-64
   k. 64-70
   l. Over 70

52. What is the highest level of education you have competed?
   a. Bachelor’s Degree
   b. Master’s Degree
   c. Doctoral Degree

53. At what point in your education did you receive your teacher training?
   a. Bachelor’s degree in Education
   b. Master’s degree in Education
   c. Doctoral degree in Education
d. Certification Program in Education (no degree)
e. Both Bachelor’s and Master’s degrees in Education
f. Bachelors, Master’s, and Doctoral degrees in Education
g. Both Master’s and Doctoral degrees in Education

54. Have you attended any professional conferences focusing on the brain or education?
   a. Yes
   b. No

55. Were you required, in your teacher preparation program (s) to take any course in biology, neuroscience, psychology, or biological basis of behavior as it relates to learning?
   a. Yes
   b. No

56. Do you have an undergraduate degree in any of the following fields: biology, neuroscience, psychology or biological basis of behavior?
   a. Yes
   b. No

57. Do you have a graduate degree in any of the following fields: biology, neuroscience, psychology, or biological basis of behavior?
   a. Yes
   b. No

58. How many years of teaching experience in your own classroom do you have at the k-12 level?

59. What is the current age/grade level of the students you teach?
   a. 4-10 years of age (kindergarten-4th grade)
   b. 11-14 (5th-8th grade)
   c. 14-19 (9th-12th grade)

60. What subject area do you primarily teach?
   a. All areas (elementary school classroom teacher)
   b. Elementary (k-6) mathematics/science
   c. Elementary (k-6) English/social studies
   d. Physical Education/Health
   e. Secondary (7-12) mathematics
   f. Secondary (7-12) science
   g. Secondary (7-12) English language arts
   h. Secondary (7-12) Social studies/social sciences
   i. Secondary (7-12) language
   j. Secondary (7-12) art or music education
   k. Other (If other, please describe your teaching position)

61. Which of the following best describes the school in which you are currently employed?
NEUROMYTHS AND INSTRUCTION

a. Suburban
b. Town
c. Rural
d. City
APPENDIX G: Pennsylvania School Category Breakdown

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Schools in Category in PA</th>
<th>Percentage of Schools in PA</th>
<th>Number of Schools in Sample</th>
<th>Percentage of Schools in Sample</th>
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</thead>
<tbody>
<tr>
<td>Total Schools</td>
<td>3,242</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Suburb: Small</td>
<td>106</td>
<td>3.27</td>
<td>3</td>
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<tr>
<td>Suburb: Medium</td>
<td>102</td>
<td>3.15</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Suburb: Large</td>
<td>1029</td>
<td>31.74</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>Town: Fringe</td>
<td>270</td>
<td>8.33</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Town: Distant</td>
<td>117</td>
<td>3.61</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Town: Remote</td>
<td>38</td>
<td>1.17</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rural: Fringe</td>
<td>471</td>
<td>14.53</td>
<td>15</td>
<td>15</td>
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<tr>
<td>Rural: Remote</td>
<td>36</td>
<td>1.11</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rural: Distant</td>
<td>340</td>
<td>10.49</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>City: Small</td>
<td>150</td>
<td>4.63</td>
<td>5</td>
<td>5</td>
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<tr>
<td>City: Mid-size</td>
<td>49</td>
<td>1.51</td>
<td>3</td>
<td>3</td>
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<tr>
<td>City Large</td>
<td>395</td>
<td>12.19</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Opened After 2007-2008</td>
<td>139</td>
<td>4.29</td>
<td>0</td>
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APPENDIX H: Copy of Email Requesting Participation

Subject: Help Me Finish My Doctorate!
Dear Educator,

I am writing to request your participation in a brief survey on your beliefs and teaching practices. Your school was one of 100 schools in the state of Pennsylvania selected to participate in the survey. The survey should take no longer than 30 minutes to complete and when you take the survey you will automatically be entered into a drawing for a $5 Dunkin Donuts gift card. The survey will remain open for 30 days and you will receive two additional emails requesting your participation.

You can access the survey by clicking on the link here:
(Disabled link)

If you have any further questions, please feel free to reach out to me at Alexandra.Murtaugh@gmail.com.

Sincerely,

Alexandra Murtaugh
Doctoral Candidate
Johns Hopkins University
APPENDIX I: COGNITIVE INTERVIEWING MEMO

Face Validity

** Teachers were asked what the survey was trying to measure, these were a sample of their answers **

- How teachers adapt to left/right brain
- Learning styles (3 teachers said this)
- Measuring teacher’s knowledge of brain processes
- Brain use as it relates to learning
- What you understand about the brain, how it applies to learning styles, and whether those ideas are true
- How the brain interprets information

Background

** Teachers were asked what informed their answers, these were a sample of their answers **

- Psychology courses (5 teachers)
- Teaching experience
- “Can’t remember” where the terms were first encountered

Challenges/Recommendations

- Many teachers noted that they felt they were answering “I don’t know a lot”
  - Questions were “too technical”
  - Language for the questions was unfamiliar
- Some teachers wanted a “neutral” option in the Likert scale instead of forced choice
NEUROMYTHS AND INSTRUCTION

- Two teachers said they didn’t know how to answer because their teaching practices varied from day to day
- #53- Some private school teachers did not have formal teacher training, so did not know how to answer the question
- #61- Did not know what the definition of the school categories was
- #26- A definition of left brain/right brain would have been useful earlier
- Did not know whether the questions should be answered in a “neuroscience sense” or an “educational sense”
  - A disclaimer about how teachers should answer would have been helpful
  - There was a conflict between “textbook answer” and “what the teacher felt was correct or their experience indicated
- #10- Movement is important, but maybe not for literacy, rather for focus or “brain stimulation”
- #31- “improve the brain” is subjective language
- #32- “what is an ‘enriched’ environment?”
- #49- blanket question, more case-by-case, hard to generalize

Final Decisions/Rationale

- Questions will continue to be forced choice
  - The forced choice is necessary because teacher’s beliefs are being measured
- Even though teachers’ practice varied, questions will ask teachers to generalize
  - Teachers are being asked to generalize because there is instructional practices will not be gaged on a day-to-day scale
- #53 will not be altered
  o Teachers in the final survey administration will all be public school teachers and, therefore, will all have had teacher training at some point

- #61- School categories will be brought down to “town”, “suburban”, “rural”, and “city”

- #26- A definition of left brain/right brain will not be provided
  o A definition will not be provided because it is a false construct (“neuromyth”)

- A disclaimer about what teachers should use to influence their answers should not be provided
  o Teachers should use all available information to answer the questions, because that is presumably what they use to make their instructional decisions

- #10- The question will not be altered
  o The question will not be altered, because this question is not intended to measure whether teachers use physical activity, but rather whether they believe physical activity will lead to changes in literacy

- #31 will not be altered
  o The language is taken from the original study (Dekker et al., 2012)

- #32 will not be altered
  o The language is taken from the original study (Dekker et al., 2012)

- #49 will not be altered
NEUROMYTHS AND INSTRUCTION

- The teacher efficacy questions require teachers to generalize because the research indicates that these generalizations affect teaching practices.
## Demographics Comparison

<table>
<thead>
<tr>
<th></th>
<th>Sample Population</th>
<th>Pennsylvania Population</th>
<th>United States Population</th>
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</thead>
<tbody>
<tr>
<td><strong>Level of Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>22.0</td>
<td>32.9</td>
<td>39.9</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>70.7</td>
<td>53.9</td>
<td>47.7</td>
</tr>
<tr>
<td>Doctorate/Specialist</td>
<td>7.3</td>
<td>8.7</td>
<td>8.7</td>
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<tr>
<td><strong>Teaching Exp.</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Less than 3 years</td>
<td>7.1</td>
<td>6.2</td>
<td>9.0</td>
</tr>
<tr>
<td>3-9 years</td>
<td>24.7</td>
<td>37.0</td>
<td>33.3</td>
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<td>10-20 years</td>
<td>34.7</td>
<td>35.8</td>
<td>36.4</td>
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<tr>
<td>Over 20 years</td>
<td>31.9</td>
<td>21.0</td>
<td>21.3</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 30</td>
<td>18.1</td>
<td>16.3</td>
<td>15.4</td>
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<td>30-39</td>
<td>33.8</td>
<td>57.5</td>
<td>28.1</td>
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<tr>
<td>40-49</td>
<td>16.8</td>
<td>10.8</td>
<td>25.0</td>
</tr>
<tr>
<td>50-59</td>
<td>24.1</td>
<td>15.3</td>
<td>22.8</td>
</tr>
<tr>
<td>60 and over</td>
<td>7.2</td>
<td>-</td>
<td>8.8</td>
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<tr>
<td><strong>School Category</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Urban</td>
<td>20.3</td>
<td>18.2</td>
<td>26</td>
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<tr>
<td>Rural</td>
<td>34.7</td>
<td>26.1</td>
<td>32</td>
</tr>
<tr>
<td>Suburban</td>
<td>33.9</td>
<td>38.2</td>
<td>27</td>
</tr>
<tr>
<td>Town</td>
<td>8.7</td>
<td>13.1</td>
<td>14</td>
</tr>
</tbody>
</table>


* Age category by state ended with “55 and over”

APPENDIX K: LITERATURE REVIEW SEARCH TERMS AND DATABASES

The literature review was conducted using various search terms and several databases to amass the most information related to neuromyths.

Search Terms

The list of search terms included: neuromyths, neuromythologies, brain gym, learning styles, multiple intelligences, VAK learning styles, neuromyths and instruction, neuromyths and pedagogy, neuromyths and practices, neuroscience literacy, hemispheric dominance, Mozart effect, neuroscience and education, neuroeducation, brain sciences and education, neuroeducational, and enriched environments and education.

Databases:

The above search terms were entered into the following databases: Google Scholar, Academic Search Complete, Education Full Text (EBSCO), ProQuest Education Journals, ERIC, JSTOR, PsycINFO, Teachers’s Reference Center, Education Source, Education Week, Education Statistics, Oxford Scholarship Online, Psychology, PubMed, and SCOPUS.
NEUROMYTHS AND INSTRUCTION

Bibliography


NEUROMYTHS AND INSTRUCTION


NEUROMYTHS AND INSTRUCTION


NEUROMYTHS AND INSTRUCTION

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152
NEUROMYTHS AND INSTRUCTION


NEUROMYTHS AND INSTRUCTION


Curriculum Vitae

Alexandra Murtaugh was born in Edison, New Jersey on March 12, 1988. She moved to Pennsylvania early in her life and attended her local public schools through her senior year. She attended West Chester University where she received a bachelors degree in Philosophy. She had two minors in Political Science and Psychology. During her time at West Chester, she was part of the Honors College, tutored for the Learning and Resource Center, participated in student government, was a research assistant, and served as a University Ambassador. She also attended the Summer Research Opportunities Program at the University of Michigan where she was a research assistant in the sociology department. Alexandra then went on to Chestnut Hill College where she received a masters in middle level science education. During her masters, she began her teaching career. She has four years of secondary science teaching experience, two at the middle level and two at the high school level. Currently, she is a 10th grade biology teacher and curriculum coordinator for a charter school in Philadelphia. In this doctoral program at Johns Hopkins, Alexandra’s specialization was Mind, Brain, and Teaching. During her doctoral studies, she also served as a teaching assistant for four courses. She is currently completing a research and statistics in social sciences certificate program through the University of Amsterdam.