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Teacher Beliefs in Sex-Specific Neuromyths and Gender-Specific Instructional Strategies: Prevalence, Predictors, and Implications

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TEACHER BELIEFS IN SEX-SPECIFIC NEUROMYTHS AND GENDER-SPECIFIC INSTRUCTIONAL STRATEGIES: PREVALENCE, PREDICTORS, AND IMPLICATIONS

by

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DEDICATION

This dissertation is dedicated to all students who have been impacted by sex and gender stereotypes.

> We need to discover new fusions of what have been thought of as male and female characteristics. Perhaps a new revolution can then take shape, an educational revolution generated by the rejection of sexism. In the course of such a revolution, we may all rediscover ourselves. – Maxine Greene, 1978

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ABSTRACT

Neuromyths are misconceptions or overgeneralizations about brain research and its relevance to education. A number of recent studies have demonstrated that teachers endorse neuromyths at high rates, but none have examined neuromyths related to sex-specific learning differences. This study is the first to create and utilize a neuromyth inventory designed to measure misconceptions about sex learning differences. The overarching goal of the study was to determine the prevalence and predictors of both sex-specific neuromyths and gender-specific instructional strategies. The study was conducted in three large South Carolina school districts that offered single-gender classes at some point between 2007–2016. An electronic survey was administered to collect demographic and experience data and to measure neuromyth and gender-specific instructional strategy endorsement. The study was conducted in two phases that included a pilot study to provide validity evidence for the inventory and a final study to address the research goals. Result from 190 teacher survey respondents suggest that the teachers endorse both sex-specific learning neuromyths and gender-specific instructional strategies. The most commonly endorsed neuromyths were related to learning and learning styles, a finding which is consistent with previous studies examining general neuromyths.

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CHAPTER 1

INTRODUCTION

1.1 BRIEF INTRODUCTION TO NEUROLOGICAL STUDIES AND EDUCATION

Neurological studies have the potential to provide key insights into how learning occurs, ways in which to best educate children, and possible interventions for learning difficulties. For example, research on multitasking and memory suggests that attention management is critical in the learning process. Strategies for attention enhancement in the classroom include reducing multitasking, limiting distractions, chunking information, allowing time to process before shifting to a new task, using novelty and surprise, making connections with prior knowledge, and modeling to explicitly teach skills for attention management (Gruart, 2014). However, neurobiologists and psychologists suggest caution when interpreting the significance of brain imaging and neurological studies in educational settings (Eliot, 2011; Goswami, 2004, 2006; Gruart, 2014; Howard-Jones, 2011; Hruby, 2012). Gruart (2014) argues for the need to not only establish a common language between education and neuroscience but also to identify a clear framework for dialogue and experimentation. Gruart (2014) concluded:

> Essentially, some of the questions arising in the classroom could be designed and tested using neuroscientific tools, and many of the data found in neuroscientific experiments could provide interesting and workable hypotheses to be tested in the

> classroom. Of course, this should be done after taking all the necessary steps, as is done in pre-clinical and clinical trials before using a new treatment in patients. (p. 42)

Despite calls for caution in the interpretation and application of neurological studies to educational settings, numerous pseudo-scientific neuromyths exist among the general population (MacDonald, 2017) and among educators (Alferink & Farmer-Dougan, 2010; Dekker et al., 2012; Howard-Jones, 2014; MacDonald, 2017). Teachers are inundated by titles on this topic, such as *Teaching with the Brain in Mind* (Jenson, 2005), *The Brain Compatible Classroom* (Erlauer, 2003), and *Teaching the Female Brain* (James, 2009) to name a few books on this topic. Popular neuromyths include notions of left-brained/right-brained learning, critical learning periods, learning styles, multiple intelligences (Alferink & Farmer-Dougan, 2010; Dekker et al., 2012; Goswami, 2004; MacDonald, 2017) and the binary of male or female brains (Eliot, 2011).

Howard-Jones (2011) reported that "authentic neuroscience" has revealed important insights about learning in educational settings; however, he cautioned that "there are many challenges in moving from brain scan to lesson plan…a simple transmission model in which neuroscience advised education on their practices should never be expected to work…research is needed to bridge the gap between laboratory and classroom" (p. 111). Hruby (2012) systematically analyzed the challenges of integrating neuroscience and education and moving beyond the "rhetorical misuse by educational marketers, policy makers, and polemicists targeting the public" (p. 2). He identified three requirements needed to justify educational neuroscience: a) intellectual coherence with precise definitions of technical terms, b) the need for educational neuroscientists to have expertise in both the study of neuroscience and education, and c) to consider the moral and ethical implications of research findings, implications and recommendations (Hruby, 2012). Hruby (2012) and Gruart (2014) pointed to the obvious fact that all learning is technically brain-based, but there is a tendency to give credence to research and strategies that claim to have a neurological basis. Hruby (2012) suggested that “reference to the brain is apparently meant to imply research-demonstrated efficacy …but only research on effective instruction can indicate the likely conditions for effective instructional methods” (pp.4-5).

1.2 BRIEF HISTORY OF SINGLE-GENDER EDUCATION IN SOUTH CAROLINA

In 2006, the United States Department of Education amended Title IX to allow public single-sex education as a legal option. As a result of this amendment, there was an explosion of single-sex schools, classrooms, programs, and trainings in South Carolina. The early trainings and strategies for differentiating by sex were heavily influenced by Leonard Sax’s 2006 book, *Why Gender Matters: What Parents and Teachers Need to Know About the Emerging Science of Sex Differences*. In 2007, former South Carolina State Superintendent of Education, Jim Rex, created the Office of Single-Gender Initiatives and hired the first dedicated Coordinator of Single-Gender Initiatives, David Chadwell, to provide professional learning, curriculum, and resources for teaching boys and girls in single-sex and coeducational settings (South Carolina Department of Education [SCDE], 2011). In 2008, I joined the South Carolina Department of Education (SCDE) as the Single-Gender Resident Intern. As the Single-Gender Resident Intern, as well as a teacher in a single-sex program, I attended and delivered sex/gender learning differences professional learning based on the ideas of six major purported differences between boys and girls considered to be important in classroom settings. These differences included seeing, hearing, engaging, processing, responding, and choosing. Initially, I accepted the six differences, but over time I began to question the validity of these claims. In an attempt to verify these claims with primary sources, meta-analysis studies, and scholarly texts, I started research on sex differences. The available literature, coupled with my own observations, made me increasingly concerned about the possibility of stereotyping in single-sex learning environments.

1.3 PROBLEM STATEMENT

In May of 2010, South Carolina led the nation with the highest number of public schools offering single-sex programs or classrooms with a total of 124 single-sex schools. Of the 124 schools, 61 were elementary, 56 were middle, and seven were high schools, and all schools were situated within nearly two-thirds of the state's school districts. The total number of teachers and students directly involved in these programs was reported to be 1,054 teachers and 19,000 students (SCDE, 2011). However, in 2014-2015 the number of South Carolina schools offering single-gender options decreased to only 26 schools. Of the 26 schools, 15 were elementary, 11 were middle, and two were high schools, and all were schools were situated in 17 districts (SCDE, 2014). In 2017-2018 (last time an official estimate was available) the number of schools offering single-gender options decreased to only 10 schools (Klein et al., 2018). The reduction in single-sex learning environments coincided with increased monitoring and enforcement of regulations governing single-sex public education introduced 2014 (Klein, 2018).

Several authors (Cohen, 2014; Eliot, 2011; Williams, 2010) have challenged many of the neurological/biological differences purported by education consultants.

These claims include that boys and girls learn differently and should be separated by sex to accommodate differences (Gurian, 2010; Sax, 2006). Given the abundance of South Carolina single-sex schools, classes, programs, and professional learning opportunities coupled with the "seductive allure" of neuroscientific explanations (Weisberg, 2008, p. 1), the present study was needed to determine the prevalence and predictors of sex difference neuromyths and beliefs in gender-specific instructional strategies.

1.4 CONCEPTUAL FRAMEWORK

Single-Sex Education and the Brain (Eliot, 2011) and *Dispelling the Myth: Training in Education or Neuroscience Decreases but Does Not Eliminate Beliefs in Neuromyths* (MacDonald, et al., 2017) are being used to frame the proposed study. Eliot, a leading expert in neurological sex differences, debunked claims of hardwired sex differences (Sax, 2005; Gurian, 2010) and challenged the validity of single-sex education based on such claims. Eliot warned against stereotyping and claimed, "The natural tendency to teach to students perceived strengths will mean further neglect of their weaker areas, inflating small academic gaps into much larger ones" (p. 376). MacDonald et al. (2017) recently conducted a large-scale study in the United States to determine the prevalence and predictors of neuromyths among the general public, educators, and individuals with high neuroscience exposure. The most commonly endorsed neuromyths across groups were related to learning styles and dyslexia. The most commonly endorsed neuromyth item was "individuals learn better when they receive information in their preferred learning style (e.g. auditory, visual, kinesthetic)" (general public, M=93%, educators, M= 76%, high neuroscience exposure M = 78%)" (p. 9). Good (1987), discussed how teacher beliefs can affect student behavior and outcomes. He cautioned that, “some teachers overreact to relatively small differences among students by teaching them in sharply divergent ways that are inappropriate” (p.35).

Cohen (2014) reported that despite years of data on how schools shortchange girls, it was not until authors like Gurain and Sax called attention to the “boy’s crisis” that Title IX was amended permitting sex segregation. He stated, “By focusing on improving the lot of boys and previously ignoring girls’ problems, the sex segregation movement showed its true color” and “that sex segregation, by definition, reifies existing sex-based hierarchies” (Cohen, 2014, p.53). Research has shown that negative stereotypes about girls’ and women’s abilities in math and science adversely affect their performance in science, technology, engineering, and math (STEM) programs (Hill et al., 2010). Critical, social, and feminist theories informed my approach to research since single-sex environments and essentialist views of gender have the potential to exacerbate inequities in education. It is interesting to consider that in education “separate is not equal” in terms of race segregation (*Brown v. The Board of Education*, 1954) but that it is acceptable to segregate based on sex. Anderson (2007) in his summary of the critical research tradition discussed how the “The Culture of Power” (p. 20) maintains the status quo and marginalization of “disadvantaged” groups. He further reported that critical researchers “challenge science educators to think about our own roles in maintaining injustice and inequity in our schools” (Anderson, 2007, p. 25).

1.5 OBJECTIVES, RESEARCH QUESTIONS, AND ASSUMPTIONS

Educators exposed to professional learning related to sex-specific learning difference and single-sex education have been told that boys and girls are fundamentally different and require different teaching strategies. Many “experts” have focused on purported neurological and cognitive sex-differences to justify teaching strategies based on gender (Gurian, 2010; Sax, 2006). While there is validity to some claims, the magnitude of those differences has been distorted and the practical implications inferred (Eliot, 2011; Williams, 2010). My assumptions are that educators who engaged in professional learning related to sex differences and taught in single-sex learning environments are likely to accept high levels of sex difference neuromyths and believe in gender-specific instructional strategies. In addition, I also assume the amount of time educators engaged in professional learning related to sex differences will predict their belief in neuromyths and gender-specific instructional strategies. Lastly, I assume educators who accept high levels of sex difference learning neuromyths will also endorse the belief that boys and girls have different instructional needs. I anticipate the number of neurology courses will reduce educator acceptance of neuromyths (MacDonald et al., 2017).

Research Objectives

This dissertation research has six main objectives:

1. Identify the percentage of certified K-12 teachers in two South Carolina school districts who have taught in single-sex learning environments.
2. Identify the percentage of certified K-12 teachers in two South Carolina school districts who have engaged in sex difference professional learning.
3. Identify the time K-12 teachers in two South Carolina school districts have engaged in various professional learning experiences related to sex learning differences.
4. Identify the types and sources of professional learning experiences related to sex learning differences that K-12 teachers in two South Carolina school districts report having engaged in.
5. Identify the prevalence and predictors of sex difference neurological learning myths among K-12 teachers in two South Carolina school districts.

6. Identify the prevalence and predictors of belief in gender-specific instructional strategies among K-12 teachers in two South Carolina school districts.

Research Questions

The overarching question that will guide the proposed study is, "What is the prevalence of and what are the predictors of belief in gender-specific instructional strategies among K-12 teachers in two South Carolina school districts?"

The specific questions this study will address include:

1. What percentage of K-12 teachers in two South Carolina school districts have taught in single-sex learning environments and/or engaged in professional learning related to sex differences in learning?

2. How much time do K-12 teachers in two South Carolina school districts report participating in various professional learning experiences related to sex differences?

3. What are the types and sources of professional learning experiences reported by K-12 teachers in two South Carolina school districts?

4. What is the prevalence of and what are the predictors of sex differences neurological learning myths among K-12 teachers in two South Carolina school districts?

5. What is the prevalence of and what are the predictors of belief in gender-specific instructional strategies among K-12 teachers in two South Carolina school districts?

1.6 SIGNIFICANCE OF THE STUDY

I believe the primary contribution of this study will result from my unique perspective on the problem. I have experience teaching in all-girls science classrooms and witnessed firsthand some benefits a single-sex environment had on my students. In addition, I observed and worked with schools which appeared to have tremendous success in terms of student behavior, engagement, and performance in single-sex learning environments. I also possess firsthand knowledge of the ways in which educators were instructed to teach boys and girls related to purported sex differences, as well as I have witnessed stereotypical lessons and teaching strategies in South Carolina classrooms. Explicit and implicit claims of sex differences have the potential to have profound negative impacts on student self-assessment, parental expectations, teacher expectations, and perceived stereotypes (Tiedmann, 2000). There is considerable debate over the potential benefits and detriments of single-sex education. The literature in favor of and in opposition of single-sex education spans many disciplines, including neuroscience, cognitive development, developmental psychology, sociology, education, and political theory.

While previous studies have examined the existence, prevalence, and predictors of general neuromyths, there are currently no studies that focus specifically on neuromyths related to sex differences, despite the emphasis single-sex advocates placed on the importance of "hardwired" differences (Chadwell, 2009; Gurian, 2010; James, 2007; Sax, 2005). The present study will explore how acceptance of sex difference neuromyths and belief in sex differences influences educators' beliefs about gender-specific instructional strategies. To date no study has specifically explored how acceptance of neuromyths or beliefs in sex differences influences classroom instruction. While classroom instruction was not directly observed for the purpose of this study, the exploration of educators' beliefs in gender-specific instructional strategies may provide insight for future research. The belief that boys and girls have innate neurological learning difference could result in differential learning experiences and outcomes.

1.7 DELIMITATIONS

The rationale for focusing on educators' beliefs about sex differences is rooted in the notion that teachers' perceptions of gender and sex differences affect how teachers interact with students (Francis, 2000; Good, 1987; Jones & Dindia 2004; She, 2000; Tiedman, 2002; van den Bergh et al., 2010). Regardless of district and school policy or mandated curriculum standards, teachers are responsible for the day-to-day decisions about what and how instruction will occur in their classrooms. The ways in which teachers interact with students can send messages about student ability and about what is or is not considered to be appropriate behavior for males and females. The influence of teachers' beliefs and expectations could be as subtle as the way a teacher speaks to and interacts with students or as overt as selecting different types of learning activities and strategies for students. A teacher who accepts gender stereotypes might differentiate instruction based on their beliefs. This could result in male and female students engaged unequally in inquiry, hands-on learning experiences, collaborative projects, or higher order thinking. It is my belief that single-sex learning environments may provide benefits for some students in certain contexts. However, separate is inherently unequal. I agree with Cohen (2014) "that sex segregation, by definition, reifies existing sex-based hierarchies". The present study can contribute to understanding the effects of the single-sex education movement in South Carolina by exploring how acceptance of sex-difference neuromyths influences educators' beliefs about gender-specific instructional strategies. Although in 2020 there are only remnants of the single-sex education movement in South Carolina, the result of the movement may have wide, deep, and lasting impacts on current and future classroom instruction.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION AND CONCEPTUAL FRAMEWORK

Historical Context and Theoretical Framework

Interpretation and reaction to the history of education in the United States has been influenced by individual belief, culture, politics, and religious affiliations (Spring, 2011). Spring (2011) summarized how an analytic approach to interpreting educational history "will cause mixed emotional responses" (p.3). He further stated, "It is not just a history of heroic and triumphant accomplishments" by people who "dedicated themselves to schooling the public for common good. But others believed schooling could serve their own personal or group interests by education compliant workers, voters, destroying cultures and languages and perpetuating their own power" (Spring, 2011, p.3). Education has been a vehicle for upholding religious and cultural traditions and has served to assimilate new populations into American culture (Spring, 2011). As an institution, schools have created and distributed knowledge to society, but because "knowledge is not neutral, a continuing debate exists about the political, social, and economic content of schooling" (Spring, 2011, p. 6). Although public education has served multiple agendas, some of which included dominance, inequality, and maintaining the status quo (Spring, 2011), I believe education has the potential to transform society and provide a path to equity and success for traditionally marginalized and disadvantaged groups.

When considering the selection and distribution of knowledge as it relates to formal education, one must consider the explicit, implicit (hidden), and the null curriculum. The explicit curriculum includes the content and courses offered by schools. The implicit curriculum includes the norms, rules, and cultures that are enforced as part of the school's policies and procedures. The null curriculum includes what is missing or absent from the school's offerings (Eisner, 1985). The explicit curriculum taught in most classrooms is typically rooted in what has been historically and traditionally taught, but Eisner (1985) claimed appropriate curriculum can only be selected if the students who will receive the curriculum are considered.

The implicit curriculum involves the socialization of students to the institutional culture of the school (Eisner, 1985). Eisner (1985) suggested that the implicit curriculum may be "profoundly more powerful and longer lasting than what is intentionally taught or what the explicit curriculum of the school publicly provides" (p. 88). The teaching of implicit curriculum occurs through the daily interactions and experiences of students (Eisner, 1985). Student interactions with peers, teachers, texts, and curricular materials send messages about what is appropriate behavior and what experiences, or subject matter, are valuable. Students must learn to function in the social context of the school, while demonstrating the expected behaviors of the teacher. Eisner (1985) concluded that "the school seeks to modify the child's behavior to comply with goals that the child has no hand in formulating and that might not have any intrinsic meaning" and creates a reward system for compliance" (p. 89). The null curriculum includes both the intellectual processes, content, and subject areas that are omitted by choice and/or by ignorance (Eisner, 1985). Eisner (1985) summarized the importance of identifying the null curriculum, “Schools have consequences not only by virtue of what they do teach, but also by virtue of what they neglect to teach. What students cannot consider, what they don’t know, processes they are unable to use, have consequences for the kinds of lives they lead” (p. 103).

Joseph (2011) suggested that curriculum is not an object but rather a dynamic, reflective, personal, and social process that allows educators to “interrogate the purposes of schooling” and that “curriculum as understanding leads us to become aware of the possibilities of education” (p. 4). Multiple perspectives and paradigms have been offered as frameworks to understand and discuss curriculum (Jospeh, 2011; Meyer, 2011; Spring, 2011). My personal beliefs about curriculum are rooted in liberal, behavioral, progressive, humanistic, and radical ideologies (Joseph, 2011). My theoretical frameworks include social justice, anti-oppression education, and queer pedagogy (Meyer, 2011). I believe that schooling and curriculum should offer every student access to broad and varied knowledge, ideas, and experiences. These experiences should prepare students to reach personal goals and provide access to resources that will allow them to thrive in society. Students should come to see and understand their historical, current, and future place in society in preparation for their roles as active citizens in a democratic society.

Gender Diversity and Equity in Education

When considering various identities, diversity, and equity, I share the beliefs of Adams et al. (2000) that “all forms of oppression are equally important, that they interact with each other in the lives of individuals and groups in complex ways, and that a fair and just society requires an end to all forms of oppression" (p. 5). Social categories are constructed, and differences are often equated with inequalities leading to groups of people that are valued above others (Adams et al., 2000; Meyer, 2011). Oppression by socially dominant or advantaged groups is usually based on race or ethnicity, gender, religion, sexual orientation, socioeconomic status, age, and physical or mental ability (Tatum, 2000). According to Tatum (2000) dominant groups have power and authority over subordinates and control what will be valued in society.

Harro (2000) described the "cycle of socialization" that we are born into which creates "a set of social identities, related to the categories of differences…and these social identities dispose us to unequal roles in the dynamic system of oppression" (p. 15). Each individual holds social identities that are oppressed and other identities that are part of the oppressive dominant culture. Harro suggested that "education for critical consciousness" and "unlearning old myths and stereotypes" can challenge the status quo, interrupt the cycle of socialization, and support structures that value all groups (pp. 20-21). I personally have social advantage as a white heterosexual; however, I am at a social disadvantage because I am female. Although I believe "There is no hierarchy of oppression" (Lorde, 1983, as cited in Adams et al., 2000), my lens for understanding oppression and the need for social justice lies in my experience as a woman.

Meyer (2011) summarized the work of critical pedagogy theorists who have "examined how the explicit and hidden curriculums in schools work to support existing dominant structures and contribute to the exclusion and oppression of marginalized groups in schools" (p. 13). Lorber (2000) asserted that, "Individuals are born sexed but not gendered, and they have to be taught to be masculine or feminine" (as cited in in Adams et al., 2000, p. 206). Schools explicitly and implicitly teach students what are socially appropriate behaviors and interests. There are multiple reasons for understanding gender and sexual diversity in schools that include the safety, physical well-being, emotional health, and the academic success of students who do not conform to heterosexual notions of femininity and masculinity (Meyer, 2011). Meyer (2011) reported that the lived experiences of individuals outside of the norm "show how the sex/gender binary is flawed and does not adequately represent the full range of human experiences and identities" (p. 21).

Gender and sexuality issues are the result of socially constructed binaries and categories that do not acknowledge or value the diversity of human gender identity and sexuality (Meyer, 2011). The terms *gender* and *sex* are often used interchangeably but have different meanings. Meyer (2011) suggested that to understand gender and sexual diversity in schools requires common language and definitions. Sex is both a legal and biological category defined by chromosomes and external genitalia and is assigned at birth. Binary definitions that include only XX for female and XY for male as normal exclude other natural variations. According to Meyer (2011) these definitions illustrate how "our need to impose normalizing categories over naturally occurring ones is an example of how the sex binary imposes artificial, socially created limits on people's lives" (p. 33). *Gender* is a psychosocial category that is constructed because of social interactions and self-concept (Meyer, 2011). The most common and socially acceptable categories are male and female. Researchers and theorist have suggested multiple identities of gender exist and should be recognized and valued (Meyer, 2011). I believe everyone benefits from the breakdown of stereotypes and defined sex roles. Greene (1978) eloquently summarized this sentiment, "We need to discover new fusions of what have been thought of as male and female characteristics. Perhaps a new revolution can then take shape, an educational revolution generated by the rejection of sexism. In the course of such a revolution, we may all rediscover ourselves" (p.158).

I believe gender and sexual diversity can be improved if educators openly confront stereotypes and look for "hidden curriculum" and other messages about sex roles and abilities. Several barriers exist to creating curriculum and learning environments free from sex typing (Adams et al., 2000). Ultimately the greatest barriers are stereotyping, conscious or unconscious, and gender conformity. Bem argued that "because gender is a powerful "schema" that orders the cognitive world, one must wage a constant, active battle, for a child not to fall into typical gendered attitudes and behavior" (as cited in Adam et al., 2000, p. 206). Anderson (2007) in his summary of the critical research tradition discussed how the "The Culture of Power" (p. 20) maintains the status quo and marginalization of disadvantaged groups. He reported that critical researchers "challenge… educators to think about our own roles in maintaining injustice and inequity in our schools" (Anderson, 2007, p. 25).

Sex and gender diversity are important issues in all educational settings, but many researchers and organizations (Eliot, 2011; Halpern, ; Williams, 2010) have specifically called for a re-evaluation of the changes to Title IX (United States Department of Education, 2006) that allow for segregation of students based on the sex/gender to which they were assigned at birth. In 2015, The United State Department of Education provided additional guidance for offering single-sex classes. Based on this guidance, single-sex classes must comply with all Title IX regulations and include a two-part justification. The justification requires that single-sex classes are designed to meet an "important objective" that will increase diversity and achievement and that the nature of the class is "substantially related" to achieving the objective (United States Department of Education, 2015). Proponents of hard-wired sex differences have encouraged educators to customize content, activities, and the learning environment for the purported differential needs of boys and girls (Gurian, 2010; Sax, 2005;). However, claims of hard-wired sex/gender differences have been scrutinized by experts. In addition, justification for sex segregation in education based on differences has been questioned and refuted (Eliot 2011; Halpern, 2007).

Teacher Beliefs and Implications of Single-Gender Education

Good (1987) recognized the necessity for teachers to meet the individual needs of students and asserted that not all students must be treated alike. However, he cautioned that "some teachers overreact to relatively small differences among students by teaching them in sharply divergent ways that are inappropriate" (Good, 1987, p. 35). Students' achievements can be directly affected through differential exposure to content and academic activities as well as indirectly affected through differential treatment (Good, 1987); therefore, educators must pause and consider the possible effects of sex segregated education. The American Council for CoEducational Schooling's (ACCES) position statement on the importance of coeducation has implications for all educational settings but is critical for reexamination of the justifications for sex segregation in education. ACCES suggested that coeducation prepares males and females to participate in co-ed families, work, and life. Advantages of coeducational schooling include embracing diversity and equality, positive peer role models of both sexes, experience with a range of personalities, activities, and lessons, friendship opportunities with both genders, and preparation for a co-ed life. Disadvantages of single-sex schooling include gender stereotyping, unfair conditions for students who do not conform to traditional roles, diversion of funding from other educational methods, diversity not being valued, failure to prepare students for co-ed life, and a perpetuated notion that separate is never truly equal (ACCES, 2011).

Single-sex education has been challenged by several authors and organizations. Williams (2010), in *Learning Differences: Sex-Role Stereotyping in Single-Sex Public Education*, called attention to the potential for stereotyping in single-sex education and discussed how "scientific rhetoric" is used to justify sex segregation despite the recognition by the United States Department of Education, as well as proponents of single-sex education, that stereotyping is a possibility. Cohen (2014) reported that despite years of data on how schools shortchange girls, it was not until authors like Gurain and Sax called attention to the "boy's crisis" that Title IX was amended permitting sex segregation. He stated, "By focusing on improving the lot of boys and previously ignoring girls' problems, the sex segregation movement showed its true color" and "that sex segregation, by definition, reifies existing sex-based hierarchies" (Cohen, 2014, p. 53). Research has shown that negative stereotypes about girls' and women's abilities in math and science adversely affect their performance in STEM programs (Hill et al., 2010). Critical, social, and feminist theories informed my approach to research since single-sex environments and essentialist views of gender have the potential to exacerbate inequities in education. It is interesting to consider that in education "separate is not equal" in terms of race segregation (*Brown v. The Board of Education,* 1954) but that it is acceptable to segregate based on sex.

2.2 HISTORICAL AND CURRENT STATUS OF SINGLE-SEX EDUCATION IN SOUTH CAROLINA

In 2006, the United States. Department of Education amended Title IX allowing public single-sex education as a legal option. These programs must be voluntary and not based on overly broad stereotypes (United States Department of Education, 2006). According to the National Association of Single Sex Public Education (NASSPE), in 2002 there were two dozen single-sex public schools. By January 2011, the number of schools blossomed to 524 (NASSPE, 2011). The majority of programs were located in schools that offered single-sex classes within coeducational schools. However, 103 were classified as single-sex schools where all students were taught exclusively in single-sex classrooms (NASSPE, 2011). In 2007, former South Carolina State Superintendent of Education, Jim Rex, created the Office of Single-Gender Initiatives and hired a full time Coordinator of Single-Gender Initiatives, David Chadwell. At the time of Chadwell's appointment he was a member of NASSPE Advisory Board. Chadwell was the first dedicated education coordinator hired to provide professional learning, curriculum, and instructional resources for teaching boys and girls in single-sex and coeducational settings (SCDE, 2011).

Shortly after the amendment to Title IX there was an explosion of single-sex schools, classrooms, programs, and trainings in South Carolina. The early trainings and strategies for differentiating by sex were heavily influenced by the book *Why Gender Matters: What Parents and Teachers Need to Know About the Emerging Science of Sex*

Differences by Leonard Sax, founder and executive director of NASSPE (2006). South Carolina hosted the NASSPE Southeast Regional Conference for three consecutive years (2005, 2006, 2007). In May of 2010, South Carolina lead the nation in the highest number of public schools offering single-sex programs or classrooms. Of the 124 single-sex schools, 61 were elementary, 56 were middle, and seven were high schools, and all schools were situated within nearly two-thirds of the state's school districts. The total number of teachers and students directly involved in these programs was reported to be 1,054 teachers and 19,000 students (SCDE, 2011). In his written forward to Chadwell's book, *A Gendered Choice: Designing and Implementing Single-Sex Programs and Schools* (2010), then state superintendent Jim Rex stated:

> I have watched in amazement as David Chadwell has engaged an entire state, and an entire profession in the process of understanding both advantages and the limitations of single-gender education. I have also watched as an incredible number of schools (at last count 200) have adopted single-gender choice programs vaulting South Carolina into national and international prominence as the leader in the number of public single-gender programs (half of the programs in America are in South Carolina (p. xi).

During the 2014 - 2015 academic year, the number of South Carolina schools offering single-gender options decreased to only 26 schools. Of the 26 schools, 15 were elementary, 11 were middle, and two were high schools situated in 17 districts (SCDE, 2014). In 2017-2018 the number decreased to only 10 schools (Klein et al., 2018). The reduction in single-sex learning environments coincided with the United States Department of Education's increased monitoring and enforcement of regulations governing public single-sex public education (Klein et al., 2018). According to the United States Department of Education's Office for Civil Rights 2015 document, *Questions and Answers on Title IX and Single-Sex Elementary and Secondary Classes and Extracurricular Activities*, single-sex classes must comply with all Title IX regulations and have a two-part justification. The justification requires that single-sex classes are designed to meet an "important objective" that will increase diversity and achievement and that the nature of class is "substantially related" to achieving the objective (United States Department of Education, 2015). In addition, all single-sex classes must "implement its objectives in an evenhanded manner; ensure that student enrollment in the single-sex class is completely voluntary; provide a substantially equal coeducational class in the same subject; and conduct periodic evaluations to determine whether the class complies with Title IX, and if not, modify or discontinue the class to ensure compliance with Title IX" (United States Department of Education, 2015, p. 4).

Klein et al. (2018) provided a complete review and history of single-sex education in the United States, which included a case study on South Carolina. They reported that between 2007 and 2017 there was an increase in U.S. public schools with single-sex classes from 645 to 927. Single-sex classes in South Carolina peaked in 2011 at approximately 200 and declined to only 10 by 2017-2018. One of the last South Carolina single-sex schools, Morningside Middle School in North Charleston, announced it would end single-gender education in 2018. *The Post and Courier* (2017) reported that Principal Stephanie Flock indicated a primary reason for the decision was "prolonged dwindling support from the S.C. Department of Education, which used to provide free training and curricula" (p.2).

A handout from the September 2009 SCDE sponsored workshop, *A Gendered Classroom: Gender Differences and Classroom Implications*, by David Chadwell, provided descriptions of the six differences between boys and girls that are claimed to be important in classroom settings. In addition to the descriptions, strategies for addressing each of the six differences were also provided. Chadwell (2009) offered this disclaimer:

> A word about the strategies: The strategies are grouped by being "for boys" or "for girls." This format allows for easy access of strategies as teachers will teach a group of boys or girls. The strategies are based on classroom experience and adaptation from research. They are a guide, a set of ideas. Certainly, the teacher should use any strategy with any group if the teacher believes it would benefit the students or a student. Using gender differences is Differentiated Instruction. Using gender differences is all about scaffolding. (slide 62)

Despite the disclaimer that teachers should use their best judgment as to which students would benefit from "for boy" or "for girls" strategies, the information provided conceptualized boys and girls as having different biological, social, and emotional needs in the classroom. In his introduction to, *A Gendered Choice: Designing and Implementing Single-Sex Programs and Schools* (2010), Chadwell stated, "the difference is not what is taught, but *how* (emphasis by author) the state and district standards are taught to boys and girls. The practice of using different instructional strategies to deliver a lesson or meet a standard with different populations of students is commonplace" (p. 3).

2.3 EDUCATIONAL IMPLICATIONS OF BRAIN BASED LEARNING RESEARCH

Neurological Basis of Learning

The neurological basis of learning is an active and controversial area of scientific research. The field of neurology has grown exponentially due to advances in technology that allow for analysis of brain structure and function. Electroencephalography (EEG), Event Related Potential (ERP), Magnetic Resonance Imaging (MRI), and Positron Emission Tomography (PET) are imaging tools used to measure and observe, both directly and indirectly, activity in the living brain. Studies involving more invasive procedures, such as lesion interference and recording electrophysiology with single electrodes, typically require animal test subjects such as rats or monkeys (Gluck et al., 2008). Passingham (2006) argues for the necessity of using animals in brain research and details the advantages and limitations of various techniques used in neurological studies.

According to Goswami (2004), studies that rely on neuroimaging tools are "based on the assumption that any cognitive task makes specific demands on the brain which is met by changes in neural activity" (p. 5). Functional MRI (fMRI) and PET imaging tools operate on the assumption that active parts of the brain require increased oxygen due to increased metabolic activity. By tracking changes in blood flow to various parts of the brain fMRI and PET images show which areas of the brain are active during various cognitive tasks. EEG and ERPs monitor the electrical activity of the brain with electrodes placed on the scalp. EEGs are a more cost-effective method of monitoring the changes in brain activity during learning and memory tasks. fMRIs and PETs are relatively precise in locating specific areas of activity, while an EEG locates only general areas of activity. However, an EEG can be measured almost instantaneously due to electrical impulses traveling to areas of brain activity at a faster rate than blood flow. While fMRIs and PETs detect changes in regional activity, they may not detect changes in the timing of brain activity. Although, both fMRIs and PETs measure local changes in blood flow and correlated metabolic changes, the results from tests of the same task do not always look identical (Gluck et al., 2008). Gluck et al.(2008), suggested that while “correlation does not imply causation…the limitations of imaging techniques simply mean that neuroscientists have to be careful in evaluating exactly what a given neuroimaging result does (and does not) show” (p. 62).

Numerous studies indicate that the hippocampus is essential in learning and memory formation, especially spatial memory (Gruart, 2014; Lynch, 2001). Lynch (2004) suggested, “Learning may be described as the mechanism by which new information about the world is acquired, and memory as the mechanism by which that knowledge is retained” (p. 88). PET studies confirm activity in the hippocampus during various learning tasks (Lynch, 2004). The hippocampus is in the temporal lobes of the cerebral cortex. The cerebral cortex, the outermost and largest part the brain, consists of two hemispheres connected by the corpus callosum. The right and left hemispheres consist of a frontal lobe, temporal lobe, parietal lobe, and occipital lobe. The cerebral cortex is responsible for a range of perceptual and cognitive processes, such as language and thought. Below the cerebral cortex is the cerebellum which is involved in coordinating movement. Located at the base of the brain, the brainstem connects the spinal cord to the brain and regulates autonomic functions. Other subcortical structures of the brain that are important in learning and memory include the thalamus, basal ganglia, and amygdala (Gluck et al., 2008). Gruart (2014) reported that while experimental evidence shows that the brain regions are specialized for specific functions “each intellectual or complex capability requires activation and coordination of many different brain areas” (p. 26).

At the cellular level, learning and memory are dependent on neural communication via electrical (action-potentials) and chemical (neurotransmitters) processes at synapses (Gruart, 2014). Neurophysiological studies involving single cell recording with microelectrodes attached to brain cells attempt to understand how neuron firing relates to behavior (Gluck et al., 2008). Learning can lead to physical changes, known as synaptic plasticity, in neurons including size, shape, number glia (cells that support and nourish neurons) and synaptic connectivity (Gluck et al., 2008). Long-term potentiation (LTP) is the process in which synaptic transmission becomes more effective as a result of recent activity and is widely believed to represent a form of synaptic plasticity that could be the neural mechanism for learning (Gluck et al.,, 2008). During LTP, synaptic transmission becomes more effective and the post-synaptic neuron has a strengthened response to future stimulation (lasting from minutes to hours) from the pre-synaptic neuron. Conversely, long-term depression (LDP) occurs when synaptic transmission becomes less effective as a result of recent activity. Although LTP is not completely understood, most researchers believe that a structural change in the post-synaptic neuron strengthens existing connections and/or builds new connections (Lynch, 2004).

The role of LTP in memory formation is well supported by neurological studies (Lynch, 2004). Lynch (2004) reported that there are “solid arguments that support the hypothesis that LTP may be a biological substrate for at least some forms of memory” (p.

90). Most studies have found a correlation between LTP and cognitive ability; however, other studies have found no evidence linking LTP and cognitive ability. This inconsistency suggests that LTP may be pathway dependent, that synaptic connections utilize different signaling molecules, and that experimental conditions (such as placing electrodes on the brain) can cause inflammation and other responses that interfere with LTP (Haung et al., 2013; Lynch, 2004). Neurons that fire simultaneously have strengthened synaptic connections, and memory formation appears to be dependent on the strengthening of neural associations (Gluck et al., 2008). Huang et al. (2013) concluded, "that LTP may be necessary for learning in some situations but unnecessary in others; the mechanisms responsible for the LTP/learning connection are unknown" (p. 432). Studies of LTP and learning rely on animals for experimentation (Gruart, 2014; Nabavi et al., 2014), and while much has been learned from these studies, caution is suggested when considering application to educational settings (Eliot, 2011; Gruart, 2014).

Synaptic plasticity, the ability of synapses to change because of experience, is one of the most researched areas of neuroscience (Gluck et al., 2008). Learning experiences can cause changes in synapses that may weaken or strengthen connections. Although synaptic plasticity is not fully understood, neurological studies show that memories cannot be formed without LTP, and LTP is only observed in animals that where recently engaged in learning (Gluck et al., 2008). Synaptic plasticity can be measured via changes in neurotransmitters and fMRI. MRI scans provide evidence that neural activity can affect myelination (Fields, 2013). Myelin, a fatty insulating substance that makes up most of the white matter in the brain, is composed of oligodendrocytes (glia cells) wrapped around neurons (Valk & van der Knapp, 1989). Myelination is believed to influence neural impulse speed, strength, and timing (Fields, 2005). Environment and experience are linked to increased myelination in the cortex and corpus callosum in both animals and humans (Fields, 2005). Teicher et al. (2004) reported that MRI scans show that childhood neglect is associated with a 17% decrease in the corpus callosum area of the brain. Rats raised in enriched environments have increased oligodendrocytes (Fields, 2005).

Fields (2005) suggested that myelination is an "overlooked mechanism of synaptic plasticity" (p. 528). Myelination of neural pathways affects impulse, speed, cognitive ability, and decision making (Field, 2005). Studies involving cab drivers (Goswami, 2006) and professional piano players (Fields, 2005) have shown increased myelination in specific regions of the brain. In studies of professional piano players, the magnitude and location of the increased myelination was associated with both the amount of practice time and the age at which the practice occurred (Fields, 2005). MRI studies indicate that the development of motor skills, reading ability, decision making, and IQ are associated with the amount of white matter in the brain (Fields, 2005), suggesting that synaptic plasticity has implications in education.

The plastic nature of the brain may facilitate learning consolidation by improving the efficiency of existing pathways or by forming new connections and increasing synaptic density (Gruart, 2014). A student's prior knowledge or experience can impact their ability to acquire and assimilate new information (Gruart, 2014). Eliot (2013) concluded that children's brains are:

> massively more malleable than at any other time of life. Neuroplasticity, defined as the structural and functional modification of the brain, is the basis of all

learning academic or otherwise: everyday experience generates the neural activity that selects and strengthens certain synapse at the expense of others, adapting each child's brain to the academic, social, and leisure tasks at hand. (p. 376)

Neurological studies have the potential to provide key insights into how learning occurs, ways in which to best educate children, and possible interventions for learning difficulties. For example, research on multitasking and memory suggests that attention management is critical in the learning process. Strategies for attention enhancement in the classroom include the following: reducing multitasking, limiting distractions, chunking information, allowing time to process before shifting to new task, using novelty and surprise, making connections with prior knowledge, and modeling to explicitly teach skills for attention management (Gruart, 2014). However, neurobiologists, psychologists, and other researchers have suggested caution when interpreting the significance of brain imaging and neurological studies in educational settings (Eliot, 2011; Goswami, 2004, 2006; Gruart, 2014; Howard-Jones, 201; Hruby, 2012). Gruart (2014) argued for the need to establish common language between education and neuroscience and to identify a clear framework for dialog and experimentation. Gruart (2014), concluded:

Essentially, some of the questions arising in the classroom could be designed and tested using neuroscientific tools, and many of the data found in neuroscientific experiments could provide interesting and workable hypotheses to be tested in the classroom. Of course, this should be done after taking all the necessary steps, as is done in pre-clinical and clinical trials before using a new treatment in patients. (p. 42)

Neuromyths in Education

Despite calls for caution in the interpretation and application of neurological studies to educational settings, numerous pseudo-scientific neuro-myths exist (Alferink & Farmer-Dougan 2010; Howard-Jones, 2011). Teachers are inundated by books on this topic, such as *Teaching with the Brain in Mind* (Jenson, 2005), *The Brain Compatible Classroom* (Erlauer, 2003) and *Teaching the Female Brain* (James, 2009). Popular neuromyths include notions of left-brained/right-brained learning, critical learning periods, learning styles, multiple intelligences (Alferink & Farmer-Dougan 2010; Dekker et al., 2012; Goswami, 2004; MacDonald et al., 2017) and the binary of male or female brains (Eliot, 2011). Howard-Jones (2011) reported that "authentic neuroscience" has revealed important insights about learning relevant in educational settings; however, he cautioned that "there are many challenges in moving from brain scan to lesson plan…a simple transmission model in which neuroscience advised education on their practices should never be expected to work…research is needed to bridge the gap between laboratory and classroom" (p. 111). Hruby (2012) systematically analyzed the challenges of integrating neuroscience and education and moving beyond the "rhetorical misuse by educational marketers, policy makers, and polemicists targeting the public" (p. 2). Hruby (2012) and Gruart (2014) pointed to the obvious fact that all learning is technically brain based, but there is a tendency to give credence to research and strategies that claim to have a neurological basis. Hruby (2012) suggested that "reference to the brain is apparently meant to imply research-demonstrated efficacy…but only research on effective instruction can indicate the likely conditions for effective instructional methods" (pp.4-5).

Goswami (2006), while not specifically discussing single-sex education, called attention to the numerous “packages” and brain-based (Brain Gym, left-brained/right-brained, and learning styles) recommendations made to teachers which are supposedly based on neuroscience. The author expressed his belief that there is a need to bridge the gap between neuroscientists and educators and stated, “The ideal communicators would be ex-scientists with an interest in education…they could fulfill a dual role: interpreting neuroscience from the perspective of, and in the language of educator” (p.7). These “communicators” should be individuals who are concerned with public interests and not-for-profit. I would argue there is a serious need for this type of “communicator” to bridge the gap between the science of sex differences and implications, or lack of, in education, especially in single-sex learning environments.

2.4 SEX DIFFERENCES IN LEARNING AND COGNITION

There is considerable debate surrounding the topic of sex differences. Cahill (2006) argued that human and animal studies confirm sex differences in brain anatomy, chemistry, and function and neuroscientists need to acknowledge these differences and the implications for understanding disease. Cahill identified five misconceptions related to neurological sex differences. The five misconceptions are the following: sex influences are small and unreliable, average differences result from extreme distributions, within-sex variation is greater than between-sex variation, differences can be explained by hormones, and neural differences only exist where behavioral differences are observed. He refuted these misconceptions with evidence from PET and MRI studies and other studies in both humans and animals. The data presented examined structural and functional differences in male and female brains. While he did discuss learning and memory, there is no mention of implications for education. Cahill stressed the effects that sex differences may have for understanding and treating disease such as Alzheimer's, attention deficit hyperactivity disorder, depression, etc.

Hyde (2005) contended that males and females are more alike than different, thus proposing the gender similarities hypothesis. The gender similarities hypothesis is supported by 46 meta-analyses studies that examined 128 psychological characteristics in six broad categories. The six categories are cognitive abilities, verbal and nonverbal communication, social or personality variables, psychological well-being, motor behaviors, and other constructs such as moral reasoning. 78% of the attributes examined had close-to-zero ($d = \leq 0.10$) or small effect sizes ($0.11 < d < 0.35$) with exceptions of motor performance, sexuality, and physical aggression which were higher in males. The magnitude of sex differences can fluctuate with age and social context. For example, student computer self-efficacy has a very small effect size of $d= 0.09$ in elementary school, but climbs to $d=0.66$ (in favor of males) in high school, a fact leaving Hyde to wonder, "What forces are at work transforming girls?" (p. 588). The magnitude of differences in aggression and helping behaviors decreased significantly when social factors were removed. Hyde concluded that "inflated claims of gender differences" can have negative implications in the workplace, for parenting, for heterosexual relationships, and psychological well-being and that context can create, erase, or reverse gender differences.

Halpern (1997) specifically discussed the implications of sex difference for education and suggested that it is not sex differences research that created stereotypes, but that "they arise inductively through experience" (p.1,091). Research is needed to determine if stereotypes are based on statistically significant difference between groups. Differences do not imply deficiencies or that one is better or worse. The problem according to Halpern, is the value society places on traits associated with each sex. She succinctly summarizes the problem of nature versus nurture, "Nature-nurture is a false dichotomy; biology and environment are as inseparable as conjoined twins who share a common heart" (p. 1,097). She proposed the psychobiosocial model as an alternative to the nature or nurture debate suggesting that some traits such as learning are both biologically and socially mediated. The following summarizes the important implications related to education: differences are based on averages, not better or worse and the misuse of data should not be permitted; no one is average; beliefs about differences influence thoughts and behaviors without conscious awareness; we should support research on cognitive differences given their potential for disease treatment; boys mature later compared to girls; spatial skills should be taught in school; we should be skeptical of sex difference claims and interpret data with caution (including her own review); the brain remains plastic throughout life; and there is no cognitive data to support single-sex education, but possibly there are social reasons. Halpern (1997) concluded, "The fact that females and males differ, on average, on some abilities, must not be used to restrict individual choices." (p. 1,098).

2.5 TEACHER BELIEFS, EXPECTATIONS, AND STEREOTYPE THREAT

Although there is considerable debate and controversy surrounding the effects of teacher beliefs and expectation on student achievement, there is a consensus that teacher beliefs do affect students (Good, 1987; Jussim & Harber, 2005). Jussim and Harber (2005) critically reviewed 35 years of research on teacher expectations and concluded, “Although some specific teacher expectations studies may have suffered flaws sufficiently serious to threaten their conclusions, the abundant naturalistic and experimental evidence shows that teacher expectations clearly do influence students – at least sometimes” (p. 13) and there may be a greater effect on stigmatized social groups. Jost and Kruglanksi (2002) suggested that inaccurate impressions are perpetuated because people “see what they want to see and act as others want them to act” (pp. 172–173). Therefore, teachers who subscribe to sex differences in student learning and achievement could have differential expectations for boys and girls that reinforce sex stereotypes and widen achievement gaps.

Jussim and Harber (2005) reported that the power of self-fulfilling prophecies was the strongest in new situations and at specific grade levels. Jussim and Harber (2005) summarized the work of Smith et al. (1999) and reported, “Teacher perceptions in sixth and seventh grade predicted significant changes in student achievement through high school” (p. 121). This is concerning considering that a large number of single-sex classes and programs existed in middle schools (Klein et al., 2018). Teachers behave differently towards students they perceive as high or low ability (Jussim & Harber, 2005). Single-sex education advocates focus on the differences between girls and boys and their strengths and weaknesses in the classroom. When I conducted single-sex professional development, the training stressed the importance of teaching to strengths, but by pointing out different strengths of one sex we were inherently pointing out the weaknesses of the other. Focusing on strengths and weaknesses could create the belief that boys compared to girls may have a higher ability in some areas and a lower ability in other areas. Jussim and Harber (2005) reported that, “Teachers are typically emotionally warmer and more supportive to their high expectancy students, provide them clearer and more positive feedback, teach them more and more difficult material, and give them more opportunities to demonstrate mastery" (p.142). Lower level students can succeed in classes with high level students and typically have more "positive interaction with teachers than they enjoyed in low-track classes" (Good, 1987, p. 39). Tiedemann (2002) examined the influence of teacher stereotypes and concluded, "Teachers' gender stereotypes have not a generalized but well defined effect on the specific beliefs about their students' ability and effort-resources. Gender stereotypes have an impact on the way teachers attribute mathematical abilities and effort resources only to average and low achieving but not high achieving boys and girls…student's performance is an essential moderator-variable in the transmission of teachers' gender stereotypes" (p. 60). Therefore, teacher expectations based on sex-difference could lead to differential treatment of students based on perceived ability level.

Teacher behaviors and expectations can have effects on students' "self-concepts, motivation, performance expectations, or attributions" (p.35) and expectation effects can operate at the individual, group, class, or school level (Good, 1987). Students are not only aware of differential treatment by teachers, but also affected by it (Good, 1987; Jussim & Harber, 2005). Jussim and Harber (2005) summarized the work of Brattesani et al. (1984) and reported the effect sizes for teacher expectation and student achievement were highest in situations where students perceived the greatest differential treatment. Studies on the effects of tracking by ability level found that "tracking may lead to the type of rigid teacher expectations most likely to create self-fulfilling prophecies" (p. 143). Separation by sex inherently sends messages to students about differences, and educators have been encouraged to use different strategies for meeting the different needs of boys and girls. Good (1987) summarized the findings of Brophy and Good (1974) on the differential treatment of girls and boys and reported, “in one set of classrooms low-achievement girls tended to have especially impoverished academic environments in the classroom, whereas high-achieving boys tended to be afforded productive and intellectually responsive environments”(p. 33). Good (1987) recognized the need for teachers to meet the individual needs of student and that not all students must be treated alike, but cautioned that, “some teachers overreact to relatively small differences among students by teaching them in sharply divergent ways that are inappropriate” (p. 35). Students’ achievement can be directly affected through differential exposure to content, academic activities, and indirectly through differential treatment (Good, 1987). Proponents of hard-wired sex differences encouraged educators to customize content, instructional strategies, and the learning environment for the purported differential needs of boys and girls.

Jussim and Harber (2005) noted, “Because stereotypes are often shared (or in the case of single-sex education, explicitly taught to teachers), perceiver after perceiver will presumably heap self-fulfilling prophecy after self-fulfilling prophecy upon stereotyped targets” (p. 148). They also reported that some research suggests cumulative effects for self-fulfilling prophecies. Good (1987) placed teachers on a continuum of “*proactive*” to “*overactive”* and cautioned that “*overactive”* teachers “Who develop rigid, stereotyped perceptions of their students based on prior records or first impressions…tend to treat their students as stereotypes rather than as individuals, and they are more likely to have negative expectation effects on their students” (p. 41). On the topic of teacher expectations and social inequities, Jussim and Harber (2000) concluded, "Given the relevance of such research to theoretical perspectives on stereotypes and prejudice, to understanding the validity of everyday social judgment, and to assessing the role of education in creating, sustaining, or alleviating social injustices, more work assessing this particular type and degree of accuracy is also clearly needed" (p. 153).

Rydell et al., (2010) were the first to provide evidence that stereotype threat not only impacts performance, but also impacts learning of novel mathematics concepts. The authors explored how stereotypes such as "women are bad at math" activate stereotype threat, directly impacting performance and learning. Stereotype threat is defined as, "the arousal, worrying thoughts, and temporary cognitive deficits evoked in situations where a group member's performance can confirm the negative stereotype about the group's ability in that domain" (p.1). The authors attributed the lack of prior research on stereotypes and learning to the difficulty of assessing learning separate from performance. The authors defined learning "as the ability to encode into memory information that is necessary for successful skill completion" (p.1).

To test the influence of stereotype threat on learning, I conducted three experiments designed to determine if stereotype threat was detrimental on a woman's ability to learn mathematics. The results indicated stereotype threat reduces women's ability to encode mathematical rules into memory, reduces learning when presented before the learning takes place, and reduces women's, but not men's, ability to learn abstract mathematical concepts. These results, combined with previous studies, suggest that stereotype threat is of concern because it not only impacts performance and execution of previously learned material, but also impairs the learning of new material. The authors called for future research to explore how stereotype threat impairs encoding of information, working memory, and the mechanisms involved in reduced learning under stereotype threat. They suggested creating and structuring learning environments free from stereotype threat as a means of reducing disparities of historically underrepresented groups. The authors concluded, "Knowing that stereotype threat reduces learning makes it more pervasive and insidious, indicating that there is much left to learn about stereotype threat and how to eradicate its influence" (Rydell et al., 2010, p.13).

Lindberg et al., (2010) reported that males and females perform similarly in mathematics and that the achievement gap in mathematics performance is no longer evident. Their conclusions were based on a meta-analysis of 242 studies published between 1990 and 2007 representing 1,286,350 people. They also analyzed data of U.S. adolescents over the past 20 years from large longitudinal studies. The authors believe that "Policy decisions, such as funding for same-sex education, as well as continuing the stereotype that girls and women lack mathematical ability, call for up-to-date information about gender differences in mathematical performance" (p. 1,123). In their review of the literature the following gender stereotypes were identified: females are inferior in mathematics is a common belief among children, adolescents, parents and teachers; college students have implicit bias about men and mathematics; parents believe their sons have higher mathematical abilities than their daughters; and teachers tend to overrate male abilities in mathematics. The authors believe these stereotypes are of concern for several major reasons. Cognitive social learning theory suggests that stereotypes influence belief in competency and self-efficacy. Studies have shown that the stereotypes of parents and teachers are correlated with students' perceptions of their own abilities. These perceptions can alter students' selections of activities and environments. The authors stated that the "second concern is that stereotypes can have a deleterious effect on actual performance" (p.1123). Stereotype threats have been found to affect children as early as kindergarten and have been documented to impair the mathematical performance of women. The authors suggested, "The stereotypes about female inferiority in mathematics stand in distinct contrast to the scientific data on actual performance" (p. 1133). Research shows that performance differences are very small with some studies finding males and others finding females favored and "strong evidence of gender similarities in mathematics performance" (p. 1133). They believe their research findings contradict the rationale for separating boys and girls in mathematics classrooms because most of the students in the studies they analyzed were in co-educational classrooms (Lindberg et al., 2010).

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION AND CONCEPTUAL FRAMEWORK

This chapter details how a sex-specific learning differences inventory (SSLDI) and teacher beliefs survey were created, validated, and revised to study the prevalence, predictors, and implications of sex-difference neurological learning myths and misconceptions in PreK-12 teachers and the prevalence, predictors, and implications of teacher belief in gender-specific instructional activities in Pre K-12 teachers. The study employed a convergent parallel mixed methods design combining quantitative and qualitative research methodologies to help establish construct validity and triangulation (Creswell, 2014). A convergent parallel design allowed for both the qualitative and quantitative data sets to be analyzed separately as a tool to confirm or disconfirm the results from both data sets (Creswell, 2014).

While previous studies have examined the existence, prevalence, and predictors of general neuromyths (Table 3.1) there are no studies that specifically focus on neuromyths related to sex differences, despite the emphasis single-sex advocates placed on the importance of "hardwired" differences (Sax, 2005; Chadwell, 2009; James, 2007; Gurian, 2011). Several authors (Cohen, 2014; Eliot, 2011; Williams, 2010) have challenged many of the neurological/biological differences purported by education consultants who claimed that boys and girls learn differently and should be separated by sex to accommodate differences (Sax, 2006; Gurian, 2011). Given the historical involvement of South Carolina school districts in single-sex schools, classes, programs, and professional learning opportunities, coupled with the "seductive allure" of neuroscientific explanations (Weisberg, 2008, p.1), the present study was needed to determine the prevalence and predictors of sex learning difference neuromyths and the prevalence of belief in gender-specific instructional strategies.

The sex-specific learning differences inventory (SSLDI)was developed using MacDonald et al. (2017) as a model for item structure and general neuromyths constructs. The initial list (Appendix B) of items were informed by my firsthand knowledge and experiences related to single-gender education and gender learning difference professional learning activities. This included, but was not limited to, teaching in a single-gender academy, working in The Office of Single-Gender Initiatives at the South Carolina Department of Education (SCDE) , and attending numerous trainings and workshops presented by Leonard Sax and David Chadwell between spring 2007 and fall 2010. At SCDE I worked under the supervision of David Chadwell, Coordinator for Single-Gender Initiatives and author of a *Gendered Choice* (2009). I presented at the National Association of Single-Sex Public Education (NASSPE) national conferences and regional and local conferences, worked as a freelance single-gender consultant, and delivered numerous trainings and workshops about teaching boys and girls. These training were influenced by *Why Gender Matters* (2005) by Leonard Sax. My firsthand knowledge of suspected gender neuromyths was validated by Lise Eliot's *Single-Sex Education and the Brain* (2011). I also relied on their first-hand knowledge of gender learning misconceptions and 15 years of classroom experience (including two in a single-gender academy) to construct the list of possible gender-specific instructional strategies.

The present study explored how acceptance of sex learning difference neuromyths influenced teacher beliefs about gender-specific instructional strategies. This is the first study that specifically explored how acceptance of neuromyths or beliefs in sex-differences may influence classroom instruction. While classroom instruction was not directly observed in the pilot or full study, exploration of educator beliefs in gender-specific instructional strategies yielded insight for future research. The belief that boys and girls have innate neurological learning differences and need different instructional strategies has the potential to result in differential learning experiences and outcomes.

The overarching research question for this study is, "What is the prevalence of and what are the predictors of belief in gender-specific instructional strategies among PreK-12 teachers in two South Carolina school districts?" A survey was developed to address the following research questions:

1. What percentage of PreK-12 teachers in two South Carolina school districts have taught in single-sex learning environments and/or engaged in professional learning related to sex difference in learning?

2. How much time do PreK-12 teachers in two South Carolina school districts report participating in various professional learning experiences related to sex differences?

3. What are the types and sources of professional learning experiences reported by PreK-12 teachers in two South Carolina school districts?

4. What is the prevalence of and what are the predictors of sex difference neurological learning myths among PreK-12 teachers in two South Carolina school districts?

5. What is the prevalence of and what are the predictors of belief in gender-specific instructional strategies among PreK-12 teachers in two South Carolina school districts?

The first three research questions provided descriptive data on how many PreK-12 South Carolina teachers have taught in single-sex learning environments and/or participated in professional learning experiences related to sex differences. In addition, question two provided an amount of time estimate for professional learning. The amount of time estimate served as an independent variable and possible predictor of sex difference neurological learning myths and beliefs in gender-specific instructional strategies in the final study. The third question identified the types and sources of sex difference professional learning experiences that teachers reported. The types and sources of descriptive data provided additional information and context for the "amount of time estimate." Demographic and experience data were used to identify predictors of gender learning difference neuromyth acceptance (Dekker et al., 2012; MacDonald et al., 2017). The final overarching research question identified predictors of belief in gender-specific instructional strategies. In particular, the study investigated how the amount of time estimate and endorsement of neuromyths influenced teacher beliefs about how boys and girls learn and should be taught. Teacher acceptance of neuromyths could impact classroom instruction. Experiences related to single-gender education and gender learning differences could impact a teacher's gender learning neuromyth acceptance. Therefore, the single-gender education movement in South Carolina could have an impact on current and future classroom instruction.

3.2 RESEARCH DESIGN AND INSTRUMENTATION

Survey research was selected because it "is a highly effective method of measurement in social and behavioral science research. Well-designed surveys can be extremely efficient and very effective in generalizability...and is particularly flexible given the numerous options available for instruments and data collection" (Ruel et al., 2016, p. 2). No published surveys were identified that could be used to answer the identified research questions. Therefore, development of a sex-specific learning difference inventory and teacher belief survey was essential for answering the research questions. A mixed methods approach was used to develop the survey and answer the research questions. Quantitative (closed-response items) and qualitative data (open-response items) were collected using electronic surveys. Closed-response items were needed to quantify the research constructs for statistical analysis (Johnson &Morgan, 2016). The quantitative data was analyzed to detect statistically significant relationships among variables (Gelo et al., 2008). Open-response items were needed to gather qualitative responses that captured unanticipated responses, provided opportunity for respondents to express their views, and for quotes that represented the language of the survey participants (Johnson & Morgan, 2016). The data was coded into themed categories used for narrative, contextual descriptions, and quotes from the participants. Open-response items were used to triangulate the data and help establish construct validity. Gelo et al.(2008) presented a complementary-continuous perspective of a mixed methods research that combines quantitative and qualitative research. They state, "this model is based on a unitary vision of science, according to which quantitative and qualitative methodologies must interact in a continuous way to allow researchers to answer different and complementary research questions" (Gelo et al., 2008, p. 279). The convergent parallel mixed methods design allowed for side-by-side comparison of the quantitative and qualitative data sets, in which the quantitative statistical results could be confirmed or disconfirmed by the qualitative findings (Creswell, 2014).

The purpose of the of the sex-specific learning differences inventory was to measure the construct and neuromyth acceptance, specifically neuromyths related to sex differences. Neuromyths are defined as “a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) to make a case for the use of brain research in education and other contexts” (Organization for Economic Co-operation and Development, 2002). Neuromyth acceptance was measured as the percent incorrect for items that represented neuromyths (MacDonald et al., 2017).

3.3 SEX-SPECIFIC LEARNING DIFFERENCS INVENTORY AND TEACHER BELIEFS SURVEY DEVELOPMENT

The sex-specific learning differences inventory was modeled after neuromyth surveys developed by Dekker et al. (2012) and adapted by MacDonald et al. (2017). Both surveys contained true or false items. Of the survey items about half of the items were considered true and supported by neuroscientific research; the other items were considered neuromyths (MacDonald et al., 2017). The inventory contained items that reflected popular sex difference learning myths (Eliot, 2011) in the domains of brain structure and development, hemispheric processing, sensory processing, and learning and learning styles. The items represented myths that were endorsed by single-sex education advocates (i.e. Sax, 2005) and later debunked by neuroscience experts (i.e. Eliot, 2011). The items were written in a similar language and style as the MacDonald et. al (2017) survey. The content of the items was based on Eliot’s (2011) summary on the validity of purported sex differences. A true and false scale was appropriate for measuring teacher knowledge of sex difference as a means to conceptualize teacher acceptance of neuromyths (Johnson & Morgan, 2016).

The gender learning difference neuromyth survey scale items were developed following the item-writing guidelines for relevance, audience, language, item structure, and conventions outlined in Johnson and Morgan (2016). The items were relevant to the study objectives, grounded in my review of the literature, and represented sex differences that have either been confirmed and held as true or have been rejected and considered neuromyths. The neuromyth items represented several popular myths and misconceptions that were endorsed and proliferated by single-sex advocates. The items were categorized under the domains of brain structure and development (BSD), hemispheric processing (HP), sensory processing (SP), and learning and learning styles (LLS). The intended audience, K-12 certified teachers who taught in selected school districts South Carolina, held at least a bachelor's degree and should have had the necessary cognitive skills and background information to answer the items. All items were written with reference to girls and/or boys. Girls and boys were selected because sex difference can vary in intensity across the lifespan (Halpern, 2000). The terms were used to encourage teachers to frame their response in reference to school aged children. Teachers should have been exposed to the construct domains in both pre-service and in-service courses and professional learning experiences. In addition, teachers should have been familiar with the technical language used (i.e. language skills, visual-spatial skills, learning styles, hemispheres, etc.). Specific determiners were necessary because all confirmed sex differences are based on averages (i.e. height, brain size, language acquisition, etc.) (Halpern, 2000). To help control against cueing respondents, there was a balance of true and false items that used the terms “typically” and “tend”. To help control respondents' tendency to guess true when unsure of the answer, approximately 60% of the items were false (Johnson & Morgan, 2016). A true or false scale was selected to gauge teacher’s knowledge of sex differences and neuromyth acceptance due to true or false scales having the ability to be used to calculate a neuromyth score. The neuromyth score was also used to predict teacher beliefs about instructional practices. All items were written as a short, concise phrase and were modeled after previously published surveys (Dekker et al., 2012; MacDonald et al., 2017). Each item was intended to address a single idea and began with qualifying phrases (girls typically, boys typically, boys and girls, the brains of, etc.) (Johnson & Morgan, 2016). All items were reviewed for correct spelling, language conventions, and typographical errors.

Expert Review and Development of Pilot Survey

The survey was reviewed for content validity by expert evaluation (Ruel, 2016). An initial item (II) list of 34 neuromyths items (Appendix B) were reviewed by sex difference expert Dr. Lise Eliot, associate professor of neuroscience at the Chicago Medical School of Rosalind Franklin University of Medicine and Science. The survey items were revised according to Dr. Eliot’s feedback. II-3 (amygdala bigger in boys) and II-4 (pre-frontal cortex bigger in girls) were excluded from the survey. Initial items II-10 (right and left hemispheres work together), II-15 (boy eyes motion), II-16 (eyes of boys drawn to colors black, blue, grey, and brown), II 17 (eyes of girls drawn to colors yellow, red, and orange), II-24 (girls acquire language skills), and II-25(boys stronger spatial skills) were revised based on the expert evaluation (Appendix B).

In addition to the revision informed by expert evaluation, I ultimately decided to exclude items II-7 (girls wired for multi-tasking), II-27 (girls and boys learn differently), and II-34 (boys and girls have learning styles dominated by senses) and to combine II-8 (boys use one hemisphere of the brain at a time) and II-9 (girls use whole brain thinking) (Appendix B). I decided to add three modified items from Dekker et al. (2012) to maintain the 40:60 true and false item ratio. The added items were (Appendix C) pilot item (PI) 30 (specific periods in childhood easier to learn certain things) PI-31 (extended rehearsal of mental process changes brain structure and function), and PI32 (information is stored in networks of cells distributed throughout the brain).The terms "boys" and "girls" were added to the three statements accepted as neurological truths (these items were not reviewed by expert evaluation until after the pilot study). As a result of expert evaluation two of the items were retained and one item was excluded (discussed below). The 32 pilot items identified for inclusion in the pilot survey are listed in Appendix C. The pilot study gender learning difference inventory contained 13 statements considered true and 19 items considered false.

The survey developed for the pilot study was divided into the following six sections: introduction, background information and teaching experience, professional experiences and activities, knowledge of gender learning differences and brain structure and function, instructional strategies, and pilot survey questions and incentive link. The background information and teaching experience section questions were designed to identify predictors of neuromyth endorsement and belief in gender-specific instructional strategies. Demographic data for teachers included age, gender, education level, and school district. Experience data included certification status, current teaching level, certification level, certification area, neuroscience course work, and National Board Certification. Teaching experience data were also collected for total years teaching, years teaching in South Carolina, years teaching single-sex classes, years teaching co-ed classes, and years teaching in a school with single-sex classes. Due to South Carolina's prolific participation in public single-sex classes and schools, it was predicted that teachers with a higher percentage of time in South Carolina and/or directly involved in single-sex learning environments would have encountered information about sex differences.

The types and sources (consultants, webpages, trade books, scholarly articles, etc.) of sex difference professional learning were recorded. A scale to measure beliefs in gender-specific instructional strategies was developed and included in both the pilot and full survey. Previous neuromyth studies have not included a measure of teacher beliefs and instructional strategies. The gender-specific instructional strategies section (Appendix D) asked respondents to identify if they believed instructional strategies met the needs of both boys and girls, met the needs of primarily boys, or met the needs of primarily girls. To quantify the construct, belief in gender-specific instructional strategies, a sex specific instructional strategies score was constructed by calculating the percentage of instructional strategies identified as meeting the needs of primarily girls, the needs of primarily boys, or meeting the needs of both boys and girls. The total score range represented no belief in gender-specific instructional strategies (0%) to a belief that the instructional needs of boys and girls are extremely different (100%).

Prior to the pilot study administration, an informal review of these items and overall survey experience was conducted by five volunteers with current or previous classroom experience and some exposure to single-gender education and /or professional learning experiences related to gender learning differences. Only minor grammatical changes were made as a result of the informal feedback. All volunteers indicated the survey questions were clear and the survey was easy to understand and navigate.

3.4 TARGET POPULATION, PILOT STUDY PARTICIPANTS, AND FINAL STUDY PARTICIPANTS

In the fall of 2019, four district level research requests were completed and submitted. Four districts (A-D) were selected since they had high numbers of schools offering single-gender classes in 2008-2009. All four districts had at least one or more schools offering single-gender classes during the 2014-2015 school year (SCDE, 2014). In 2017-2018, three of the districts reported offering single-gender classes (Klein, 2018). It was theorized that these districts would have educators who either taught single-gender classes and/or were exposed to professional learning related to sex differences. However, due to high teacher attrition in South Carolina, as well as the recently terminated Teacher and Employee Retention Incentive (TERI) program (Pedersen, 2018), it was theorized that there would also be educators who transferred into these districts or novice educators who were recently certified or seeking initial alternative certification. It was theorized that the four selected districts would have a population of educators with diverse and varied experience, as well as exposure to single-sex learning environments and professional learning related to sex differences. I planned to use a convenience sample (Fink, 2013) consisting of 25 to 50 K-12 certified teachers representing males and females from varied racial, ethnic, and cultural backgrounds from School District A.

School Districts A and B approved the research requests, but School Districts C and D denied the research requests. All schools in School District B were invited to participate. However, several schools were closed to research requests. The principals of two high schools open to research requests agreed to let their teachers voluntarily complete the electronic survey. A research request was sent to and approved by a fifth school district, School District E, after the four initial requests were approved or denied. This district was also theorized to have a population of educators with diverse and varied experience and exposure to single-sex learning environments and professional learning related to sex differences based on the number of single-sex schools and classes in the district from 2007 to 2014. It was determined that School District A and School District E would have the largest number of potential respondents because all schools were eligible to participate. Therefore, School District B was selected for the pilot study to maximize the total potential respondents for the final full study. This limited the pilot study population to approximately 150 teachers from two high schools in School District B, Meadow High School (pseudonym) and City High School (pseudonym).

The combined teacher population of School District A and School District E was approximately 3,600. In the final full survey, school name was recorded as part of the background information to generate an estimated number of eligible teacher participants and response rate. Based on the participating schools, the number of eligible teacher respondents were estimated to be 1,498 in District A and 293 in District E.

Limited information about the participating districts is provided to preserve anonymity. All three participating districts had student enrollments of 20,000 plus students, 30 plus schools, and employed 1,500 plus teachers (SCDE, 2019). All three district were comprised of 50% or more minority students (majority Black and Hispanic) and included neighborhoods that could be characterized as city, suburban, and rural

3.5 PILOT STUDY ADMINISTRATION, ANALYSIS, AND SURVEY REVISION

The objective of the pilot study was to test the survey process, provide validity evidence for the gender learning differences inventory, and collect feedback from participants to inform survey revision. The pilot study specifically addressed the following questions:

1. What survey items should be used to measure teacher knowledge of sex-specific learning difference facts and myths?
2. How can the pilot study data be used to revise and improve the full study survey?

To assist in answering the pilot study research questions, the participants were asked to provide feedback and suggestions on the introductory email, survey layout, and ease of usage. An email from was forwarded by the two principals in School District B to their teaching staff on Monday, December 9, 2019. The email contained an introductory letter, the survey password, and the link to the survey hosted in Qualtrics (Appendix E). The true and false knowledge items were presented in random order on one continuous page. This allowed participants to modify their responses at any time prior to completing all 32 items and advancing to the next section of the survey. The gender-specific instructional strategies items were all presented in random order. The initial survey settings were set to prevent multiple entries from the same IP Address and to record responses after four hours of beginning the survey. On Sunday, December 15, 2019, I examined the partial data set and noticed numerous incomplete responses. The settings prevented respondents from completing the survey after the four-hour window. To increase response rate, a reminder email was sent that also indicated respondents with incomplete surveys could retake the survey. All incomplete responses were omitted from the data set. There was no incentive for participants to complete the survey more than one time. At the completion of the survey, participants were redirected to an independent survey that collected their name, school, and district email address. All participants received a $15.00 Amazon eGift Card for their participation. Respondents were informed that they would need to provide identifying information to receive the gift card and that their survey responses would remain separate and anonymous. Requiring school name and district email address helped ensure only eligible teachers participated in the survey. The survey was set to capture up to 50 responses, but the maximum quota was not met. The survey closed on December 20, 2019 with 51 total responses recorded. Only 40 of the responses were complete and used for data analysis. There were approximately 150 combined teachers at the two high schools. The completed survey response rate for both schools combined was 27%.

Pilot Study Scale Reliability Analysis

Scale reliability was analyzed using SPSS. Johnson and Morgan (2016) reported that acceptable alpha levels (Cronbach's alpha) for research scales are as follows: below 0.60 – unacceptable, between 0.60 and 0.65 – undesirable, between 0.65 and 0.70 – minimally acceptable, between 0.70 and 0.80 – respectable, and between 0.80 and 0.90 – very good. Cronbach's alpha tests the internal consistency of the items to provide reliability evidence that the items are measuring the same construct. (George & Mallery, 2020). Alpha values are influenced by the number of items and item intercorrelations (George & Mallery, 2020), Cronbach's alpha for the 13 true items was determined to be 0.446, which is considered unacceptable. Further analysis indicated that alpha for the true items would be higher (0.514) with pilot items (PI) 7 (right and left hemispheres work together) deleted. Cronbach's alpha for the 19 false items was determined to be 0.843, which is considered very good. Items analysis indicated that alpha for the false items would be higher (0.857) with PI-16 (stress inhibits learning for girls) and PI-17 (stress enhances learning for boys) deleted. Cronbach's alpha for all 32 items was 0.841 which is considered very good. Cronbach's alpha for the remaining 29 items would have been 0.860.

Pilot Study Qualitative Data Analysis

The qualitative responses were systematically examined for patterns and themes utilizing NVIVO 12. The data was coded into categories designed to encapsulate the various ideas, beliefs, and opinions of the respondents. The survey feedback open-response items informed the survey revision process. The items responses were also used to determine if the questions were clear and concise and if the survey was easy to use. No major revisions were made to the survey based on this feedback. Appendix F includes summary data for each feedback question by code, count, and general discussion/description. Respondent answers to, "What is your general understanding of gender/sex learning differences?" were used to identify general themes and beliefs about gender learning differences (Appendix F). The themes and codes that emerged were used as a starting point for the open-response data analysis in the final study.

Development of Final Gender Learning Differences Inventory

Appendix G summarizes and justifies the revisions made to the sex learning difference neuromyth scale. Most items were not revised and were retained in the final survey. However, several items were revised based on the pilot study data. Both the quantitative and qualitative data informed the final revisions. In critically reviewing the data and survey items, I determined that PI-6 (boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) and girls tend to use both hemispheres of the brain at the same time (whole brain thinking) should be modified to measure only one construct. Originally there were two separate items designed to address the neuromyth that boys tend to use one hemisphere at a time compared to girls who were reported to be “whole brain thinkers", but I combined/revised the items in an effort to balance the number of true and false items. The items were ultimately revised as indicated in Appendix G. The idea that girls are better multi-taskers is linked to the notion that they use “whole brain” thinking (Eliot, 2011). I included a simplified version of initial item (II) 7 (the brains of girls are wired for multi-tasking) from the initial item list. I felt the final revision resulted in two items written in more concise and clear language with each measuring only one (but related) construct. Similarly pilot item (PI) 8 (some boys and girls are “left-brained” and some boys and girls are “right-brained” and this helps explain differences in how individuals learn) as it was written implied two constructs: the first being the idea of right and left brains; the second being left or right brained affects learning. The item was revised with simplified language (boys and girls can be classified as “left-brained” or “right-brained” thinkers) that captured the essences of both constructs.

The most significant revision was the deletion of PI-17 (stress inhibits learning for girls). This item paired with PI-16 (stress enhances learning for boys) was designed to address a popular neuromyth endorsed by single-sex education advocates (Eliot, 2011). PI-17 (stress inhibits learning for girls) was written with the correct response being false. However, the open response from one pilot respondent forced me to reexamine the item.

The respondent explained that they only marked true for the question concerning girls learning under stress because, “I suspect that everyone learns worse under stressful situations.” As a result of this response, a review of the literature was conducted. Vogel and Schwabe (2016) reported that the effects of stress on learning and memory in the classroom “...were found to be complex, though, with stress having both enhancing and impairing effects on memory…”Item analysis indicated that 90% of the respondents selected true, which indicated their belief that stress tends to inhibit learning for girls. The item was intended to have false as the correct response. This discrepancy led me to wonder if other respondents thinking mirrored the thinking of the respondent who provided qualitative data about the item. Scale reliability analysis indicated a higher alpha value if both stress items were removed. When the data was looked as collectively it resulted in the decision to delete the stress item related to girls and learning. However, PI-16 (stress tends to enhance learning for boys) was retained because it represented a popular neuromyth related to boys (Eliot, 2011). PI-30, which was modified from previously published gender neuromyth survey studies to include the verbiage of “boys” and “girls”, was deleted after a final expert review (this item was not a part of the initial item reviewed list). To balance the number of true and false items, PI-11 was deleted since PI-9 essentially measured the same characteristic. The pilot study resulted in a final gender learning differences inventory composed of 30 item, 18 false, and 12 true (Appendix H).

Consideration was given on whether an “I don’t know” option should be included. Previous studies have included (Herculano-Houzel, 2002) and excluded (MacDonald et al., 2017) this option. However, one study attempted to solve the issue by utilizing a

Likert Scale (Grospietsch & Mayer, 2019). There are advantages and disadvantages to both options. The decision was made to not include the "I don't know" option in the pilot and subsequent study. However, two changes were made to the survey to reduce respondent concern over being forced to select true or false. In the directions preceding the 30 true and false items, respondents were instructed that they would answer a series of true and false items and would have an opportunity to rate their confidence in their responses after completing the items.

Revision of Remaining Pilot survey Questions

In addition to revision and modification of the true and false gender learning differences inventory, several other questions and sections were revised based on the pilot survey data analysis, review, and reflection. There were only minor changes to section one, background information. The response categories for pilot question (PQ) 4 (current teaching level) were changed from Pre-K, K-5, 6-8, and 9-12 to early childhood, elementary school, middle school, and high school on final question (FQ) 4) for consistency with FQ3 (levels certified to teach). The term "self-identified" was added to PQ9 (gender). The three options for gender were limited for simplicity purposes to male, female, and other, the term "self-identified" was intended to provide clarity that the question was about gender (social construct) and not sex (biological). I acknowledged that "other" is an oversimplification of the full range of gender identities. In the pilot study, district requirements prohibited participants from being forced to answer the question about their age. In the full final survey, all questions were required except for the "comments" question at the end of the survey. Participants were free to end the survey at any time. However, only participants who completed the entire survey were eligible for the gift card incentive.

For the pilot study the amount of time estimate was measured on a 7-choice Likert scale (LS) that coupled with a range of hours (i.e., almost no time at all – less than one hour or an extremely large amount of time – 50 or more hours). As someone who has personally spent countless hours studying about sex learning differences, I would have responded “an extremely large amount of time”. However, the actual time would be much greater than 50 hours. The responses from the pilot study indicated that the participants only utilized a portion of the scale. One individual reported having 12 years experience teaching in a single-sex classroom, but only self-reported “large amount of time”. In the final survey the amount of time option was measured using a slider bar for number of hours, but also included LS descriptors. The question was divided into two parts, FQ14c (hours learning about differences 1 – 60 hours) and FQ14d (hours learning about differences 61 – 120 hours). Participants who selected 60+ hours (large amount of time) were directed to a follow up question allowing them to select up to 120+ hours (extremely large amount of time). The slider bar option allowed participants to select a specified number of hours versus a range of hours. The LS descriptors were intended to assist participants in recalling and estimating the amount of time spent learning about sex differences. The intent of the slider bars coupled with the LS descriptors was to reduce “recall loss” and reduce the amount of mental energy needed to provide the time estimate (Ruel et al., 2016).

The final survey contained additional LS items. All four items [FQ17 (confidence in true false items), FQ18 (describe your knowledge of learning differences), FQ19 (characterize learning differences), and FQ22 (characterize instructional needs) were written with six choices. The even number of choices created a forced choice question (Ruel et al., 2016) to limit bias towards the middle (Johnson & Morgan). The following determiners were utilized across all four items for consistency across all items: not at all, slightly, somewhat, moderately, very, and extremely (Ruel, 2016). The LS was reduced from seven choices in the pilot survey to six in the final survey. The pilot data indicated that participants were not utilizing the full seven choice scale. FQ17 (confidence in true and false items) was added based on pilot survey respondent feedback to address the "I don't know" option for the true and false items. FQ19 (characterize learning differences) was added to the final survey to provide a data point for capturing the construct of gender learning differences. The intent was to provide triangulation for the neuromyth score, open response data for FQ20 (understanding learning differences), and FQ19 (characterize learning differences). The LS items were treated as of a continuous variable ranging from 0 (not at all) to 5 (extremely). It was predicted that individuals neuromyth scores would also have a higher Likert score for how different they rated gender learning difference. The open-response items were intended to provide validity evidence to support the neuromyth score and respondent answers for how different they believed gender difference to be. Individuals who endorse neuromyths and/or higher levels of learning differences were predicted to provide qualitative statements that indicate that they believe boys and girls learn differently. Similarly, FQ22 (characterize instructional needs) was added for triangulation with endorsement of gender- specific instructional strategies (FQ21, instructional needs inventory) and open response FQ23 (understanding or belief about instructional needs). A final optional question FQ24 (additional comments) was added to allow participants to make additional comments about the survey or survey topics.

3.5 FULL STUDY SURVEY DISTRIBUTION AND SAMPLE SIZE

The final full study survey (Appendix I) was distributed in School District A via email on February 21, 2020. The district research director forwarded an email to all district principals (Appendix J). The email provided principals and teachers with an overview of the research project, the survey link and password, research team contact information, and served as informed consent for study participation. A reminder email was sent by the district research director on March 4, 2020. The survey opened Monday, February 27, 2020 and closed on Monday, March 9, 2020 with a total of 208 survey attempts recorded. Of the 208 survey attempts recorded, 181 of the respondents indicated that they were a part-time or full-time classroom teacher. The survey terminated for all other participants. The 155 fully completed teacher surveys were logged for further analysis. The response rate for District A was estimated to be 10.3% (Appendix K).

In School District E survey distribution was not coordinated through the district research director. An individual email was sent to each principal on Tuesday, February 18, 2020. The email provided principals with an overview of the project and a copy of the approved district research application. A follow-up email was sent to all principals requesting that they forward the survey to their teachers if they consented to their participation. The email provided principals and teachers with an overview of the research project, the survey link and password, research team contact information, and served as informed consent for study participation. Several email replies from principals indicated confusion and concern over whether or not the district had approved the research request (Appendix J). Follow up emails with the district research director confirmed approval, but it is suspected that this confusion and lack of district coordination severely impacted participation and response rates. A survey deadline reminder email was sent to all principals and the district research director on Friday, March 6, 2020. The district research director was included in the email to confirm approval and encourage participation. The survey opened Wednesday, February 26, 2020 and closed on Wednesday, March 11, 2020 with a total of 41 survey attempts recorded. Of the 41 survey attempts recorded, 39 of the respondents indicated that they were a part-time or full-time classroom teacher. The survey terminated for all other participants. The 36 fully completed teacher surveys were logged for further analysis. The response rate for District E was estimated to be 12.3% (Appendix K). The data for both districts were combined resulting in 191 complete teacher surveys logged for analysis with an estimated response rate of 10.7% (Appendix K). However, one participant was dropped after examining duration to complete the survey (final participant count 190). The participant left the survey open for 8 days but did not provide substantive open responses (NA, no thanks, etc.). It was suspected the respondent used the time to look up answers (77% overall survey accuracy) but was not genuinely engaged in the survey to provide reliable data for the study.

3.7 FULL STUDY QUANTITATIVE STATISTICAL ANALYSIS

Demographic and Predictor Variables

The demographic and experience data were collected as possible predictors of neuromyth endorsement and belief in gender-specific instructional strategies. Possible predictors included, certification status (Q2), certification level (Q3), current teaching level (Q4), certification category (Q5), education level (Q6), National Board Certification (Q7), number of neuroscience courses (Q8), self-identified gender (Q9), age (Q10), total years teaching experience (Q11), years teaching in South Carolina (Q12), percent time teaching in South Carolina (Q12 divided by Q11), teaching in single gender school/classroom (Q13a), years teaching in single-gender/sex school (Q13b), years teaching in single-gender/sex classroom (Q13c), participating in gender/sex learning difference professional learning experiences/activities (Q14a), types of gender/sex learning professional learning experiences (Q14b), amount of time engaged in gender/sex learning difference professional learning experiences (Q14c), knowledge of gender/sex learning differences (Q18), and beliefs about gender/sex learning differences (Q19). Appendix L reports the values, codes, recoded values, and scales for all potential quantitative variables. Several variables were collapsed into groups for analysis. All gender learning differences scores were summed and calculated as a percent incorrect for false items and percent correct for true items, thus giving each item equal weight despite the different factor loadings (Johnson& Morgan, 2016) Similarly, all instructional strategy scores were treated as dichotomous (boys or girls, coded yes and both boys and girls, coded 0) and summed and calculated as a percent. The final demographic and experience variables selected for inclusion in multiple regression analysis included age, gender (dummy coded), education level (dummy coded), current teaching level (dummy coded), certification area, neuroscience courses, teaching in a single-gender school, and total hours of professional learning (Appendix L).

Sample Size Adequacy and Assumption Testing for Factorability

The sample size of 190 respondents met the 10:1 person-to-item ratio for EFA analysis (Nguyen, 2010). SPSS was used to conduct Kaiser-Mayer-Olking (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity for the 18 neuromyth items. The KMO value (0.753) indicated that factor analysis may be useful in identifying underlying factors (George & Mallery, 2020). The significant Bartlett's Test p-value of <0.001 indicated that the survey items were related, and that factor analysis could be useful (George & Mallery, 2020). To determine if the set of 18 false neuromyth items could be reduced to a smaller number of latent variables (Johnson & Morgan, 2016), exploratory factory analysis was conducted. The KMO value (0.833) for the set of 14 instructional strategies indicated that factor analysis may be useful in identifying underlying factors. The significant Bartlett's Test p-value of <0.00 1indicated that the survey items were related, and that factor analysis could be useful (George and Mallery, 2020). To determine if the set of 14 instructional strategy items could be reduced to a smaller number of latent variables (Johnson and Morgan, 2016), exploratory factor analysis was conducted.

Exploratory Factor Analysis and Confirmatory Factor Analysis

All factor analyses were conducted in MPlus version 8.4. For the exploratory factor analyses, the geomin rotated solution was found. Geomin is an oblique type of rotation, so the correlations between factors are provided. Also, since all items were dichotomous (true/false) or categorical (girls/boys/both), the weighted least squares mean variance (WLSMV) estimator was used in both the exploratory and confirmatory factor analyses. The WLSMV is a robust estimator which does not assume normally distributed variables and provides the best option for modeling categorical data (Brown, 2006). The

WLSMV estimator has better power and better control of Type I error in smaller samples (n < 200) compared to maximum likelihood (Bandalos, 2014).

Individual parameters must be examined within the estimated model to see how well the proposed model fits the driving theory. Due to different measures of fit capturing different elements of the fit of the model, a selection of different fit measures are reported. Root Mean Square Error Approximation (RMSEA) is a fit index where a value of zero indicates the best fit. Most researchers concur that a RMSEA of 0.5 or lower indicates good fit and a value of .5 to .8 indicates acceptable fit (Hu & Bentler, 1999). Standardized Root Mean Residual (SRMR) is a popular absolute fit indicator. It is suggested 0.08 or smaller as a guideline of good fit (Hu & Bentler, 1999). Comparative Fit Index (CFI) is another popular fit index. The CFI depends on the average size of the correlations in the data. If the average correlation between variables is not high, then the CFI will not be very high. A CFI value of 0.9 or higher is preferred (Hu & Bentler, 1999).

Scale Reliability Analysis and Convergent Validity Evidence

Internal consistency and scale reliability for the gender learning difference and instructional strategy scores were analyzed using SPSS to calculate Cronbach's alpha. Convergent validity was examined by performing a correlation between the total neuromyth score and gender learning difference Likert scale score. The two items are intended to measure the construct of how different the participant believes gender learning differences are. It was hypothesized that the two items would be correlated because they were attempting to measure the same underlying construct (Ruel, et al., 2016).

Multiple Regression Analysis

Multiple regression analysis was conducted for each measure of respondent belief (confidence, self-rated knowledge, gender/sex learning differences, and instructional needs). Multiple regression was conducted for each measure of neuromyth endorsement (total neuromyth, senses neuromyth, learning styles neuromyth, and concepts learning myth) and for true item accuracy. Multiple regression analyses were conducted to determine how much each of the selected demographic and experience variables predicted neuromyth endorsement and belief in gender-specific instructional strategies. Two sets of regressions one for total neuromyth score and one for the three neuromyth factors (senses, concepts, and learning styles) as independent predictors of instructional strategies (all strategies, active learning strategies, passive learning strategies, inquiry strategies, and collaboration strategies) were performed. A Bonferroni adjustment was applied to the multiple regressions for total neuromyth score and for three neuromyth factors to correct for possible Type I familywise errors (Abdi, 2007). The correction was needed because the three neuromyth factors are calculated from the same pool of items that are used to calculate the total neuromyth score. The simple calculation for a Bonferroni adjustment (Abdi, 2007) was calculated by dividing the alpha per test (PT) by the number of times neuromyth scores was used as a dependent variable to determine the alpha per family of tests (PF) ($0.05/2 = 0.025$). Therefore, only p values < 0.025 were interpreted as significant for the regressions using neuromyths as a dependent variable and instructional strategies as the independent variables (Abdi, 2007).

3.8 FULL STUDY QUALITATIVE ANALYSIS

Qualitative open responses were analyzed in NVIVO 12 using deductive content analysis to identify and quantify categories and themes (Cho & Lee, 2014). Deductive content analysis was appropriate for the open-end survey questions because the predetermined codes were derived from my prior knowledge and sex learning differences literature (Cho & Lee, 2014). In addition, content analysis was appropriate for the large open responses data set. The two open response questions each had 190 participant responses available for analysis. The data were coded for manifest, the visible and surface, content meaning (Cho & Lee, 2014). The goal of content analysis was to describe the meaning of the participants' open responses and triangulation of the non-neuromyth, neuromyth, and instructional strategy items and scores.

The pre-determined categories used for "What is your general understanding of gender/sex learning differences?" were organized by the four domains identified for the non-neuromyth and neuromyth items: brain structure and development, learning and learning styles, sensory processing, and hemispheric procession. Nested under each domain were codes derived from the individual non-neuromyth and neuromyth items. New categories were created as themes emerged from the data.

The predetermined codes for "What is your general understand and/or beliefs about the differing instructional needs of boys and girls?" were organized by the 14 instructional strategies: collaborative, competitive, hands-on, independent, inquiry, manipulatives, movement, partner, project-based, silent reading, small group, student led, teacher direct, and teacher led. An unexpected or uncategorized category was created to capture responses that did apply to any of the predetermined codes. Pre-liminary review of the data indicated that responses to “general understanding of differences” and “differing instructional needs” were often intermingled. Therefore, both responses for each participant were analyzed and coding simultaneously and sequentially. The responses were coded into the categories above regardless of which question the responses were contained in. If the response from an individual continued multiple themes or topics, the sentiments were coded into multiple categories. However, each thematic or topical statement was only placed into one code. Therefore, an individual may have contributed statements to multiple categories, but each statement was counted only one time in the reported totals.

The summarized themes and specific examples were used to provide context for the quantitative data. The themes were also used to provide validity evidence for the constructs of gender learning difference neuromyths, factual knowledge about gender learning similarities and differences, and gender-specific instructional strategies.

Sources or Gender Learning Differences Professional Learning Activities

Participant responses for professional learning source were grouped by college and university, individuals/authors, and agencies and organizations. The quality and detail of the open responses varied greatly with some respondents providing only individual last name, only the full names, only the publication titles, or both publication titles with author full name. I used personal knowledge of the subject and sources to fill in missing information. In some cases, Google searches were conducted to identify first names of individuals and/or the authors of publications. Only names and titles that could be confidently reported are included. The data were organized by author/individual and summed for total number of times referenced. Any relevant titles or activities associated with the individual were listed below the author name.

Understanding of Gender Learning Differences and Instructional Needs

The emergent codes identified in the pilot study were imported into NVINO 12 as a new node. Prior to coding the final data, I used the word search feature to get an overview and general feel for the qualitative data. The selected words were informed by the pilot study data, the quantitative constructs and topics covered in the survey, and review of the literature. Overlap in response for the questions was observed, meaning some respondents discussed instructional needs in the "understanding" question, while other respondents discussed learning difference in the "understanding" question. All 190 responses were sequentially analyzed and coded separately by question, "understanding of gender difference" and "instructional needs." If the pilot study node did not contain a code that captured the response idea or theme, a new code was created. The "understanding question" was reviewed and coded before the "instructional needs" question was coded. A new node was created with the same codes from the pilot study and new codes created during review of the first question. New codes were created as needed. Responses in each code for each question were reviewed to confirm or refute placement in the category. After all codes and relevant responses were reviewed for placement, all unused categories were deleted, redundant codes were combined, and if needed new codes created. The number of responses in each category were summed and a general description was created during the final review. In addition, exemplary quotes and cases were identified.

Table 3.1 Historical Neuromyth Survey Studies

Reference	**Population**
Herculano-Houzel (2002)	35 senior neuroscientists and 2158 members of the public of Rio de Janeiro
Howard-Jones, P. A., Franey, L., Mashmoushi, R., and Liao, Y.-C. (2009)	158 graduate trainee teachers in the United Kingdom
Dekker, S., Lee, N.C., Howard-Jones, P., & Jolles, J. (2012)	242 primary and secondary teachers interested in the neuroscience of learning in the United Kingdom and the Netherlands
Karakus, O., Howard-Jones, P.A., & Jay,T. (2015)	278 primary and secondary teachers in Turkey
Ferrero Marta, Garaizar Pablo, Vadillo Miguel A. (2016)	254 teachers in Spain and meta-analysis
Papadatou-Pastou, M., Haliou, E., & Vlachos, F. (2017)	479 undergraduate and 94 postgraduate perspective teachers in Greece
Macdonald, K., Germine, L., Anderson, A., Christodoulou, J., & McGrath, L.M. (2017)	598 educators, 234 individuals with high neuroscience exposure, and 3045 individuals representing the general public in the United States
Horvath Jared Cooney, Donoghue Gregory M., Horton Alex J., Lodge Jason M., Hattie John A. C. (2018)	50 pre-primary, secondary and tertiary educators from the United Kingdom, United States, and Australia who had won a national or international teaching excellence award between 2013 and 2015
Grospietsch and Mayer (2019)	550 pre-service teachers specializing in biology in Germany

CHAPTER 4

RESULTS

4.1 PILOT STUDY

Pilot Study Demographics and Experiences Results

There was a total of 40 pilot study participants representing two high schools located in a large school district within the state of South Carolina. The majority of the participants were in the 30-39 age range (n=16) and over 50% were under the age of 39 (n=17). There were 11 male and 29 female participants. The majority of the participants (N=26) possessed a master's degree. All of the participants were certified to teach high school, but eight participants were also certified in early childhood/elementary and 13 were certified to teach middle school. Nineteen of the participants reported taking a neuroscience related course and three were National Board Certified Teachers. Six reported teaching in a single-gender learning environment and 32 reported participating professional learning related to gender difference (Table 4.1). The average total years teaching was 14.0 (range = 1 to 31 or more years) and the average total years teaching in South Carolina was 12.0 (range = 1 to 31 or more years) (Table 4.2). The six participants who reported teaching in a single-gender learning environment spent an average of five years (range = 1 to 13 years) teaching single-gender classes (minimum 1 and maximum was 13 year) (Table 4.2).

Pilot Study Professional Learning Activities and Experiences Related to Gender Learning Differences

Fifteen percent of participants reported teaching in a single-gender learning environment and 80% of participants indicated they had participated in some type of activity or experiences related to gender learning differences. The most commonly reported experiences and activities were teacher degree program (n=15), college or university courses (n=15), professional development courses (n=13), school based professional learning (n=13), and district based professional learning (n=11) (Table 4.3). Participants estimated the total hours of participation in all activities combined (Table 4.4). The 32 participants utilized four of the seven categories on the Likert scale intended to quantify hours. The responses ranged from "almost no time at all" (less than one hour) to "moderate amount of time" (20–29 hours) with most respondents reporting "a small amount of time" (10 – 19 hours).

The 40 participants utilized five of the seven categories on the Likert scale intended to quantify self-reported knowledge of gender learning differences. The responses ranged from "not at all" to "knowledgeable" with 17.5% of respondents reporting being "not at all", and 7.5% being "knowledgeable" (Table 4.5). Thirty-five percent of respondents reporting being "slightly knowledgeable" (Table 4.5).

Pilot Study Gender Learning Differences Inventory Performance

The average percent correct (knowing an item represented a true gender differences) for all 13 non-neuromyth items (Cronbach's alpha=0.446) was 77.5% (Table 4.6). Seventy-two percent or more of the respondents correctly identified 11 out of the 13 non-neuromyth items (Table 4.6). Ninety-five percent of respondents correctly identified "the brains of boys and girls develop at different rates", but only 25% correctly identified "on average the brains of boys are bigger than the brains of girls" (Table 4.6).

The average percent incorrect (neuromyth acceptance) for all 19 neuromyth items (Cronbach's alpha=0.843) was 55.9% (Table 4.7). Over 50% of participants endorsed 14 of the neuromyth items. The most endorsed neuromyth was "stress tends to inhibit learning for girls" (90%) (Table 4.7). As noted in the methodology, this item was removed from the final survey considering the quantitative and qualitative pilot survey data and probably should not have been considered a neuromyth. Eighty-five percent of participants endorsed the neuromyth "boys and girls learn better when the receive information in their preferred learning style" (Table 4.7). All three items addressing specific learning styles (kinesthetic, visual, and verbal) were endorsed by over 67% of participants. The least endorsed neuromyth was "stress enhances learning for boys" (17.5%) and "boys tend to learn abstract concepts better than girls: (37.5%) (Table 4.7). The average overall percent accuracy on the gender learning differences inventory (all 32 items) (Cronbach's alpha=0.841) was 57.7% (Table 4.7).

Pilot Study Instructional Strategy Inventory Performance

Most of the respondents viewed the instructional strategies as "for both boys and girls". However, several strategies were overwhelmingly identified as for girls or for boys (Table 4.8). "Collaborative activities" (87.5% both boys and girls) was the least likely to be viewed as "for girls" or "for boys" compared to sustained silent reading (47.5% both boys and girls) which was viewed as "for girls" by 50% of the respondents (Table 4.8). The following strategies were identified as for girls: observing a teacher lead demonstration (22.5% girls; 0% boys), participating in teacher led direct instruction

(27.5% girls; 2.5% boys), participating in student led inquiry (30% girls; 7.5% boys), working independently (47.5% girls; 2.5 % boys), working in a small group (17.5% girls; 5% boys) and sustained silent reading (50% girls; 2.5 % boys) (Table 4.8). The following strategies were identified as for boys: participating in an activity the requires movement (0% girls; 50% boys), participating in hands-on activities (0% girls; 30% boys), solving problems with manipulatives (10% girls; 27.5% boys), and participating in competitive activities (0% girls, 42.5% boys) (Table 4.8).

Pilot Study Understanding of Gender Learning Differences Open-Responses

The open response data from the pilot study indicated that boys were characterized as visual, spatial, kinesthetic, and competitive learners who were more likely to be aggressive, distracted, and take risks (Table F.4). Boys were identified as “kinesthetic” and/or needing movement by five (12.5%) of the respondents (Table F.4). In contrast, girls were characterized as passive, auditory, and cooperative learners. Girls were identified as being organized and self-motivated (Table F.4). Twelve (30%) of the respondents believed that gender/sex had an influence on learning (Table F.4). One respondent indicated that, “It is a known fact that gender influences how a student learns. There are some factors beneficial to students if their preferences are accommodated properly” and another indicated that, “Females and males require different teaching techniques”. In comparison, six (15%) of the respondents believe that socialization and environment influence student behaviors, learning, expectations, and outcomes (Table F.4). One respondent felt very strongly about gender socialization and reported that, “I believe most perceived gender learning differences are cultural/social and not scientific/innate. I do not think we can ever say "all girls learn this way" or "all boys learn this way." It is narrow-minded and sexist. I find it dangerous to group students by gender in regard to perceived learning differences; the only reason behind grouping students by gender would be for social development reasons" (Table F.4).

Qualitative Analysis Pilot Study Feedback

Nine respondents identified concerns about true and false items. Respondents reported feeling "uncomfortable" or "unsure" and would have liked an "I don't know" option (Table F.2). Twenty-nine responded "no" indicating they did not have any concerns about question clarity. In response to suggestions for improving the survey, four respondents indicated that they would like the "I don't know" option for some of the questions, but 35 responded "no" or that they did not have any specific feedback (Table F.3). Sixteen participants indicated they were motivated to participate because they wished to contribute to and/or support educational research, 11 indicated the monetary incentive, nine were interested in the topic, and 12 believed the survey topics addressed the needs of students (Table F.1).

4.2 FULL STUDY DEMOGRPAHICS AND EXPERIENCES

Full Study Demographics and Experience Results

There were total of 190 full study participants representing two school districts located in the state of South Carolina. Females represented over 80% of the participants, the majority of the participants were in the 40-49 age group (31.6%), and over 75% had earned a master's degree (Table 4.9). The percentage of female teachers was representative of the percentage of female teachers in the state (South Carolina Department of Education, 2019a). However, the percentage of teachers with a master's degree was 14% higher than the state average (South Carolina Department of Education, 2019a.) The reported current teaching levels were 47.4% childhood/elementary teachers (SC 58%), 29.9% high school teachers (29%), and 23.7% middle school teachers (16%) (Table 4.10) (Teacher Certification Degrees, n.d.). The majority of the teachers were in a non-STEM certification category (76.3%) (Table 4.10). Forty percent completed at least one course related to neuroscience and 24.7% were National Board Certified Teachers (NBCT) (Table 4.10). The percentage of NBCT was 12.8% high than the state average (South Carolina Department of Education, 2019b). The average teaching experience was 15 years and the average time teaching in South Carolina was 12.5 years (Table 4.11). The participant sample was representative of teachers in South Carolina with the exception of higher education level and higher NBCT.

Experience in Single-Gender Leaning Environments and Gender Difference Professional Learning (Research Question One and Two)

Of the participants, 24.2% reported teaching in a single-gender learning environment and 69.5% reported participating in professional learning activities related to gender learning differences at some point in their career (Table 4.10). Teachers with experience in a single-gender learning environment spent an average of five years in a school that offered single-gender classes and an average of 2.9 years teaching in a single-gender classroom (Table 4.12). The average number of hours engaged in activities and experiences related to gender difference was 17.59 hours for the 132 who reported past participation (Table 4.13). The range (histogram) of estimated total hours for the total sample (n=190) was 0-120 hours (mean=12.22, SD=20.18) (Figure 4.1).

Types and Sources of Professional Learning (Research Question Three)

The most commonly reported experiences and activities were college or university courses (n=69), teacher degree program (n=58), professional development courses (n=50), school based professional learning (n=48), and reading books (n=46) (Table 4.14). The specific sources identified by the participants in the open responses are summarized in Table 4.15. Seven colleges and universities were identified by name with the University of South Carolina having the highest number of references (n=9) (Table 4.15). The two participating school districts were identified by name with 17 references for District A and one reference for District E (Table 4.15). Thirty authors/individuals were identified by name and in some instances the specific publications or activities were also identified. Only three of the authors/individuals were mentioned more than one time: Leonard Sax (n=6), Michael Gurian (n=5), and David Chadwell (n=2). *Why Gender Matters* (Sax, 2005) and *Strategies for Teaching Boys and Girls* (Gurian, 2008) were specifically referenced as sources (Table 4.15). It could not be determined if the reference for *Strategies for Teaching Boys and Girls* (Gurian, 2008) was the Pre-K – 5 or the grades 6 – 12 editions. The agencies, organizations, and print media specifically mentioned each only had one reference (Table 4.15).

4.3 FULL STUDY EXPLORATORY AND CONFIRMATORY FACTOR ANALYSIS

Neuromyth Scale Exploratory Factor Analysis

Exploratory factor analysis identified six factors with eigenvalues greater than 1.0 for the 18 neuromyth items (Table M.1). Factors with eigenvalues of greater than 1.0 explain more variation than any one single item (Johnson and Morgan, 2016). Factors 2, 4, and 5 had significant factor loadings (Table M.2). Of the significant items loading on factor 2, only “boys tend to hear better when a teacher uses a loud voice” had a factor loading (0.507) above 0.4 which is considered the lower bound of acceptability (Johnson and Morgan, 2016) (Table M.2). The other four items “girls tend to hear better than boys” (0.332), “the eyes of boys are more attuned to motion than the eyes of girls” (0.332), “”boys tend to learn better under stress” (0.332) and “girls tend to be verbal learners” (0.387) had factor loading above 0.3 which is slightly below the lower bound of acceptability (Table M.2). Four of the five items “girls tend to hear better than boys”, “the eyes of boys are more attuned to motion than the eyes of girls”, and ”boys tend to learn better under stress” represented neuromyths related to the domain of sensory processing and one item “girls tend to be verbal learners” represented a neuromyth related to the domain of learning and learning styles (Table M.2).

Of the significant items loading on factor 4 only “boys tend to be kinesthetic learner” (0.838) had a factor loading above the lower bound of acceptability (Table M.2). The other three items “girls tend to be better at multi-tasking” (0.377), “girls tend to be verbal learners” (0.339), and “boys tend to be visual learners” (0.299) had factor loading near or above 0.3 (Table M.2). Three of the four items “boys tend to be kinesthetic learner”, “girls tend to be verbal learners”, and “boys tend to be visual learners” represented neuromyths related to the domain of learning and learning styles. In fact, the items represented the common misconception of three learning styles – visual, auditory, kinesthetic (VAK) (Dekker et. al., 2012 and MacDonald et al. 2017) (Table M.2). The remaining item “girls are better at multi-tasking” was intended to represent a neuromyth in the domain of hemispheric processing (Table M.2) (See Appendix B for item development and justification). Item “girls tend to be verbal learners” loaded significantly on both factor 2 (0.387) and factor 4 (0.339) (Table M.2).

Of the significant items loading on factor 5 “boys tend to learn abstract concepts better than girls (0.624) and “girls tend to learn concrete concepts better than boys (0.521), both had acceptable factor loadings (Table M.2). Both items represented neuromyths in the domain learning and learning styles, specifically related to abstract and concrete concepts (Table M.2).

The fit indices, including Root Square Error of Approximation (RMSEA) value of 0.011 (< 0.06), Comparative Fit Index (CFI) value of 0.995 (> 0.95) and the Standardized Root Mean Square Residual (SRMR) value of 0.034 (< 0.08), all suggest that the model was appropriate and a good fit for the data (Table M.3). The results suggested the existence of three latent neuromyth variables conceptualized as a senses neuromyth (factor 2), a learning styles neuromyth (factor 4), and a concepts neuromyth (factor 5). The correlation for the senses neuromyth and learning styles neuromyth was significant (r=0.345), and the correlation for the learning styles neuromyth and concepts learning myth was significant (r=0.288) (Table M.3). There was no significant correlation between the senses neuromyth and the concepts learning myth (Table M.4). There were several items that significantly loaded on more than one factor. The factor loadings were aligned to the prior conceptualized domains of gender neuromyths, sensory processing and learning and learning styles (Table M.2). The overall good fit of the model, alignment to pre-determined domains, and overlap in item factor loading resulted in conducting a confirmation factor analysis.

Neuromyth Confirmatory Factor Analysis

Confirmatory factor analysis results are summarized in (Table M.5). The measurement model was appropriate for the analysis because it, “is preferred when studying the causal relationships and latent constructs among variables” (Cangur & Ercan, 2015, p. 152). The fit indices for Root Square Error of Approximation (RMSEA) value of 0.035 (good fit), Comparative Fit Index (CFI) value of 0.95 (acceptable), and the Standardized Root Mean Square Residual (SRMR) value of 0.086 (appropriate) suggested that the model was appropriate and an acceptable fit for the data (table M.5). The results confirmed three latent neuromyth variables identified in the EFA (M.6)

The senses neuromyth factor consisted of three items with standardized factor loadings above 0.361 and significant p-values “girls tend to hear better than boys” (0.361; p=0.005), “boys tend to learn better when a teacher used a loud voice” (0.989; p<0.001), and “the eyes of boys are more attuned to motion than the eyes of girls” (0.480; p=0.002) (Table M.6). Although the factor loading for “girls tend to hear better than boys” was below 0.4, it was retained because of acceptable good model fit and significant p-value (0.005) for the item (Table M.6).

The learning styles neuromyth factor consisted of three items with factor loadings above 0.355 and significant p-values “girls tend to be better at multi-tasking” (0.451; p=0.002), “girls tend to be verbal learners” (0.663; p<0.001), and “ boys tend to be kinesthetic learners” (0.355; p=0.010) (Table M.6). Although the factor loading for “boys tend to be kinesthetic learners” was below 0.4, it was retained because of acceptable good model fit and significant p-value (0.010) for the item (Table M.6).

The concepts neuromyth consisted of two items with factor loading above 0.468 and significant p-values “boys tend to learn abstract concepts better than girls” (0.611; p=0.001) and “girls tend to learn concrete concepts better than boys” (0.468; p=0.001) (Table M.6). The correlation for the senses neuromyth and learning styles neuromyth was significant (r=0.631). The correlation for the learning styles neuromyth and concepts learning myth was significant (r=0.774). The correlation for the senses learning myth and concepts learning myth was significant (r=0.605) (Table M.6).

Full Study Exploratory Factor Analysis for Gender-Specific Instructional Strategies

Exploratory factor analysis identified four factors with eigenvalues greater than 1.0 for the 14 instructional strategy items (Table N.1). All four factors had items with significant factor loadings (Table N.1). Of the significant items loading on factor 1 (attention strategies), only one was above the 0.4 lower bound of acceptability “participating in an activity that requires movement” (0.246) (Table N.2). The other five items “participation in competitive activities” (0.499), “observing a teacher led demonstration” (0.705), ”participating in a teacher led direct instruction” (0.743) and “participating in sustained silent reading” (0.435) had factor loading above 0.40 (Table N.2).

Factor 2 (working with other students) had one significant item that was below 0.40 “participating in student-led instructional strategies” (0.335) (Table N.2). The other two items “working with a partner”(0.692) and “working in a small group” (0.688), had factor loadings above 0.40 (Table N.2). Factor 3 (student led strategies) had one significant item that was below 0.40 “participating in sustained silent reading” (0.348) (Table N.2). The other three items, “participating in student led instructional activities”

(0.432), “participating in student led inquiry” (0.809), and “working independently” (0.486) were above 0.40 (Table N2). Factor 4 (active learning strategies) has one item significant item that was below 0.40 “solving problems with manipulative” (0.318) (Table N.2). The other three items, “participating in collaborative activities” (0.491), “participating in hands-on activities” (0.771), and “participating in an activity that requires movement” (0.493) were above 0.40 (Table N.2). Two items, “working independently” and “participating in sustained silent reading” cross loaded significantly on factor 1 and factor 2 (Table N.2). One item ”participating in student led instructional activities” cross loaded significantly on factor 2 and factor 4 (Table N.2). All four instructional strategy factors were significantly correlated (0.352–0.512) with each factor ($p<0.001$) (Table N.3).

The fit indices for Root Square Error of Approximation (RMSEA) value of 0.052 (good fit), Comparative Fit Index (CFI) value of 0.97 (good fit), and the Standardized Root Mean Square Residual (SRMR) value of 0.029 (good fit) all suggest that the model was appropriate and a good fit for the data (Table N.4). The results suggested the existence of four latent instructional strategy variables; factor 1-attention strategies, factor 2 -working with other students, factor 3 -student-led strategies, and factor 4 -active learning strategies (Table N.3). The overall good fit of the model, alignment of the item constructs, and overlap in item factor loading resulted in conducting a confirmation factor analysis.

Full Study Confirmatory Factor Analysis for Gender-Specific Instructional Strategies

The fit indices, including Root Square Error of Approximation (RMSEA) value of 0.061 (good fit), Comparative Fit Index (CFI) value of 0.98 (good), and the Standardized

Root Mean Square Residual (SRMR) value of 0.073 (acceptable), all suggest that the model was appropriate and a good fit for the data (Table N.6). The results confirmed four latent instructional strategies identified in the EFA (Table N.2).

The classifications of the four instructional strategy factors were modified as a result of the CFA, and were conceptualized as active learning strategies, passive learning strategies, collaborative strategies, and inquiry strategies (Table N.6), The active learning strategy factor consisted of four items, all with standardized factor loadings above 0.40 and significant p-values. The items were “participating in collaborative activities” (0.726; $p<0.001$), “participating in an activity that requires movement” (0.879; $p<0.001$), “solving problems with manipulative” (0.790; $p<0.001$), and “participating in hands-on activities” (0.696; $p<0.001$). (Table N.6).

The passive learning instructional strategy factor consisted of four items, all with factor loadings above 0.40 and significant p-values. The items were “participating in competitive activities” (F2=0.686; $p<0.001$), “working independently” (F3=0.808; $p<0.001$), “observing a teacher led demonstration” (F5=0.568; $p<0.001$), and “participating in sustained silent reading” (F14=0.896; $p<0.001$) (Table N.6).

The collaboration instructional strategy factor consisted of two items, both items had factor loadings above 0.40 and significant p-values. The items were “working with a partner” (0.869; $p<0.001$), and “working in a small group” (0.812; $p<0.001$) Table N.6). The inquiry instructional strategy factor consisted of two items, both items had factor loadings above 0.40 and significant p-values. The items were “participating in student led inquiry” (0.885; $p<0.001$), and “participating in student led activities” (0.816; $p<0.001$)

(Table N.6). All four instructional strategy factors were significantly correlated with each factor ($p<0.001$) (Table N.2)

4.4 FULL STUDY SEX-SPECIFIC LEARNING DIFFERENCES INVENTORY PERFORMANCE

The overall percent accuracy (knowing an item represented a true gender difference) for all 12 non-neuromyth items was 74.1% correct (Table 4.16). Eleven of the 12 non-neuromyth items were correctly identified at rate of over 63%. The remaining item, "on average the brains of boys are bigger than the brains of girls" had the lowest average percent correct (17.4%). The "brains of boys and girls develop at different rates" had the highest percent correct. Five additional items were all correctly identified at a rate of over 80%; "boys are more likely to be color blind" (88.9%), "extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains" (87.4%), "information is stored in the brains of boys and girls in networks of cells distributed throughout the brain (86.3%), "boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)" (85.8%), and "on average girls acquire language skills before boys" (84.2%) (Table 4.16).

The overall average percent incorrect (believing an item represented a true difference that was actually a neuromyth) for the 18 neuromyth items was 56.3 %. The average percent incorrect for the senses neuromyth factor was 45.3%, concepts neuromyth factor was 30.8%, and learning styles neuromyth factor was 77% (Table 4.17). Ten of the 18 neuromyth items were incorrectly identified at a rate of 60% or higher. The most endorsed neuromyth was "boys and girls learn better when they receive information in their preferred learning style" (94.7%). All three of the specific learning style items were endorsed at high rates; “boys tend to be kinesthetic learners” (71.1%), “girls tend to be verbal learning” (67.4%), and “boys tend to be visual learners” (57.4%). The learning style neuromyth was comprised of the “boys tend to be kinesthetic learners” and “girls tend to be verbal learners” items plus “girls tend to be better at multi-tasking” (75.3%). The two items that comprised the concepts neuromyth were endorsed at a rate of 31.6% for “girls tend to learn concrete concepts better” and 68.9% for “boys tend to learn abstract concepts better”. The senses neuromyth items were endorsed at a rate of 55.3% for “the eyes of boys are more attuned to motion”, 51.1% for “girls tend to hear better than boys”, and 29.5% for “boys tend to learn better when a teacher used a loud voice”. The least endorsed neuromyth was “stress tends to enhance learning for boys” (22.6%) (Table 4.17). The overall average percent accuracy for all 30 gender learning differences items was 55.6% (Table 4.17)

4.5 FULL STUDY GENDER-SPECIFIC INSTRUCTIONAL STRATEGY INVENTORY PERFORMANCE

The overall gender-specific instructional strategy (all 14 items) percent different (believing a strategy was primarily for girls or for boys) was 34.25% different (Table 4.19). Three of the four items for the passive learning strategy factor (45.39% different) were disproportionately identified as for girls, “observing a teacher led demonstration” (28.4% girls, 5.3% boys, both 66.3%), “working independently” (31.6% girls, 12.1% boys, both 56.3%), “sustained silent reading” (51.1% girls, 1.1% boys, both 47.9%), but “participating in competitive activities” was disproportionately identified as for boys (0.5% girls, 51.6% boys, both 47.9%) (Table 4.22). The opposite trend was observed for the active learning strategy (32.6% different). Three of the four items were disproportionately identified as for boys, “participating in hands-on activities” (0.50% girls, 24.7% boys, both 74.7%), “solving problems with manipulatives” (1.6% girls, 33.7% boys, both 64.7%), “participating in an activity that requires movement” (0.0% girls, 45.8% boys, both 54.2%), but “participating in collaborative activities” was disproportionately identified as for girls (19.5% girls, 4.7% boys, both 75.8%) (Table 4.18).

The inquiry instructional strategy percent different was 29.7% different and both of the strategy items (working with a partner and working in small group) were identified as for girls versus for boys. The collaboration instructional strategy was 27.6% different and both of the strategy items (participating in student led inquiry and participating in student led instructional activities) were identified as for girls versus for boys (Table 4.18). The two remaining items were not associated with any of the factors. “Participating in student led inquiry” had a high percent average for both boys and girls and was identified as gender specific. “Participating in teacher led direct instruction” also had a high percent average for both boys and girls but was identified as for girls versus for boys (Table 4.18).

4.6 GENDER LEARNING DIFFERENCE NEUROMYTH INVENTORY

The final gender learning difference neuromyth inventory (Appendix H) contained 12 items that were considered true gender differences (non-neuromyths) supported by neuroscientific research and 18 false items that were considered neuromyths as defined by OECD (2002) and confirmed by expert review (Appendix B and Appendix G). Cronbach’s alpha was 0.471 for the 12 non-neuromyth items, 0.769 for18 neuromyth items, and 0.774 for all 30 items. The 30 items were conceptualized to represent four domains related to the brain and learning: brain structure and development, hemispheric processing, sensory processing, and learning and learning styles. Factor analysis identified three latent variables that were conceptualized as a senses neuromyth, a concepts neuromyth, and learning styles neuromyth. Cronbach's alpha was 0.499 for the senses neuromyth items, 0.541 for the concepts neuromyth items, and 0.394 for the learning styles neuromyth. Gender learning difference belief and overall neuromyth score were correlated ($p < 0.01$; $r=0.370$) providing validity evidence for the gender neuromyth scale(Table R.1).

4.7 GENDER-SPECIFIC INSTRUCTIONAL STRATEGY INVENTORY

The gender-specific inventory of the full survey (Appendix I) contained 14 items that represented common instructional strategies. Cronbach's alpha was 0.863 for all 14 instructional strategies. Factor analysis identified four latent variables that were conceptualized as active learning strategy, passive learning strategy, collaborative strategy, and inquiry strategy. Cronbach's alpha was 0.726 for the active learning items, 0.733for passive learning items, 0.727 collaborative items, and 0.655 for the inquiry items. Instructional needs and overall instructional score were correlated ($p < 0.01$; $r=0.456$) providing validity evidence for the instructional strategy scale (Table R.2).

4.8 PREDICTORS OF BELIEFS, NEUROMYTHS, AND SEX SPECIFIC INSTRUCTIONAL STRATEGIES

Using the enter method it was found that total hours of professional learning related to sex-differences (Beta=0.016, $t(13)=3.94$, $p=0.025$) and possessing a master's degree (Beta=0.883, $t(13)=2.42$, $p=0.017$) explained a significant amount of the variance in self-reported confidence on the true and false items ($F(13, 176)=2.68$, $p=0.002$, R2=0.165, R2Adjusted=0.104) (Table O.1). Total hours of professional learning related to sex-differences explained a significant amount of the variance in self-rated knowledge of gender learning differences (F(13, 176)=5.73, p<0.001, R2=0.297, R2Adjusted=0.245) (Table O.2) and belief in gender learning differences (F(13, 176)=2.04, p=0.020, R2=0.131, R2Adjusted=0.067) (Table O.3), but not belief in gender-specific instructional strategies (F(13, 176)=1.13, p=0.340, R2=0.077, R2Adjusted =0.009) (Table O.4).

Multiple regression analysis did not identify any significant predictors of total neuromyth score (F(13,176)=0.981, p=472, R2=0.068, R2Adjusted=-0.001)(Table P.1), senses neuromyth factor (F(13,176) =0.954, p=498, R2=0.066, R2Adjusted=-0.003) (Table P.2), concepts neuromyth factor (F(13,176)=1.229, p=262, R2=0.083, R2Adjusted=0.015) (Table P.3), or learning styles neuromyth factor (F(13,176) =1.211, p=0.275, R2=0.082, R2Adjusted=0.014)(Table P.4).

Total neuromyth score was found to be a significant predictor of total instructional strategy score (% different) (F(14,175)=5.331, p<0.001, R2=0.299, R2Adjusted=0.243 (Table Q.1) and collaboration learning strategy score (F(13,176) =2.448, p=0.004, R2 =0.164, R2Adjusted=0.097) (Q.3). Total neuromyth score predicted an increase (Beta=0.636, t(14)=5.596, p<0.001) and teaching at the elementary level predicted a decrease (Beta=-15.841, t(14)=-2.759, p=0.006) in the active learning strategy score (F(14,175) =4.075, p<.001, R2=0.246, R2Adjusted=0.186) (Table Q.2). Total neuromyth score predicted an increase (Beta=0.887, t(14)=7.667, p<0.001) and completing one or more neuroscience course predicted a decrease (Beta=-12.694, t(14)=-2.677, p=0.008) in the passive learning score (F(14,175)=5.960, p<0.001, R2=0.323, R2Adjusted=0.269) (Table Q.4). There were no significant predictors of the inquiry instructional strategy score at the 0.025 significance level (Bonferroni adjustment) ($F(14,176)=1.863$, $p=0.033$, $R2=0.130$, R2Adjusted=0.060)(Table Q.5). Therefore, four of the five instructional strategy scores were predicted by total neuromyth score.

Three of the five instructional strategies were significantly predicted by one or more of the three neuromyth factors. The learning styles neuromyth (Beta=0.223, $t(16)=3.097$, $p=0.002$) and the concepts neuromyth (Beta=0.133, $t(16)=2.529$, $p=0.012$) both significantly predicted the total instructional strategies score($F(16,173)=3.272$, $p<.001$, $R2=0.232$, R2Adjusted=0.161) (Table Q.6). The learning styles neuromyth (Beta=0.215, $t(16)=2.391$, $p=0.018$) predicted an increase in the active learning score, but teaching at the elementary level (Beta=-16.914, $t(16)=-2.813$, $p=0.005$) predicted a decrease in the active learning strategy score ($F(16,173)=2.837$, $p<0.001$, $R2=0.208$, R2Adjusted=0.135) (Table Q.7). The passive learning strategy was significantly predicted ($F(16,173)=3.860$, $p<0.001$, $R2=0.263$, R2Adjusted=0.195) by all three of the neuromyth factors: learning styles neuromyth (Beta=0.279, $t(16)=2.998$, $p=0.003$), senses neuromyth (Beta=0.231, $t(16)=2.764$, $p=0.006$) concepts neuromyth(Beta=0.155, $t(16)=2.287$, $p=0.023$) (Table Q.8).

There were no significant predictors of the collaboration learning score ($F(16,173) =1.532$, $p=.093$, $R2 =.124$, R2Adjusted = .043) (Table Q.9) or the inquiry instructional strategy score ($F(16,173) =1.379$, $p=.157$, $R2 =.113$, R2Adjusted = .031 (Table Q.10). Therefore, the sub-scale neuromyths (factors) were predictors of some, but not all, of the instructional strategy scores. The only subscale neuromyth to consistently predict instruction strategies was the learning styles myth. Teaching at the elementary predicted a decrease in the active strategy score. The multiple regression results indicate that both the total neuromyth score and the sub-scale neuromyths are predictors of some instructional strategy score. Analyzing the data by total score and by the subscale scores, yields similar results.

4.9 FULL STUDY OPEN-RESPONSE CODES, COUNTS, AND PERCENTAGES

Table 4.19 summarizes the open-response data by broad categories for both the “understanding of learning differences” and “understanding or beliefs about differing instructional needs”. The responses related to “learning differences” were organized and quantified as “same, similar, or individual variation”, “learning differences exist”, and “no answer, not sure, or not codable”. Same, similar, or individual variation responses were generalized statements indicating that there were little to no gender learning differences or that learning differences are based on each individual and not defined by gender. The following quote provides a representative example, “ While there may be general differences in how males and females learn, what is more important is finding out what each learner needs”. “Differences exist” responses varied from generic statements such as, “There are specific differences in gender/sex learning” to very specific statements identifying learning style types (kinesthetic, auditory/verbal, visual) or sensory differences (seeing, hearing, and stress responses). No answer, not sure, or not codable captured responses such a “NA” and “I am not an expert and know some information”. Most responses indicted that the respondents believed gender learning differences exist (58.9%) with only 16.3% specifically stating that they do not exist, are very small, or that learning differences are not gender specific (Table 4.19).

The responses for the “differing instructional needs” question were organized in the same manner as the “learning differences” (Table 4.19). Same, similar, or individual variation responses explicitly stated or implied that students do not have different instructional needs based on gender. For example, “I think the needs are based off individual students rather than their gender”. Instructional needs are different responses also ranged from generic statements such as, “The needs are different” to very specific statements about strategies that meet the needs of either boys or girls (collaborative, competitive, hands-on, small group, movements, teacher led, etc.). Slightly more respondents indicated that the instructional needs were different (45.8%) compared to 38.4% who indicated the needs were the same or very similar (Table 4.19). As mentioned in the methods sections, each respondent was counted one time and the categories reported totaled 100% (N=190).

In an attempt to categorize the rich and descriptive statements provided by some respondents, their statements were deconstructed by categorizing specific components of the responses (Table 4.20). An example for learning differences is provided for clarity, “Girls tend to be better at multi-tasking (coded as multi-tasking) and are less likely to speak in front of a group of people (not coded). Boys tend to be more kinesthetically motivated (coded as kinesthetic) and tend to participate in class discussion without prompting more (not coded). Another example for instructional strategies is provided for clarity, “All students can benefit from instructional strategies that require them to lead (coded as student led). Boys prefer movement and doing (coded as movement), but get more work done by themselves (coded as independent). Girls learn better collaboratively (coded as collaborative) and thinking/processing out loud with one another (coded as social emotional)”.

Table 4.20 summarizes the most common specific responses for both “learning differences” and “instructional needs”. Ten percent of the participants provided a statement indicating they are aware that girls and boys develop at different rates (non-neuromyth). Thirty-six percent of the respondents provided statements that indicated they endorsed the concept of learning styles. Of the 69 respondents who explicitly referenced learning styles, 49.3% assigned students to the VAK categories based on their gender (boys kinesthetic and visual learners and girls verbal/auditory learners). Girls were identified as being better multi-taskers by 4.7% of the respondents (Table 4.20). The qualitative responses are consistent with the sex-specific learning differences inventory (SSLDI) results that showed teachers endorsed sex-specific learning style myths.

Table 4.20 summarizes the most common instructional strategies identified by the participants. Strategies were combined to create more generalized groupings. For example, statements about active learning, hands-on learning, and manipulatives were combined because they represent some form of active or physical engagement in the learning process. Similarly, statements about teacher led instruction such as observing a teacher, direct instruction, or explicit modeling were combined because they represent some form of passive learning that is teacher directed. The results are consistent with the gender-specific instructional strategies inventory (GSISI) results that showed some teachers believed in dichotomous instructional strategies for boys and girls. Both data sets suggest that teachers are more likely to identify passive, independent, and collaborative activities as for girls and active, movement, and competitive strategies for boys (Table 4.20). The social emotional category was not predetermined but emerged during the deductive data analysis. Reponses categorized girls as more social and emotional learners and suggested that their emotional needs are important in classroom interactions. The following responses provide representative examples, "In general, girls tend to learn best in an environment of encouragement and routine support" and, "I can approach boys differently about grades or work than I can girls, feelings get in the way with girls where I can just state what I need to with boys" (Table 4.20).

Although the open-response questions did not specifically ask about single-sex learning environments, 16 respondents included statements that explicitly or implicitly referenced single-gender classrooms or programs. Codes were created during data analysis to capture whether or not the participants had a positive or negative sentiment regarding single-sex learning environments. Thirteen of participants indicated a positive sentiment and 3 indicated a negative sentiment about single-sex learning environments.

The open responses also provided evidence that some respondents were aware of the pseudoscience of hard-wired gender learning differences:

> A lot of the materials I've read recently contradict what I learned in school -- a lot of what we think of as boy or girl-specific learning differences are more learned than "natural" (ie boys being better than girls in math or girls better at multi-tasking). Much of these differences are actually gender biases that the kids then internalize, leading to learning 'differences'. What we know about the human brain is infinitesimal and changing/expanding constantly.

Another respondent expressed concerns that generalizing about gender "can be extremely dangerous". Other responses suggested that some teachers accept the notion of hard-wired differences that were endorsed by single-sex education advocates, "Boys and girls' brains are wired differently, therefore, they receive information better in different ways".

Table 4.1: Pilot Study Demographics, Certifications, and Experience

Demographic	Category	Count
Age	20-29	9
	30-39	16
	40-49	7
	50-59	4
	60-69	1
Gender	Male	11
	Female	29
Education Level	Bachelor Degree	4
	Bachelor Plus 18	1
	Masters Degree	26
	Master Plus 30	9
	Doctorate Degree	0
Certification Status	South Carolina	38
	Other State	0
	Alternative Program	1
	International	1
Certification Level	Early Childhood	1
	Elementary	7
	Middle Level	13
	High School	40
Certification Area	Science	7
	Social Studies	5
	Fine Arts	4
	Physical Education	2
	World Language	2
	Special Education	5
	ESOL	0
	Computer Science	1
	Health Science	0
	Business or Marketing	1
	Engineering	5
	Other	2
Current Teaching Level	Early Childhood	0
	Elementary	0
	Middle Level	0

	High School	40
Number of Neuroscience Courses	0	21
	1	9
	2	7
	3	1
	4	1
	5	1
	6+	0
National Board Certified Teacher	Yes	3
Taught in a School with Single-Gender	Yes	6
Participated in Professional Learning Related to Sex Differences	Yes	32

Table 4.2: Pilot Study Descriptive Data Years of Experience

	Total Years			
	Teaching	**South Carolina**	**Single-Gender School**	**Single-Gender Classes**
Mean	14	12	5	5
Standard Deviation	10	9	5	5
Median	11	11	3	3
Mode	26	4[a]	1	1
Minimum	1	1	1	1
Maximum	31	31	13	13
95.0% Lower CL for Mean	11	10	0	0
95.0% Upper CL for Mean	17	15	10	10

[a]multiple modes exist

Table 4.3: Pilot Study Type of Professional Learning Activities and Experiences

Professional Learning Activity	Count (N=32)
Teaching degree program	15
College/university courses	15
Professional development course	13
School based professional learning	13
District based professional learning	11
Workshops	8
Reading books	8
Reading news articles	8
Conferences	7
Reading peer reviewed journal articles	7
Consulting websites	6
School faculty meetings	5
Alternative teacher certification program	4
State department based professional learning	2
Reading magazines	2
Consulting blogs	1

Table 4.4: Pilot Study Estimated Amount of Time Participating in Professional Learning Related to Gender Sex Learning Differences

Category	Count (N=32)
An extremely large amount of time (50+ hours)	0
A very large amount of time (40 - 49 hours)	0
A large amount of time (30 - 39)	0
A moderate amount of time (20 - 29 hours)	8
A small amount of time (10 - 19 hours)	13
A very small amount of time (1-9 hours)	9
Almost no time at all (less than 1 hour)	2

Table 4.5: Pilot Study Estimated Knowledge of Sex Learning Differences

Category	**Percent of Participants (N=40)**
Extremely knowledgeable	0.0
Very knowledgeable	0.0
Knowledgeable	7.5
Moderately knowledgeable	15.0
Somewhat knowledgeable	25.0
Slightly knowledgeable	35.0
Not knowledgeable at all	17.5

Table 4.6: Pilot Study Non-Neuromyth Performance Results

True Items	**% Correct**
PQ16.1 The brains of boys and girls develop at different rates	95
PQ16.30 There are specific periods in childhood when it's easier for boys and girls to learn certain things	92.5
PQ16.32 Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain	92.5
PQ16.15 Boys are more likely to be color blind	90
PQ16.23 Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)	90
PQ16.20 Boys are more likely to be diagnosed with dyslexia	85
PQ16.31 Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains	85

PQ16.7 The right and left hemispheres work together in both boys' and girls' brains	80
PQ16.21 On average girls acquire language skills before boys	80
PQ16.4 Girls' brains finish growing at an earlier average age than boys' brains	77
PQ16.5 The brains of males and females are more alike than they are different	72.5
PQ16.22 On average boys have stronger visual-spatial skills than girls	42.5
PQ16.2 On Average the brains of boys are bigger than the brains of girls	25
Average Non-Neuromyth Percent Correct (All 13 Items)	77.5

Table 4.7: Pilot Study Sex-Specific Neuromyth Results

False Items	**% Incorrect**
PQ16.16 Stress tends to enhance learning for boys	17.5
PQ16.27 Boys tend to learn abstract concepts better than girls	37.5
PQ16.3 Most human brains can be classified as "male-brains" or "female-brains"	40
PQ16.28 Girls tend to learn concrete concepts better than boys	40
PQ16.10 Boys tend to learn better when a teacher uses a loud voice	42.5
PQ16.13 The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown)	52.5
PQ16.14 The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)	52.5
PQ16.18 Girls tend to learn better in warmer ambient temperatures	52.5
PQ16.6 Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) and girls tend to use both hemispheres of the brain at the same time (whole brain thinking)	55
PQ16.9 Girls tend to hear better than boys	55
PQ16.11 Girls tend to hear low volume voices better than boys	55
PQ16.8 Some boys and girls are "left-brained" and some boys and girls are "right-brained" and this helps explain differences in how individuals learn	57.5
PQ16.19 Boys tend to learn better in cooler ambient temperatures	60

PQ16.12 The eyes of boys are more attuned to motion than the eyes so girls	65
PQ16.24 Girls tend to be verbal learners	67.5
PQ16.25 Boys tend to be visual learners	67.5
PQ16.26 Boys tend to be kinesthetic learners	75
PQ16.29 Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)	85
PQ16.17 Stress tends to inhibit learning for girls	90
Neuromyth Factor Score (19 false items)	55.9
Overall Accuracy (all 32 items)	57.7

Table 4.8: Pilot Study Gender-Specific Instructional Strategy Results

		Percent
PQ19.1 Participating in collaborative activities	% Primarily Girls	7.5
	% Primarily Boys	5.0
	% Both Boys and Girls	87.5
PQ19.7 Participating in student led instructional activities	% Primarily Girls	7.5
	% Primarily Boys	10.0
	% Both Boys and Girls	82.5
PQ19.5 Observing a teacher led demonstration	% Primarily Girls	22.5
	% Primarily Boys	0.0
	% Both Boys and Girls	77.5
PQ19.12 Working in a small group	% Primarily Girls	17.5
	% Primarily Boys	5.0
	% Both Boys and Girls	77.5
PQ19.4 Working with a partner	% Primarily Girls	7.5
	% Primarily Boys	17.5
	% Both Boys and Girls	75.0
PQ19.6 Participating in teacher led direct instruction	% Primarily Girls	27.5
	% Primarily Boys	2.5
	% Both Boys and Girls	70.0
PQ19.11 Participating in hands-on activities	% Primarily Girls	0.0
	% Primarily Boys	30.0
	% Both Boys and Girls	70.0
PQ19.13 Participating in problem/project-based learning	% Primarily Girls	15.0
	% Primarily Boys	10.0
	% Both Boys and Girls	75.0
PQ19.9 Participating in student led inquiry	% Primarily Girls	30.0
	% Primarily Boys	7.5

	% Both Boys and Girls	62.5
oPQ19.10 Solving problems using manipulatives	% Primarily Girls	10.0
	% Primarily Boys	27.5
	% Both Boys and Girls	62.5
PQ19.2 Participating in competitive activities	% Primarily Girls	0.0
	% Primarily Boys	42.5
	% Both Boys and Girls	57.5
PQ19.8 Participating in an activity that requires movement	% Primarily Girls	0.0
	% Primarily Boys	50.0
	% Both Boys and Girls	50.0
PQ19.3 Working independently	% Primarily Girls	47.5
	% Primarily Boys	2.5
	% Both Boys and Girls	50.0
PQ19.14 Participating in sustained silent reading	% Primarily Girls	50.0
	% Primarily Boys	2.5
	% Both Boys and Girls	47.5

Table 4.9: Full Study Demographics

Demographic	**Category**	**Percent (N=190)**
Age	20-29	11.2
	30-39	24.1
	40-49	31.6
	50-59	24.1
	60-69	9.1
Gender	Male	19.3
	Female	80.7
Education Level	Bach	18.7
	Masters	75.9
	Doctorate	5.3
District	District A	82.4
	District E	17.6

Table 4.10: Full Study Certifications and Experiences

Certification and Experience	**Category**	**Percent (N=190)**
Certification Status	South Carolina	95.8
	Other State	1.1
	Alternative Program	1.6
	International	1.6
Current Teaching Level	Early Childhood/Elementary	47.4
	Middle	23.7
	High	28.9
Certification Level	Early Childhood/Elementary	41.6
	Middle	8.9
	High	19.5
	Multi	30.0
Certification Area (PreK-12)	STEM	23.7
	Non-STEM	76.3
Neuroscience Courses	Yes	40.5
National Board Certified Teacher	Yes	24.7
Taught in a School with Single-Gender Classes	Yes	24.2
Participated in Professional Learning Related to Sex Differences Learning	Yes	69.5

Table 4.11: Full Study Total Years Teaching and Total Years Teaching in South Carolina

	Total Teaching Experience	**Experience in South Carolina**
N	190	190
Minimum	1	1
Maximum	31	31
Mean	15.18	12.46
Std. Deviation	8.789	8.233

Table 4.12: Full Study Years Teaching in Single-Gender Learning Environments

	Years Teaching in a School that Offered Single-Gender Classes	**Years Teaching in a Single-Gender Classroom**
N	46	46
Minimum	1	1
Maximum	17	17
Mean	5.04	2.91
Std. Deviation	3.864	2.905

Table 4.13: Full Study Estimated Hours Engaged in Professional Learning Related to Sex-Specific Learning Differences

	Estimated Hours Engaged in Professional Learning Related to Gender Learning Differences
N	132
Minimum	1
Maximum	120
Mean	17.59
Std. Deviation	22.182

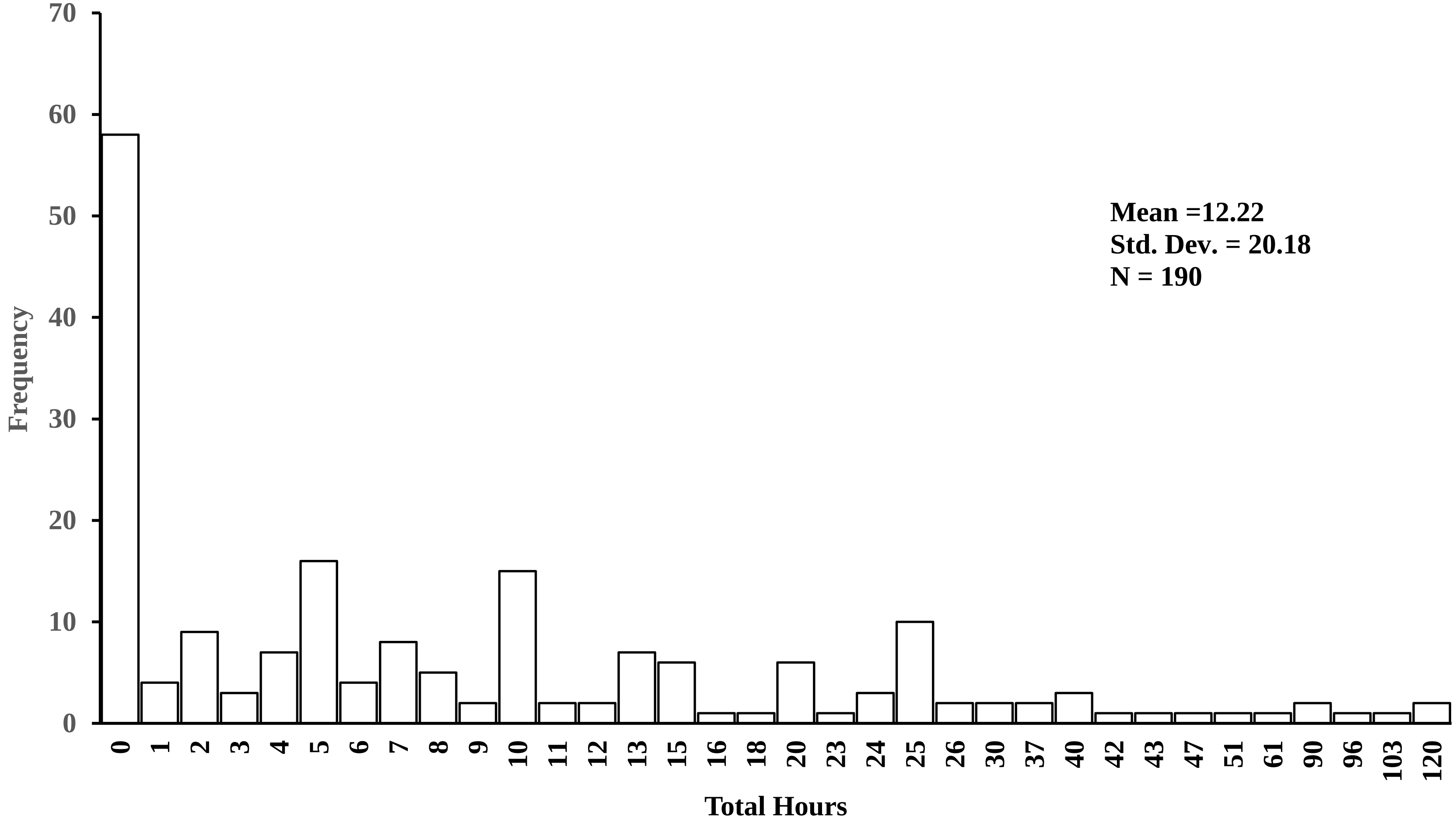

Figure 4.1: Total Hours Engaged in Professional Learning Related to Gender Differences

Table 4.14: Full Study Type of Professional Learning Activities and Experiences

Professional Learning Activity	**Count (N=132)**	**Percent Participants**
Teaching degree program	58	44.3
Teacher certification program	7	5.3
College/university courses	69	52.7
Professional development course	50	38.2
School faculty meetings	44	33.6
School based professional learning	48	36.6
District based professional learning	34	26.0
State department based professional learning	4	3.1
Conferences	41	31.3
Workshops	24	18.3
Reading books	46	35.1
Reading peer reviewed journal articles	36	27.5
Reading magazines	18	13.7
Reading news articles	40	30.5
Consulting websites	20	15.3
Consulting blogs	8	6.1
Average number of activities per respondent	4	

Table 4.15: Full Study Sources of Professional Learning Activities and Experiences

Source Type	**Source**	**Count**
Colleges and Universities		
	Columbia College	2
	Drexel University	1
	Grand Canyon University	2
	University of Florida	1
	University of South Carolina	9
	Winthrop University	2
	Walden University	1
School District		
	District A	17
	District E	1
	District B (Pilot Study District)	1
	Unidentified District	6

Individuals/Authors/Title (if provided)		
	Biddulph, Steve	1
	Brizedine, Louann	1
	Chadwell, David	2
	DeBeauvior, Simone	1
	Eliot, Lise	1
	Fausto-Sterling, Anne	1
	Ferlazzo, Larry	1
	Fine, Cordelia	1
	Friedan, Betty	1
	Geneva Centre for Security Sector Governance Title: *Teaching Gender in the Military*	1
	Gurian, Michael. Title: *Teaching Boys and Girls* Gurian Institute: Presentations, Webinars Co-Authors: Stevens, Kathy; King, Kelley	5
	Friedman, Jaclyn and Valenti, Jessica	1
	Hattie, John	1
	James, Abigail. Title: *The Male Brain*	1
	Jensen, Eric. Title: *The Brain in Mind, Brain Compatible Strategies*	1
	Karges-Bone, Linda. Title: *More than Pink and Blue*	1
	Maccoby, Eleanor	1
	Marshall, Carol Sue	1
	Ngozi Adichie, Chimamanda	1
	Petersen, Jordan	1
	Piper, Mary. Title: *Reviving Ophelia: Saving the Selves of Adolescent Girls*	1
	Reichct, Michael and Hawley, Richard. Title: *Reaching Boys, Teaching Boys: Strategies that Work -- and Why*	1
	Rosemond, John	1
	Sax, Leonard. Title: *Why Gender Matters* Conference Workshop	6

	Severiens, S.E. and G.T.M. Ten Dam. Title: *Gender Differences in Learning Styles: a narrative review and a quantitative meta-analysis*	
	Simmons, Rachel. Title: *Odd Girl Out*	1
	Solnit, Rebecca	1
	Sousa, David. Title: *How the Brain Learns*	1
	Vrooman, Marilyn Kaye	1
	Wiseman, Rosalind. Title: *Queen Bees and Wannabes: Helping Your Daughter Survive Cliques, Gossip, Boyfriends, and the New Realities of Girl World*	1
	AMLE Conference Session	
Agencies and Organization		
	Association for Middle Level Education	1
	Center for Reproductive Rights	1
	Equality Now	1
	Global Fund for Women	1
	GLSEN	1
	National Science Teachers Association	1
	Planned Parenthood	1
	UN Women	1
	Women’s Environment & Development Organization	1
	Womankind Worldwide	1
Journals, Magazines, Newspapers		
	English Journal	1
	American Society for Curriculum Development	1
	LGBTQIA Journal	1
	New York Times	1
	Psychology Today	1

Table 4.16: Full Study Average Percent Correct on Non-Neuromyth Items

Question	Non-Neuromyth Item True	Domain	% Correct
FQ16.1	The brains of boys and girls develop at different rates	BSD	88.4
FQ16.7	Boys are more likely to be color blind	SP	87.9
FQ16.10	Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains	BSD	87.4
FQ16.6	Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain	BSD	86.3
FQ16.3	Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)	LLS	85.8
FQ16.5	On average girls acquire language skills before boys	LLS	84.2
FQ16.9	The right and left hemispheres work together in boys' and girls' brains	HP	79.5
FQ16.8	The brains of males and females are more alike than they are different	BSD	72.6
FQ16.11	Boys are more likely to be diagnosed with dyslexia	LLS	71.1
FQ16.4	Girls' brains finish growing at an earlier average age than boys'	BSD	65.8
FQ16.12	On average boys have stronger visual-spatial skills than girls	LLS	63.2
FQ16.2	On average the brains of boys are bigger than the brains of girls	BSD	17.4
Total Non-Neuromyth (all 12 non-neuromyth items) Percent Correct			74.1

BSD = Items related to brain structure and development
HP = Items related to hemispheric processing
SP = Items related to sensory processing
LLS = Items related to learning and learning styles

Table 4.17: Full Study Average Percent Incorrect on Neuromyth Items

Question	Neuromyth Item False	Domain	% Incorrect
FQ16.30	Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)	LLS	94.7
FQ16.27	Boys tend to be kinesthetic learners[a]	SP	88.4
FQ16.14	Girls tend to be better at multi-tasking[a]	BSD/LLS	75.3
FQ16.15	Boys and girls can be classified as "left-brained" or "right-brained" thinkers	HP	71.1
FQ16.28	Boys tend to learn abstract concepts better than girls[b]	LLS	68.9
FQ16.25	Girls tend to be verbal learners[a]	LLS	67.4
FQ16.20	The eyes of boys are naturally drawn to cool colors (black, blue, grey, and brown)	SP	63.2
FQ16.21	The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)	SP	63.2
FQ16.24	Boys tend to learn better in cooler ambient temperatures	SP	60.5
FQ16.23	Girls tend to learn better in warmer ambient temperatures	SP	60.0
FQ16.26	Boys tend to be visual learners	LLS	57.4
FQ16.19	The eyes of boys are more attuned to motion than the eyes of girls[c]	SP	55.3
FQ16.16	Girls tend to hear better than boys[c]	SP	51.1
FQ16.13	Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking)	HP	31.6
FQ16.29	Girls tend to learn concrete concepts better than boys[b]	LLS	31.6
FQ16.18	Most human brains can be classified as "male-brains" or "female-brains"	BSD	30.5

FQ16.17	Boys tend to learn better when a teacher uses a loud voice[c]	SP	29.5
FQ16.22	Boys tend to learn better under stress	SP	22.6

Average Percent Incorrect Senses Neuromyth	45.3
Average Percent Incorrect Concepts Neuromyth	30.8
Average Percent Incorrect Learning Styles Neuromyth	77.0
Total Neuromyth Percent Incorrect (18 neuromyth items)	56.3
Overall Survey Accuracy (all 30 items)	56.9

[a]Item loads senses neuromyth factor
[b]Item loads on concepts neuromyth factor
[c]Item loads on learning and learning styles factor
BSD = Items related to brain structure and development
HP = Items related to hemispheric processing
SP = Items related to sensory processing
LLS = Items related to learning and learning styles

Table 4.18: Full Study Average Percent Different on Gender-Specific Instructional Strategy Items

Instructional Strategy		**Percent (N=190)**
Passive Learning (for girls) Strategies Factor	Average Different	45.39
FQ21.5 Observing a teacher led demonstration[b]	Primarily Girls	28.4
	Primarily Boys	5.3
	Both Boys and Girls	66.3
FQ21.3 Working Independently[b]	Primarily Girls	31.6
	Primarily Boys	12.1
	Both Boys and Girls	56.3
FQ21.2 Participating in competitive activities[b]	Primarily Girls	0.5
	Primarily Boys	51.6
	Both Boys and Girls	47.9
FQ 21.14 Participating in sustained silent reading[b]	Primarily Girls	51.1
	Primarily Boys	1.1
	Both Boys and Girls	47.9
Active Learning (for boys) Strategies Factor	Average Different	32.6

FQ21.1 Participating in collaborative activities[a]	Primarily Girls	19.5
	Primarily Boys	4.7
	Both Boys and Girls	75.8
FQ21.11 Participating in hands-on activities[a]	Primarily Girls	0.50
	Primarily Boys	24.7
	Both Boys and Girls	74.7
FQ21.10 Solving problems using manipulatives[a]	Primarily Girls	1.6
	Primarily Boys	33.7
	Both Boys and Girls	64.7
FQ21.8 Participating in an activity that requires movement[a]	Primarily Girls	0.0
	Primarily Boys	45.8
	Both Boys and Girls	54.2
Collaborative Strategies Factor	Average Different	29.7
FQ21.12 Working in a small group[d]	Primarily Girls	13.7
	Primarily Boys	12.1
	Both Boys and Girls	74.2
FQ21.4 Working with a partner[d]	Primarily Girls	25.8
	Primarily Boys	7.9
	Both Boys and Girls	66.3
Inquiry Strategies Factor	Average Different	27.6
FQ21.9 Participating in student led inquiry[c]	Primarily Girls	18.4
	Primarily Boys	7.4
	Both Boys and Girls	74.2
FQ21.7 Participating in student led instructional activities[c]	Primarily Girls	22.1
	Primarily Boys	7.4
	Both Boys and Girls	70.5
Remaining Items		
FQ21.13 Participating in problem/project-based learning	Primarily Girls	6.8
	Primarily Boys	11.1
	Both Boys and Girls	82.1
GQ21.6 Participating in teacher led direct instruction	Primarily Girls	28.9
	Primarily Boys	5.3
	Both Boys and Girls	65.3
Average percent different (both boys and girls) all gender-specific instructional strategy items		34.3

[a]Item loads on for active learning gender-specific instructional strategy factor

[b]Item loads on passive gender-specific instructional strategy factor

[c]Item load on inquiry gender-specific instructional strategy factor

[d]Item load on collaboration gender-specific instructional strategy factor

Table 4.19: Full Study Open-Response Codes, Counts, and Percentages for General Categories

What is your general understanding of gender learning differences?	**Count**	**Percent**
Same, Similar, or Individual Variation	31	16.3
Learning Differences Exist	112	58.9
No Answer, Not Sure, or Not Codable	47	24.7
Total	190	100
What is your understanding and/or beliefs about the instructional needs of boys and girls?		
Same, Similar, or Individual Variation	73	38.4
Instructional Needs are Different	87	45.8
No Answer, Not Sure, or Not Codable	30	15.7
Total	190	100

Table 4.20: Full Study Open-Response Codes, Counts, and Percentages for Specified Categories

Neuromyths(N) and Non-Neuromyths (NN)

Category	**Count**	**Percent**
Brains Develop at Different Rates (NN)	20	10.5 Correct
General Learning Styles (N)	69	36.3 General

Girls Better Multi-tasking (N)	9 Girls; 0 Boys	4.7 Girls
Boys Kinesthetic (N)	14 Boys; 0 Girls	7.4 Boys
Girls Verbal/Auditory (N)	14 Girls; 1 Boys	7.4 Girls
Boys Visual (N)	5 Boys; 1 Girls	2.6 Boys
Hearing and Sound Tolerance: Boys Loud and Girls Quiet (N)	7	3.7
Other Sensory Processing: Temperature, Sight, Stress (N)	8	4.2
Instructional Strategies		
Collaborative, Small Group	12 Girls; 0 Boys	6.3 Girls
Active, Hands-on, Manipulatives	18 Boys; 0 Girls	9.5 Boys
Movement	20 Boys; 0 Girls	10.5 Girls
Competitive	4 Boys; 0 Girls	2.1 Boys
Independent	6 Girls; 1 Boys	3.2 Girls
Observe Teacher, Direct Instruction, Modeling, Explicit Directions	8 Girls; 1 Boys	4.2 Girls
Social Emotional	10 Girls; 3 Boys	5.3 Girls

Table 4.21: Open-Response for Participant Sentiment Related to Single-Gender Education

Single-Gender Education (Unsolicited Responses)		
	Count	**Percent**
Positive Sentiment	13	6.8
Negative Sentiment	3	1.6

CHAPTER 5

DISCUSSION

This mixed methods survey study examined the prevalence and predictors of sex-specific learning difference neuromyths and the prevalence and predictors of gender-specific instructional strategies among Pre-K through 12 teachers in two large South Carolina public school districts. Although the initial intent of this study was not to develop a novel survey instrument, development became necessary when no suitable survey instrument could be identified. When I began this research over 10 years ago, the single-sex education movement was at its peak in South Carolina. At that time, I found few vocal critics (e.g. Lieberman, 2010) of the "hard-wired" sex differences claimed by single-gender advocates. My individual research into peer-reviewed journals (e.g. Hyde, 2005) and authoritative texts (e.g. Halpern, 2000) on biological sex differences, convinced me of existing disconnect between the field of sex difference neurobiology and the claims of "hard-wired" differences. While my personal research brought awareness of this disconnect, I lacked the credentials and expertise to raise legitimate concerns from a scientific standpoint. The desire to raise legitimate concerns was the source of inspiration for the present study. Fortunately, it was not long after I began this work that experts from the fields of neuroscience (Eliot, 2011; Halpern et al., 2011), psychology (Bigler & Signorella, 2011), curriculum and instruction (Jackson, 2011) and political science (Williams, 2010) began challenging the pseudoscientific claims that permeated the single-sex education movement. There was also growing research in the field of neuromyths in education (Alferink & Farmer-Dougan, 2010; Dekker et al., 2012: Goswami, 2006; Howard-Jones, 2011;Weisberg, 2008). The results of this study are a convergence of the fields of sex-specific learning differences misconceptions and general neuromyths and misconceptions.

Using critical feminist theory as a theoretical framework, I created a teacher beliefs survey intended to identify the prevalence and predictors of sex-specific learning difference neuromyths and gender-specific instructional strategies. In addition, was also interested in estimating the number of South Carolina teachers who previously taught in single-sex learning environments and/or participated in professional learning related to sex-specific learning differences. The teacher beliefs survey contained demographic, experience, and beliefs data as well as two novel categorical inventories. The sex-specific learning differences inventory (SSLDI) was a dichotomous true and false scale containing 12 non-neuromyth items (difference considered true and supported by research) and 18 neuromyth items (differences considered not true, over-generalized, or not supported by research). The gender-specific instructional strategies inventory (GSISI) was a categorical scale containing 14 instructional strategy items that respondents identified as “primarily for girls”, “primarily for boys”, or “both boys and girls”.

I analyzed scale reliability and content validity evidence (quantitative and qualitative) to evaluate the reliability and validity of the two novel inventories. The SSLDI was modeled after previously published general neuromyth inventories (Dekker et al., 2012; MacDonald et al., 2017), informed by my personal knowledge and experiences related to single-sex education, sex-specific learning differences, and instructional strategies, and reviewed by a neuroscience expert for content validity. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) identified three sub-scale sex-specific neuromyths (learning styles neuromyth, senses neuromyth, and concepts neuromyth) and four sub-scale gender-specific instructional strategies (active learning, passive learning, collaboration, and inquiry). Multiple regression analyses were conducted to determine if any of the demographic or experience variables predicted teacher beliefs, sex-specific neuromyth endorsement, and gender-specific instructional strategies. Total hours of participation in professional learning related to sex-specific learning differences predicted self-reported beliefs of knowledge of sex-specific learning differences and beliefs about to what extent gender learning differences exist. The only significant predictor of accepting sex-specific instructional strategies was endorsing sex-specific neuromyths. However, teaching at the elementary level and completing a neuroscience course predicted lower acceptance of some instructional strategies.

There are six key findings from this study: the novel inventories developed can serve as a starting point for future exploration of sex-specific neuromyths, a high percentage of the teachers participants reported participating in professional learning related to sex-specific learning differences, teachers reported multiple types and sources of professional learning related to sex-specific learning differences, teacher beliefs about gender learning differences are predicted by participation in sex-specific learning differences professional learning, teachers endorsed sex-specific neuromyths related to learning styles and sensory processing and, endorsement of sex-specific neuromyths predicts endorsement of gender-specific instructional strategies.

5.1 SEX-SPECIFIC LEARNING DIFFERENCES INVENTORY

The novel sex-specific learning differences inventory developed in the present study represents a first attempt at measuring sex-specific learning difference neuromyths. The results of the study suggest the inventory can be used to measure aspects of sex-specific neuromyth endorsement related to sensory processing and learning and learning styles. Model surveys such as Dekker et al. (2012) and MacDonald et al. (2017) provided a starting point for survey development. In addition, the results from previous studies were also used to provide context and aid in interpreting results from the present study.

However, recent studies have offered alternative survey methodologies for investigating neuromyths (Tovazzi et al., 2020) and specifically learning styles neuromyths (Nancekivell et al., 2020; Papadatou-Pastou et al., 2020). Papadatou-Pastou et al., 2020 used qualitative methodologies to explore the various ways the term “learning styles” was interpreted by teachers. Nancekivell et. al. (2020) used Likert scale items, vignette, and provided a clear and concise explanation of learning styles to ensure a consistent definition. Tovazzi et al., (2020) compared the traditional true and false neuromyth inventory (Dekker et al., 2012) with a modified version utilizing a Likert scale. It is my suggestion that future revisions of the survey adopt a Likert style scale or categorical responses similar to the GSISI used in the present study. Respondents could be asked if a statement applies “more to girls”, “more to boys” or “both boys and girls equally”.

A limitation of the sex-specific inventory resulted from my attempt to align items to fit popular general neuromyths versus focusing on items that were more relevant to gender. For example, being “right-brained or left-brained” was identified as one of the "classic neuromyths" by MacDonald et al. (2017). Item 16.15 (boys and girls can be classified as "left-brained" or "right-brained" thinkers) does not reveal any information about sex differences only that the respondent does or does not endorse the right-brain left-brain neuromyth. Similarly, item 16.6 (information is stored in the brains of boys and girls in networks of cells distributed throughout the brain) only determines if the respondent knows how information is stored in the brain, but nothing specific to sex differences. Future revisions of the inventory should focus on measuring non-neuromyths and neuromyths that could have the most significant impacts in the classroom. For example, the items 16.23 and 16.24 both address the misconception that ambient room temperature affects learning (Gurian, 2009; Sax, 2006;), but one can argue that this misconception more than likely has less significant implications for classroom instruction than learning styles misconceptions.

5.2 SINGLE-GENDER AND PROFESSIONAL LEARNING EXPERIENCES

This study attempted to estimate the extent to which South Carolina educators have taught in single-gender learning environments and participated in professional learning related to gender learning differences. The selection criteria for the participating districts is a source of bias in the estimates reported in the results section. Only districts that offered single-sex classes before, during, and after the single-sex education peak in South Carolina (Klein et al., 2018) were approached for participation. While this was necessary to ensure the sample would contain teachers with diverse experiences related to the research topics, it is also a limitation. Due to the two districts historical and recent offering of single-sex classes, it was not surprising that 24.2% of the participants had taught in a school that offered single-sex classes. I found it interesting that all of the teachers who reported teaching in a school that offered single-sex classes also reported having taught in single-sex classrooms.

The data and results presented in this study may not be representative of all South Carolina school districts due to differences in the offering of single-sex class. My firsthand knowledge of the two participating districts implementation of single-sex education is the basis for why I would predict high numbers in the two participating districts. In addition, the data presented by Klein et al. (2018) indicated that single-sex offerings varied by district. Klein et al. (2018) reported that in 2008 – 2009 South Carolina was the most active state in the nation to promote public single-sex education with 216 schools offering single-sex classes or programs. The number of schools decreased to 84 in 2011-2012, 69 in 2012-2013, 26 in 2014-2015, and there were only 10 confirmed schools in 2017-2018. Due to the pervasiveness of single-sex education in South Carolina, it is likely that other school districts have teachers who taught in schools that offered single-sex classes or programs.

Despite the limitation imposed by district selection criteria, the fact that 69.5% of the participants had engaged in professional learning related to gender learning difference suggests that the topic is commonplace in educator training and professional learning. This is further substantiated by the fact that all 16 of the activities and experience presented in the survey check list were reported by the participants. The results indicate that college and university courses, teaching degree and alternative certification programs, and professional development courses are the most common types of professional learning experiences. The data from this study indicates that teachers may encounter information about sex-specific learning differences during both pre-service and in-service experiences. There is also evidence that suggests that districts and schools are a common source or vehicle for sex-specific learning differences professional learning. School faculty meetings, school based professional learning, and district based professional learning were also highly reported as types of activities. It is impossible to determine if the other types of activities in the survey checklist were included in the above-mentioned activities, or if they occurred independently. Reading books and journal articles, both highly reported as sources, are common components of college and professional development course work.

The average number of hours (18 hours) teachers reported engaging in activities suggests that the activities were on-going or in-depth experiences. This raises concern because key features of effective professional learning include that they are on-going over time and have explicit links to classroom lessons (Desimone & Garet, 2015). Desimone and Garet (2015) also reported that changing teacher, "procedural behavior is easier than improving content knowledge…" (p. 254). Single-sex education advocates such as David Chadwell (2010) sent a consistent message that, "the difference is not what is taught, but *how* (emphasis by author) the state and district standards are taught to boys and girls. The practice of using different instructional strategies to deliver a lesson or meet a standard with different populations of students is commonplace" (p. 3). Single-sex education advocates encouraged teachers to modify structural, behavioral, and instructional procedures to meet the differing needs of boys and girls. It should be noted that one limitation of the present study stems from not having firsthand knowledge of the quality and content of the sex-specific learning differences professional learning. It is possible that some of these experiences did not include neuromyths and provided sound scientific information about sex differences.

Teacher self-rated beliefs about sex-specific learning differences were predicted by the total number of hours engaged in sex-specific learning differences professional development. Teachers with higher numbers of hours were more confident in their responses on the SSLDI, believed they were more knowledgeable about sex differences, and believed sex learning difference were different. It is not known if the number of hours actually caused teachers to hold these beliefs or confirmed previously held beliefs. As Parjares (1994) reported, it is very difficult to modify the beliefs of adults and that new information is more likely to be assimilated if it confirms existing beliefs.

The open response results for source of professional learning provided some insight into the specific sources. Three South Carolina institutions of higher education were specifically identified: Columbia College, Winthrop University, and the University of South Carolina. General learning styles neuromyths are reported as being prevalent in higher education institutions (Newton, 2015). Two of the most highly criticized single-gender advocates, Leonard Sax and Michael Gurian, were identified as sources by multiple respondents. Despite criticisms from neurobiologists (Eliot, 2011; Halpern et al., 2011; Miller & Halpern, 2014), political scientists (Williams, 2010; Williams, 2016), and civil rights organizations (ACLU, 2015; Klein, 2018) Sax and Gurian both currently offer teacher training on sex-specific learning differences and the implications for instruction. Experts in the field of neuroscience consistently agree that neuroscientific findings should not be used to directly inform educational practice. However, in a video introduction to his *The Minds of Boys and Girls®* a fee-based online course for teachers Micheal Gurian (2020) states:

> I really believe we're in a science-based revolution and we need to apply this science to sex and gender to the minds of boys and girls to the ways boys and girls learn in some ways the way they learn differently…I feel like it is a kind of small revolution that we're all involved in that is based in the science and then goes immediately to the strategies.

The above statement advocates for direct and "immediate" application of neuroscientific evidence on sex-specific learning difference to instructional strategies in the classroom. Leonard Sax currently offers fee-based workshops aligned with the second edition of *Why Gender Matters*, (Sax, 2017). Although the existence of single-sex classes and programs in both South Carolina and the United States have decreased, the misapplication of sex-specific neurobiological learning difference continues. The results from the present study suggest that both higher learning institutions and local school districts are probable sources of sex-specific learning differences misconceptions.

5.3 PREVELANCE OF SEX-SPECIFIC LEARNING DIFFERENCE NEUROMYHS

A major goal of the present study was to identify the prevalence of sex-specific learning differences neuromyths. The results of this study are consistent with previous studies of general neuromyths that identified learning styles (visual, auditory, kinesthetic = VAK) neuromyths as one of the most prevalent and difficult to eradicate (Duffin, 2020). Ferrero et al., (2016) conducted a meta-analysis exploring neuromyth endorsement in eleven different countries and reported that neuromyths are prevalent across nations. The meta-analysis also revealed that while there are similarities and differences in the rates for specific neuromyths endorsement, learning styles are endorsed by 85.8 to 97.1% of teachers. MacDonald et. al. (2017) conducted the first large scale study in the United States that explored neuromyths among educators. In the U.S. teacher sample, learning styles myths were endorsed by 76% teachers (MacDonald et al., 2017). The only other data including teachers from the United States is Horvath et al. (2018). The small sample size (n=50) make the results less interpretable; however, it is worth noting that the learning styles myth was the most endorsed. A unique contribution of the present study is that it is the first to examine teacher endorsement of sex-specific learning styles. In both the quantitative and qualitative results boys were consistently identified as kinesthetic and visual learners and girls were identified as auditory/verbal learners.

Two items in the present study were also included in the MacDonald et al. (2017) study, "the brains of boys and girls develop at different rates" and "on average the brains of boys are bigger than girls". Both items are considered non-neuromyths. In fact, Eliot (2009) concluded, "that only two facts have been reliably proven…one is that boys' brains are larger than girls" and "girls brains finish growing about one to two years earlier than boys' (p.5). Eliot (2009) further explained that brain size is relative to body size and male bodies and brains are on average larger than females. There is no evidence that larger brain volume equates to higher intelligence or cognitive ability (Eliot, 2009; Halpern, 2000). Interestingly, the participants in the present study accurately identified development rates as a true gender difference (88.4% correct, the highest for all non-neuromyths), but had the lowest percent accuracy for the average brain size (17.4%). These findings are contradictory to MacDonald et al. (2017) in which 69% of educators correctly identified that boys have bigger brains and 19% correctly identified that the brains of boys and girls develop at different rates. A possible explanation for why the respondents in the present study failed to identity brain size as a true gender difference is the tendency of respondents to provide answers they believe are culturally acceptable or socially desirable (Johnson & Morgan, 2016). It might be inferred that if social desirability (in part) explains the low percentage correct for brain size, that the high endorsement of gendered learning styles is socially acceptable. This discrepancy in the present data is an area for future research.

5.4 PREDICTORS OF SEX-SPECIFIC LEARNING DIFFERENCE NEUROMYHS

A goal of the present study was to identify predictors of sex-specific learning difference neuromyths. Due to the historical prevalence of single-sex classrooms and programs in South Carolina that relied on pseudoscientific conceptions of "hard-wired" sex differences, it was predicted that total hours of professional learning related to sex-specific learning differences would influence neuromyth acceptance. Data analysis did not reveal any significant predictors of neuromyths. However, the number of hours engaged in professional learning activities did significantly predict beliefs about learning differences. Teacher beliefs influence classroom interactions and instruction (Good, 1987; Pajares, 1994) and it is possible that teachers who believe in sex-specific learning differences are more likely to send stereotypical messages.

5.5 PREVELANCE OF GENDER-SPECIFIC INSTRUCTIONAL STRATEGIES

The overarching goal of the present study was to explore the prevalence and predictors of gender-specific instructional strategies. Previous neuromyth studies explored the prevalence of neuromyths in various teacher populations (see Table 3.1). Until recently, there were no previous studies that specifically explored how acceptance of neuromyths influenced classroom instruction. Recently, Tovazzi et al. (2020) and Papadatou-Pastou et al. (2020) concluded that neuromyth acceptance may have impacts on classroom instruction. Although, classroom instruction was not directly observed for the purpose of the present study, the exploration of educators' beliefs in gender-specific instructional strategies suggested potential implications.

While the overall endorsement of gender specific instructional strategies was low, some important themes emerged from the data. Factor analysis resulted in two categories of interest, passive learning strategies and active learning strategies. The data suggested that teachers believe passive strategies are for girls and active strategies for boys. More teachers indicated that they believe the strategies meet the instructional needs of both boys and girls equally. However, examination of the data for the respondents who did not believe the strategy meets the needs of both girls and boys revealed a clear dichotomy.

The individual strategies that composed the passive learning strategy factor were primarily viewed as for girls with the exception of competitive activities. The opposite theme emerged when examining the active strategies factor. All of the individual strategies that compose the active learning strategy factor were viewed as for boys with the exception of collaborative activities. Although, developing a valid and reliable gender- specific instructional strategies inventory was not a goal of this study the results suggest that this is an area for future survey development and exploration.

The impact of stereotypes and stereotype threat are well documented in literature (Hill & St. Rose, 2010). Despite gains in some STEM majors, (i.e. biology and chemistry) women still lag behind in many STEM areas such as engineering and computer science (Liben &Coyle, 2016). In addition, girls are underrepresented among students who take STEM Advanced Placement tests (Liben & Coyle, 2016). Perhaps most concerning is that women are underrepresented in the STEM workforce and despite some proportional increases over the years, "the general picture of women's underrepresentation has remained remarkably similar over the year" (Liben & Coyle, 2016, p. 81). Success in STEM coursework and careers require skills that are associated with both the active learning strategy and passive learning strategy identified in this study. Teacher belief in gender- specific instructional strategies could impact the types of activities and experiences they provide for students and/or send messages about what they believe are appropriate activities for students. This could create inequities for both boys and girls but is particularly concerning given the historical underrepresentation of women in STEM (Cahoon & Aspray, 2006; Hill & St. Rose, 2010; Margolis & Fisher, 2002).

In addition to the empirical findings in the present study that suggested teachers endorse girls as passive learners and boys active learners, my personal observations during the time I was directly involved in single-sex education and professional learning are cause for concern. During that time, I directly and indirectly witnessed stereotypical lessons in STEM classrooms. I also observed, the phenomenon that Liben (2016) refers to as making STEM "pink". Rather than removing barriers and stigmas associated with STEM fields, many single-sex classrooms aligned instruction with stereotypical and traditional views of girls. In Liben's discussion of the past, present, and future of gender equality, she provides several examples such as the marketing of pink Legos® for girls, Goldie Blox, and the science cheerleaders (see Liben, 2016 for full discussion). I personally witnessed an elementary school classroom where girls were encouraged to wrap their science notebooks in bows. I also encountered science lessons for girls that focused on cosmetic chemistry and math lessons on budgeting for outfits and fashion accessories. Overtly and inadvertently, the single-sex education movement contributed to and reinforced gender stereotypes.

5.6 PREDICTORS OF GENDER-SPECIFIC INSTRUCTIONAL STRATEGIES

The overarching goal of the present study was to determine the prevalence and predictors of gender specific instructional strategies. The only consistent predictor identified was neuromyth endorsement. Total neuromyth endorsement predicted total gender-specific instructional strategy score, active learning strategy score, passive learning strategy score, and collaboration strategy score. Completing neuroscience coursework predicted a decrease in the passive learning score, and teaching at the elementary level predicted a decrease in the active learning score. MacDonald et al. (2017) also noted that neuroscience exposure reduced neuroscience endorsement. Although neuroscience exposure did not significantly decrease sex-specific neuromyths, it did significantly predict a decreased belief in the passive learning strategy. Future studies examining neuromyths or gender-specific instructional strategies should continue to examine neuroscience exposure as possible protection against neuromyth endorsement and stereotypical instructional practices. The results suggest that neuroscience course work should be included in teacher preparation programs if such courses provide teachers with the knowledge and skills to distinguish facts from pseudoscience.

5.7 CONCLUSION

Researchers continue to raise concern about the impacts of single-sex education and essentialist views of gender (Liben, 2016; Williams, 2020) and impacts of believing in learning styles myths (Duffin, 2020). Figure 5.1 is presented as a possible visual representation of how sex-specific neuromyths, gender-specific instructional strategies, and accepted sex learning differences intersect. The visual representation suggests that future revisions to the sex-specific neuromyth inventory should focus on the sensory processing and learning styles items for the following reasons: factor analysis identified the senses and the learning styles neuromyths, factor analysis identified the passive learning and active learning strategies, the concepts of the neuromyth items and the learning strategy items are aligned, all four constructs are related to accepted on average gender differences, and the items and constructs represent or are derivative of the most prevalent persistent general neuromyth, visual – auditory – kinesthetic (VAK) learning styles.

The most significant contribution of this study is that the results indicate conversations concerning learning style misconceptions should be situated within the context of sex difference misconceptions. Endorsing VAK and tailoring instruction to meet multiple modalities might not translate into differential student outcomes. However, assigning students by gender to learning categories that do not exist has the potential to impact student experiences and outcomes. The results of this study suggest that teachers who accept sensory processing and learning styles myths also believe that students have gender-specific instructional needs.

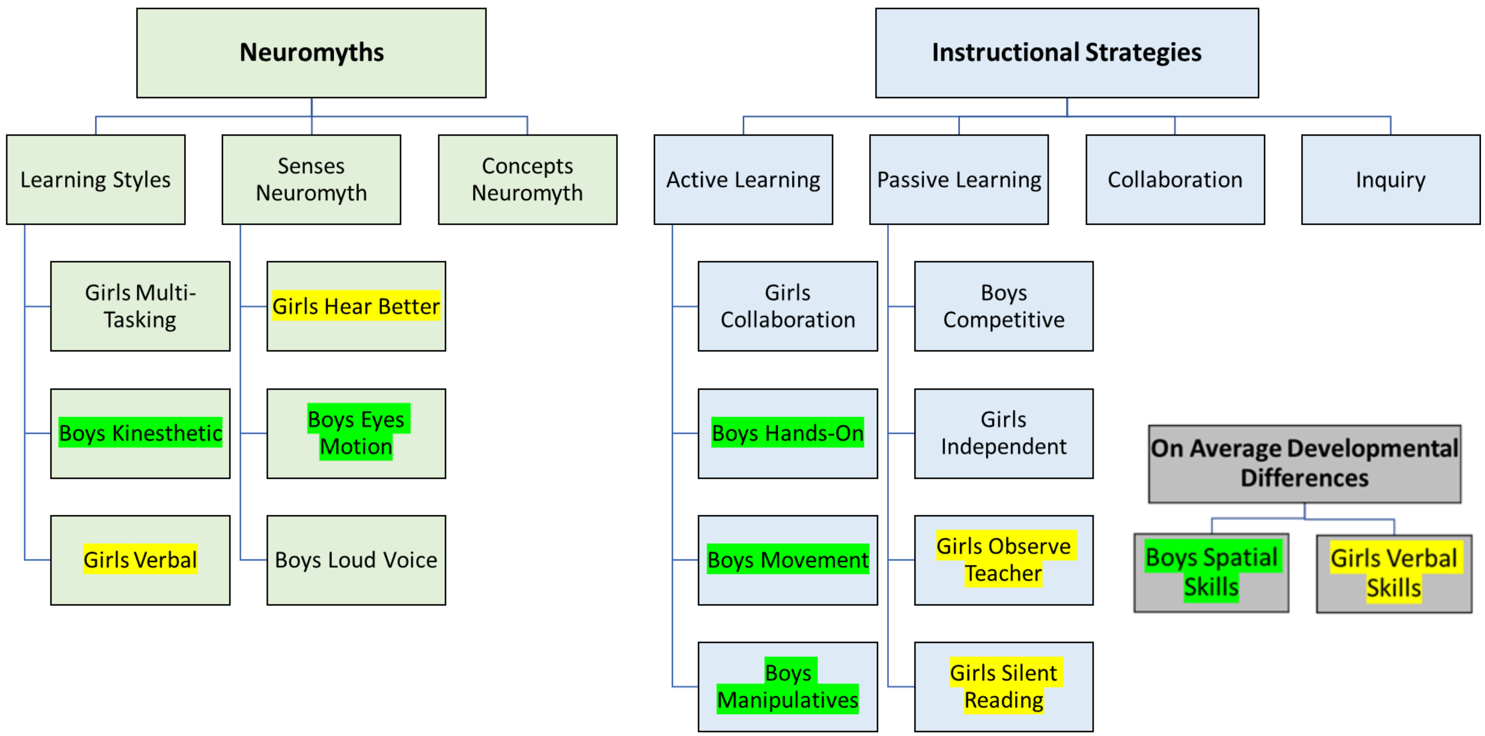

Figure 5.1: Intersection of sex-specific neuromyths, gender-specific instructional strategies, and accepted on average differences

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER for EXEMPT REVIEW

Marriah Schwallier
1563 Brennen Rd
Columbia, SC 29206 USA

Re: **Pro00090340**

Dear Ms. Marriah Schwallier:

This is to certify that the research study ***Teacher Beliefs* in Gender/Sex Specific Instructional Strategies: Prevalence, Predictors, and Implications** was reviewed in accordance with 45 CFR 46.104(d)(2) and 45 CFR 46.111(a)(7), the study received an exemption from Human Research Subject Regulations on **8/15/2019**. No further action or Institutional Review Board (IRB) oversight is required, as long as the study remains the same. However, the Principal Investigator must inform the Office of Research Compliance of any changes in procedures involving human subjects. Changes to the current research study could result in a reclassification of the study and further review by the IRB.

Because this study was determined to be exempt from further IRB oversight, consent document(s), if applicable, are not stamped with an expiration date.

All research related records are to be retained for at least three (3) years after termination of the study.

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). If you have questions, contact Lisa Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

APPENDIX B

INITIAL ITEM LIST SSLDI ITEM BANK: DISCUSSION, JUSTIFICATION, EXPERT COMMENTS, AND SUBSEQUENT EDITS

Table B.1 Initial Item List SSLDI Item Bank: Discussion, Justification, Expert Comments, and Subsequent Edits

Initial Item 1: The brains of boys and girls develop at different rates (True) This item is taken directly from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017). The item was included to balance the number of false items. Domain: Brain Structure and Development
Initial Item 2: The brains of boys are bigger than the brains of girls (True) This item is taken directly from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017). The item was included to balance the number of false items. Domain: Brain Structure and Development
Initial Item 3: The region of the brain (amygdala) associated with emotional and motivational responses (aggression, fear, anger, pleasure, etc.) tends to be bigger in the brains of boys compared to girls (True) This item is considered a confirmed sex difference (Eliot, 2011). The specific determiner "tends" is included to balance items that are false and contain similar determiners. Domain: Brain Structure and Development **Eliot Comments: "**This is not true, as written. We completed a meta-analysis in 2017 (Marwha et al.) that found no significant sex difference in amygdala volume once you normalize to individuals' total brain volume. Furthermore, as written, it suggests that larger amygdalae are associated with stronger aggression/fear etc. which is not true". **Edits:** This item was excluded

Initial Item 4: The region of the brain (prefrontal cortex) associated with executive function (decision making, consequences, determining good from bad, social control, etc.) tends to be bigger in girls' brains compared to boys (True) This item is considered a confirmed sex difference (Eliot, 2011). The specific determiner "tends" is included to balance items that are false and contain similar determiners. Domain: Brain Structure and Development **Eliot Feedback:** "Similarly, this claim about PFC is not well-proven and is contradicted by many large recent studies (of adult men vs women). Definitely not accurate as written in relation to executive function". "If you want another true statement, could say that "Girls' brains finish growing at an earlier average age than boys'". **Edits:** This item was excluded, and the suggested true statement was added
Initial Item 5: Human brains can be classified as "male-brains" or "female-brains" (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Brain Structure and Development
Initial Item 6: The brains of males and females are more alike than they are different (True) This item is based on *The Gender Similarities Hypothesis* (Hyde, 2005) which maintains that results from meta-analysis support that males and females are alike on most, but not all psychological variables. Domain: Brain Structure and Development
Initial Item 7: The brains of girls are wired for multi-tasking (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Brain Structure and Development
Initial Item 8: Boys tend to use one hemisphere of the brain at a time (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Hemispheric Processing
Initial Item 9: Girls tend to use whole brain thinking (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Hemispheric Processing
Initial Item 10: The left and right hemispheres of boys' and girls' brains work together (True) This item was revised from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017) by including "boys' and

girls'" to maintain consistency in question structure and language. Domain: Hemispheric Processing **Eliot Feedback:** "A little confusing, as written. Can you change to: "The left and right hemispheres work together in both boys' and girls' brains." Otherwise, it sounds like girls' and boys' hemispheres are working with each other". **Edits:** Item edited as indicated above
Initial Item 11: Some boys and girls are "left-brained" and some boys and girls are "right-brained", and this helps explain differences in how individuals learn (False) This item was revised from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017) by including "boys and girls'" to maintain consistency in question structure and language. Domain: Hemispheric Processing
Initial Item 12: Girls tend to hear better than boys (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Sensory Processing
Initial Item 13: Boys tend to learn better when a teacher uses a loud voice (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Sensory Processing
Initial Item 14: Girls tend to hear low volume voices better than boys (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Sensory Processing
Initial Item 15: The eyes of boys are attuned to motion (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing **Eliot Feedback:** Is true as written; all eyes are attuned to motion (boys and girls). Need to say "more in boys" if you want to present as a myth. **Edits:** The item was revised to, "The eyes of boys are more attuned to motion that the eyes of girls"

Initial Item 16: The eyes of boys are drawn to cool colors (black, blue, grey and brown) (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing **Eliot Feedback:** add "naturally" **Edits:** The item was revised to, "The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown)"
Initial Item 17: The eyes of girls are drawn to warm colors (yellow, red, and orange) (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing **Eliot Feedback:** add "naturally" **Edits:** The item was revised to, "The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)"
Initial Item 18: Boys are more likely to be color blind (True) This item is considered a confirmed sex difference (Eliot, 2011). The terms "boys' and girls' are used to maintain consistency in question structure and language. The item was created to balance the number of false items. Domain: Sensory Processing
Initial Item 19: Stress enhances learning for boys (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing
Initial Item 20: Stress inhibits learning for girls (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing
Initial Item 21: Girls learn better in warmer ambient temperatures (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing
Initial Item 22: Boys learn better in cooler ambient temperatures (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Sensory Processing
Initial Item 23: Boys are more likely to be diagnosed with dyslexia (True) This item is considered a confirmed sex difference (Eliot, 2009). The term "boys" is used to maintain consistency in question structure and language. The item was created to balance the number of false items. Domain: Learning and Learning Styles

Initial Item 24: Girls typically acquire language skills before boys (True) This item is considered a confirmed sex difference (Eliot, 2011) but is age specific and based on averages. The terms boys and girls cue the respondents to think about children versus adults. The item was created to balance the number of false items. Domain: Learning and Learning Styles

Eliot Feedback: I don't like "typically" because it sounds like most every girl has more advanced language than most every boy, when in fact the divide is going to be about 60/40. Same for the spatial skills in next item.

Edits: The item was revised to, "On average, girls acquire language skills before boys"

Initial Item 25: Boys typically have stronger visual-spatial skills than girls (True) This item is considered a confirmed sex difference (Eliot, 2011) but is age specific and based on averages. The terms boys and girls cue the respondents to think about children versus adults. The item was created to balance the number of false items. Domain: Learning and Learning Styles

Eliot Feedback: I don't like "typically" because it sounds like most every girl has more advanced language than most every boy, when in fact the divide is going to be about 60/40. Same for the spatial skills in next item.

Edits: The item was revised to, "On average, boys have stronger visual-spatial skills than girls"

Initial Item 26: Boys and girls show preference for the mode in which they receive information (auditory, visual, kinesthetic) (True) This item was revised from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017) by including "boys and girls'" to maintain consistency in question structure and language. The item was included to balance the number of false items. Domain: Learning and Learning Styles

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Initial Item 27: Girls and boys learn differently (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). Domain: Learning and Learning Styles

Edits: The research deleted this item to balance the number of true and false items. Items 28 - 32 all address the concept of boys and girls learning differently, but in more precise language.

Initial Item 28: Girls tend to be verbal learners (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Learning and Learning Styles.

Initial Item 29: Boys tend to be visual learners (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Learning and Learning Styles
Initial Item 30: Boys tend to be kinesthetic learners (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Learning and Learning Styles
Initial Item 31: Boys learn abstract concepts better than girls (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Learning and Learning Styles
Initial Item 32: Girls learn concrete concepts better than boys (False) This item was created to represent a sex difference neuromyth (Eliot, 2011). The specific determiner "tend" is included to balance items that are true and contain similar determiners. Domain: Learning and Learning Styles
Initial Item 33: Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic) (False) This item was revised from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017) from "Individuals learn…" to "Boys and girls learn…" in order to maintain consistency in question structure and language. Domain: Learning and Learning Styles
Initial Item 34: Boys and girls have learning styles that are dominated by specific senses (i.e., seeing, hearing, touch) (False) This item was revised from previously published general neuromyth inventories (Dekker et. al., 2012 and MacDonald et. al., 2017) from "Children have…" to "Boys and girls have…" to maintain consistency in question structure and language. Domain: Learning and Learning Styles

APPENDIX C

PILOT ITEM LIST FOR SSLDI

Table C.1 Pilot Item List for SSLDI

Pilot Item 1: The brains of boys and girls develop at different rates (True)
Pilot Item 2: On average the brains of boys are bigger than the brains of girls (True)
Pilot Item 3: Girls' brains finish growing at an earlier average age than boys' (True)
Pilot Item 4: Most human brains can be classified as "male-brains" or "female-brains" (False)
Pilot Item 5: The brains of males and females are more alike than they are different (True)
Pilot Item 6: Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) and girls tend to use both hemispheres of the brain at the same time (whole brain thinking) (False)
Pilot Item 7: The right and left hemispheres work together in both boys' and girls' brains (True)
Pilot Item 8: Some boys and girls are "left-brained" and some boys and girls are "right-brained" and this helps explain differences in how individuals learn (False)
Pilot Item 9: Girls tend to hear better than boys (False)
Pilot Item 10: Boys tend to learn better when a teacher uses a loud voice (False)
Pilot Item 11: Girls tend to hear low volume voices better than boys (False)
Pilot Item 12: The eyes of boys are more attuned to motion than the eyes so girls (False)
Pilot Item 13: The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown) (False)

Pilot Item 14: The eyes of girls are naturally drawn to warm colors (yellow, red, and orange) (False)
Pilot Item 15: Boys are more likely to be color blind (True)
Pilot Item 16: Stress tends to enhance learning for boys (False)
Pilot Item 17: Stress tends to inhibit learning for girls (False)
Pilot Item 18: Girls tend to learn better in warmer ambient temperatures (False)
Pilot Item 19: Boys tend to learn better in cooler ambient temperatures (False)
Pilot Item 20: Boys are more likely to be diagnosed with dyslexia (True)
Pilot Item 21: On average girls acquire language skills before boys (True)
Pilot Item 22: On average boys have stronger visual-spatial skills than girls (True)
Pilot Item 253 Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic) (True)
Pilot Item 24: Girls tend to be verbal learners (False)
Pilot Item 25 Boys tend to be visual learners (False)
Pilot Item 26: Boys tend to be kinesthetic learners (False)
Pilot Item 27: Boys tend to learn abstract concepts better than girls (False)
Pilot Item 28: Girls tend to learn concrete concepts better than boys (False)
Pilot Item 29: Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic) (False)
Pilot Item 30: There are specific periods in childhood when it is easier for boys and girls to learn certain things (True)
Pilot Item 31: Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains (True)
Pilot Item 32: Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain (True)

APPENDIX D

PILOT STUDY SURVEY INSTRUMENT

Teacher Beliefs Final Pilot

Start of Block: Introduction

Thank you for your interest in participating in my pilot study. The results from this pilot study will be used to improve and revise the final survey instrument used in my doctoral research. Your complete and honest answers are essential for the success of my research. As a thank you for your time and participation, you will receive a $15.00 Amazon eGift Card.

This survey is divided into five sections and should only take 10 - 15 minutes to complete. The survey will close when 50 teacher responses are recorded or on December 20, 2019 at 5:00 p.m. whichever comes first.

Please Note: Only **City High School and Meadow High School teachers** are eligible to participate and receive the $15.00 Amazon eGift Card.

You will have to provide your name and district email address to claim your gift card. Your contact information will be collected after you have completed the pilot survey and will not be linked to your responses. **Your responses will remain anonymous.** You may only complete this survey one time. There is a limit of one gift card per eligible individual.

Before you proceed to the survey, please complete the reCAPTCHA below.

Section One: Background Information and Teaching Experience

PQ2. Which statement best describes your current certification status?

PQ3. What level(s) are you certified to teach? Select all that apply.

PQ4. What levels do you currently teach? Select all that apply.

PQ5. Which subjects or areas are you certified to teach? Select all that apply.

PQ6. What is the highest degree you have earned?

PQ7. Are you or have you ever been a National Board Certified Teacher?

PQ8. How many undergraduate or graduate level neuroscience related courses have you completed?

PQ9. What is your gender?

PQ10. What is your age? Your response is requested, but not required for this question.

PQ11. How many years of classroom teaching experience do you have?

PQ12. How many years have you taught in South Carolina?

PQ13a. Have you ever taught single-gender **classes** (classes with only boys or classes with only girls) OR in **a school** that offered single-gender classes?

Start of Block: Single-Gender

PQ13b. How many years of teaching experience do you have **teaching in a school** that offered single-gender classes?

PQ13c. How many years of teaching experience do you have **teaching in single-gender classes**?

PQ13d. How many years of teaching experience do you have **teaching in co-educational** (classes with both boys and girls) classes?

Start of Block: Experience Reflection

Section Two: Professional Experiences and Activities

Please reflect on the experiences and activities you have engaged in as part of your certification program (traditional and alternative) and during your career as an educator. This includes college course work, teacher preparation training, on-line modules, internships, workshops, conferences, faculty meetings, district in-services, school in-services, professional learning communities, book studies, etc. It also includes your personal professional learning activities such as reading books, magazines, journal articles, websites, blogs, news articles, etc.

PQ14a. Did any of your past experiences or activities include information about gender/sex learning differences?

Start of Block: Experience and Time

PQ14b. Which of the following experiences or activities included information about gender/sex learning differences? Select all that apply.

PQ14c. How much time would you estimate that you spent learning about gender/sex learning differences?

PQ15. If known, please list any specific agencies, authors, individuals, organizations, consultants, or companies that provided/sponsored/authored any of your experiences and activities that included information about gender/sex differences in which you participated.

Start of Block: True False Knowledge Intro

Section Three: Knowledge of Gender Learning Differences and Brain Structure and Function

In this section of the survey, you will be asked to respond to a series of true or false questions related to gender/sex learning differences. There is a total of 32 questions in this section.

Start of Block: True or False

PQ16.1 The brains of boys and girls develop at different rates

PQ16.2 On average the brains of boys are bigger than the brains of girls

PQ16.3 Most human brains can be classified as "male-brains" or "female-brains"

PQ16.4 Girls' brains finish growing at an earlier average age than boys'

PQ16.5 The brains of males and females are more alike than they are different

PQ16.6 Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) and girls tend to use both hemispheres of the brain at the same time (whole brain thinking)

PQ16.7 The right and left hemispheres work together in boys' and girls' brains

PQ16.8 Some boys and girls are "left-brained" and some boys and girls are "right-brained", and this helps explain differences in how individuals learn

PQ16.9 Girls tend to hear better than boys

Q16.10 Boys tend to learn better when a teacher uses a loud voice

PQ16.11 Girls tend to hear low volume voices better than boys

PQ16.12 The eyes of boys are more attuned to motion than the eyes of girls

PQ16.13 The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown)

PQ16.14 The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)]

PQ16.15 Boys are more likely to be color blind

PQ16.16 Stress tends to enhance learning for boys

PQ16.18 Girls tend to learn better in warmer ambient temperatures

PQ16.19 Boys tend to learn better in cooler ambient temperatures

PQ16.20 Boys are more likely to be diagnosed with dyslexia

PQ16.21 On average girls acquire language skills before boys

PQ16.22 On average boys have stronger visual-spatial skills than girls

PQ16.23 Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)

PQ16.24 Girls tend to be verbal learners

PQ16.25 Boys tend to be visual learners

PQ16.26 Boys tend to be kinesthetic learners

PQ16.27 Boys tend to learn abstract concepts better than girls

PQ16.28 Girls tend to learn concrete concepts better than boys

PQ16.29 Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)

PQ16.30 There are specific periods in childhood when it's easier for boys and girls to learn certain things

PQ16.31 Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains

PQ16.32 Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain

Start of Block: Knowledge of Gender/Sex Learning Differences

PQ17. Which statement best describes your knowledge of gender/sex learning differences?

PQ18. What is your general understanding of gender/sex learning differences?

Start of Block: Instructional Strategies

Section Four: Instructional Strategies

PQ19. Indicate whether you believe each instructional strategy would meet the needs of primarily girls, primarily boys or both boys and girls.

PQ19.1 Participating in collaborative activities

PQ19.2 Participating in competitive activities

PQ19.3 Working independently

PQ19.4 Working with a partner

PQ19.5 Observing a teacher led demonstration

PQ19.6 Participating in teacher led direct instruction

PQ 19.7 Participating in student led instructional activities

PQ 19.8 Participating in an activity that requires movement

PQ 19.9 Participating in student led inquiry

PQ 19.10 Solving problems using manipulatives

PQ 19.11 Participating in hands-on activities

PQ 19.12 Working in a small group

PQ 19.13 Participating in problem/project-based learning

PQ 19.14 Participating in sustained silent reading

Start of Block: Pilot Study Questions

Section Five: Pilot Survey Questions

The following questions are designed to gather feedback from participants about the survey instrument and experience. These questions will be used to revise and improve the survey instrument and experience. Your complete and honest answers are essential for the success of my research.

PQ20. The final survey will offer the chance to win one of five $50 Amazon Gift Cards. Based on the information in the study introduction email, would you be persuaded to respond to the survey? Why or why not?

PQ21. Were any questions on the survey unclear? Please give specific examples.

PQ22. Is the format and layout of the survey easy to use? Please explain.

PQ23. Do you have any suggestions for improving the survey instrument or the study introduction email?

Start of Block: Incentive

PQ24. Would you like to receive a $15.00 Amazon eGift Card?

APPENDIX E

PILOT STUDY EMAIL INFORMED CONSENT AND COMMUNICATION

From: SCHWALLIER, MARRIAH [mailto:schwallm@email.sc.edu]
Sent: Sunday, December 8, 2019 5:56 PM
To: Meadow High Principal < >; City High Principal < >
Cc: District B Research Director < >
Subject: Teacher Beliefs Doctoral Research Survey

Dear Meadow High School Principal and City High School Principal,

Thank you for allowing me to conduct my pilot study at your schools. I appreciate your support of my doctoral research. Please forward the following invitation and informational email to your teachers. The survey will close when 50 teacher responses are recorded or on December 20, 2019 at 5:00 p.m. whichever comes first.

If you have any questions or concerns, please do not hesitate to contact me.

With gratitude, Marriah Schwallier

Dear Classroom Teacher,

My name is Marriah Schwallier. I am a doctoral candidate in the Instruction and Teacher Education Department, College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Teaching and Learning, and I would like to invite you to participate in my pilot survey (link below).

The results from the pilot survey will be used to improve and revise the final survey. If you choose to participate in the pilot study, you will receive a **$15.00 Amazon eGift Card** for completing and submitting the survey. The pilot survey will only accept submissions from the first **50 teacher respondents.**

I am studying teacher knowledge of gender/sex learning differences and teacher beliefs about instructional strategies. If you decide to participate, you will be asked to complete an electronic survey about your teaching experience, professional learning related to gender/sex differences, knowledge of gender/sex learning differences and brain structure and function, and your beliefs about instructional strategies. **The survey should take only 10 - 15 minutes to complete. The survey will close when 50 teacher response are recorded or on December 20, 2019 at 5:00 p.m.** whichever comes first. You can only complete the survey one time, and there is a limit of one gift card per individual.

Participation is anonymous, which means that no one (not even the research team) will be able to identify your responses. So, please do not include your name or other identifying information on any of the study items. Participation is voluntary and there will be no negative consequences if you choose not to participate.

We will be happy to answer any questions you have about the study. You may contact me at schwallm@email.sc.edu or my faculty advisor, Dr. Christine Lotter, 803-777-6593, and lotter@mailbox.sc.edu. Thank you for your consideration. If you would like to participate, please open the link, and begin completing the survey. When you are done, submit the survey and follow the instructions for claiming your $15.00 Amazon eGift Card.

With kind regards,

Marriah Schwallier

University of South Carolina
Instruction and Teacher Education
College of Education
schwallm@email.sc.edu

If you are ready to begin the survey, please click the link below.
Password: XXXXX
Survey Link: https://uofsc.co1.qualtrics.com

From: SCHWALLIER, MARRIAH [mailto:schwallm@email.sc.edu]
Sent: Friday, December 13, 2019 7:22 AM
To: Meadow High Principal < >; City High Principal < >
Cc: District B Research Director < >
Subject: Teacher Beliefs Survey: eCards, Expired Sessions, and Survey Deadline Reminder

Dear Meadow High School Principal and City High School Principal,

Thank you again for your school's participation in my research. The survey is still accepting responses and has not meet the 50-teacher response limit. Please send the following email reminder/update to your teachers. I appreciate your continued support.

Thank you, Marriah

Dear Classroom Teachers,

If you completed and submitted the survey and requested the Amazon eGift Card you should have received the card via your District B email (if you provided a valid District B email address as indicated in the survey directions). Thank you for your participation!

If you would like to participate the **survey is currently accepting responses** and has not meet the 50-teacher quota. **If you started the survey and were locked out due to an expired session, you can still participate if you re-open the link sent in the previous email.** The survey settings have been adjusted to prevent session expiration. The survey will close on December 20th or when an additional 18 complete responses are recorded.

With kind regards,

Marriah Schwallier

APPENDIX F

PILOT STUDY QUALITATIVE OPEN RESPONSE CODES, COUNTS, AND DESCRIPTIONS

Table F.1: Pilot Study Willingness to Participate Open-Responses

Codes	**Count (N=40)**	**Discussion**
Contribute to Research	16	The respondents indicated that they were motivated to participate to contribute to educational research.
Incentive	11	The respondent specifically identified the monetary incentive as a reason for participating.
Interested in Topic	9	The respondents indicated they were interested in the survey topics.
Needs of Students	12	The respondents indicated that they participated because they felt the survey topics addressed the needs of students.
Professional Learning	4	The respondents indicated that they believed the survey topics could be important for teacher professional development.
Time	1	The respondent mentioned the short amount of time needed to complete the survey.
No	2	One respondent indicated no, because they" usually do not win door prizes". The other respondent indicated that they would be willing to help a peer regardless of the introductory email.
Maybe	1	The respondent indicated maybe depending on the amount of time required.

Yes	37	Most of the respondents indicated that they would be persuaded to participate. The reasons for participating (if provided) are identified in the above categories.

Table F.2: Pilot Study Question Survey Clarity and Survey Layout Open-Responses

Codes	Count (N=40)	Discussion
No	29	
Length	1	The respondent suggested reducing the wording for the question about reflecting on experience and activities related to gender learning differences.
Stress	1	The respondent explained that they only marked true for the question concerning girls learning under stress because, "I suspect that everyone learns worse under stressful situations".
True and False	9	The respondents identified concerns over the true and false items. Respondents expressed that they were "uncomfortable" or "unsure" and would have liked an "I don't know" option. Some respondents expressed concerns about the wording of specific items.
Bias	1	The respondent indicated that they felt the survey had a bias and that they were being judged and trying to give the correct answer versus their opinion.
Instructional Activities	2	One respondent expressed that they did not think some of the instructional activities would be engaging for either boys or girls. One respondent thought the instructional activities would be beneficial to all students and had difficulty deciding if a strategy was better suited for girls or boys.

Table F.3: Pilot Study Suggestion for Improvement Open-Responses

Codes	Count (n=40)	Discussion
Gender Binary	1	The respondent raised the concern that gender is not binary.
Get Results	1	The respondent indicated that they would like to receive their results.
I Don't Know Option	4	The respondents indicated that they would like an "I don't know" option.
No	35	Most respondents indicated that they did not have any suggestions. The specific suggestions (if provided) are identified in the above categories.

Table F.4: Pilot Study Understanding of Gender/Sex Learning Differences Open-Response

Codes	Count (n=40)	Discussion
Adolescence	2	The respondents indicated gender learning differences were significant or important during adolescence.
Affects Learning	12	The responses indicated that the twelve respondents believed gender influenced how students learn.
Boys Action	1	The respondent indicated that "Boys need action and movement".
Boys and Aggression	1	The respondent indicated that "Boys are more aggressive than girls".
Boys and Competition	2	The two respondents indicated that boys were more competitive than girls.
Boys and Critical Thinking	1	The respondent indicated that, "Boys don't want to memorize or take notes and instead feel more comfortable in an environment in which they can get by simply utilizing some critical thinking".
Boys and Disabilities	1	The respondent indicated that boys are more often diagnosed with disabilities.
Boys and Peers	1	The respondent provided a list of traits for boys and a list or traits for girls. The respondent indicated boys are "peer motivated".

Boys Kinesthetic/Movement	6	The six respondents indicated that boys need action, are tactile, need movement, and prefer hands-on activity. One respondent specifically identified boys as kinesthetic.
Boys Math	1	The respondent indicated that, “it has been my experience that boys are quicker to grasp the logic associated with mathematical topics”.
Boys Practical	1	The respondent indicated that boys, “have a knack for practical applications”.
Boys Risk	1	The respondent indicated that boys are “more willing to take risks in the classroom”.
Boys Spatial	2	One respondent indicated that boys have an easier time with visualizing mentally. The respondent identified rotating 3D objects, which is considered a confirmed sex difference with a reasonably high effect size (Halpern et. al, 2007). The other respondent provided a list of traits for boys and a list or traits for girls. The respondent indicated boys are “spatial”.
Boys Visual	2	The respondent provided a list of traits for boys and a list or traits for girls. The respondent indicated boys are “visual”.
Development	3	The respondents indicated that there are differences in brain development that affect learning.
Environmental Influences	6	The respondents indicated that the social environment plays a role in student behaviors, expectations, learning, and outcomes. One respondent indicated that they, “believe most perceived gender learning differences are cultural/social and not scientific/innate”.
Girls Abstract Concepts	1	The respondent indicated that girls were more likely to have the ability to focus on abstract content.
Girls and Lecture	2	The respondents indicated that girls were more likely to respond to or be more successful with lecture and/or note-taking.

Girls and Organization	2	The respondents indicated that girls are more organized than boys.
Girls Auditory	1	The respondent provided a list of traits for boys and a list or traits for girls. The respondent indicated girls are “auditory”.
Girls Cooperation	1	The respondent indicated that girls were more likely to prefer cooperative or solitary learning activities.
Girls Language Skills	1	The respondent indicated that girls' language skills, “tend to be more tuned than boys”.
Girls Resilient	1	The respondent indicated that girls were more resilient than boys when dealing with failure.
Girls Safety	1	The respondent indicated that, “girls need safety and understanding”.
Girls Self-Motivated	2	The respondents indicated that girls were more self-motivated than boys.
Girls Variety	1	The respondent provided a list of traits for boys and a list or traits for girls. The respondent indicated girls “prefer variety”.

APPENDIX G

FINAL ITEMS FOR SSLDI SELECTION, REVISION, AND FINAL EXPERT EVALUATION

Table G.1: Final Items for the SSLDI Selection, Revision, and Final Expert Evaluation

Item (myths in bold)	**Final Revision**
Final Item 1: The brains of boys and girls develop at different rates (True)	No revision
Final Item 2: On Average the brains of boys are bigger than the brains of girls (True)	No revision
Final Item 3: Girls' brains finish growing at an earlier average age than boys' (True)	No revision
Final Item 4: Most human brains can be classified as "male-brains" or "female-brains" (False)	**No revision**
Final Item 5: The brains of males and females are more alike than they are different (True)	No revision
Final Item 6: Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) and girls tend to use both hemispheres of the brain at the same time (whole brain thinking) (False)	**Major Revision: The item addresses two constructs. See below for item revision. Scale reliability and PFA suggested the item was problematic.**
Revised Item: Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking) (False)	**Added to address issues identified in Item 6**
Added Item: Girls tend to be better at multi-tasking (False)	**Added to balance true and false items and to help balance items with girls as the specific determiner**

Final Item 7: The right and left hemispheres work together in both boys' and girls' brains (True)	No Revision
Final Item 8: Some boys and girls are "left-brained" and some boys and girls are "right-brained" and this helps explain differences in how individuals learn (False)	**Deleted: As written the item addresses two constructs. Scale reliability and PFA suggested the item was problematic.**
Revised Item: Boys and girls can be classified as "left-brained" or "right-brained" thinkers (False)	**Added: The item was added to replace Item 8. As written the item is more specific and only addresses one construct.**
Final Item 9: Girls tend to hear better than boys (False)	**No revision**
Final Item 10: Boys tend to learn better when a teacher uses a loud voice (False)	**No revision**
Final Item 11: Girls tend to hear low volume voices better than boys (False)	**Deleted due to redundancy with Item 9**
Final Item 12: The eyes of boys are more attuned to motion than the eyes so girls (False)	**No revision**
Final Item 13: The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown) (False)	**No revision**
Final Item 14: The eyes of girls are naturally drawn to warm colors (yellow, red, and orange) (False)	**No revision**
Item 15: Boys are more likely to be color blind (True)	No revision
Final Item 16: Stress tends to enhance learning for boys (False)	**No revision: despite evidence that the effect of stress can be both enhancing and inhibiting, the item was retained because it represents a popular neuromyth about boys.**
Final Item 17: Stress tends to inhibit learning for girls (False)	**Deleted due to respondent feedback,**

	response accuracy, scale reliability analysis, PFA, and additional review of the literature.
Final Item 18: Girls tend to learn better in warmer ambient temperatures (False)	**No revision**
Final Item 19: Boys tend to learn better in cooler ambient temperatures (False)	**No revision**
Final Item 20: Boys are more likely to be diagnosed with dyslexia (True)	No revision
Final Item 21: On average girls acquire language skills before boys (True)	No revision
Final Item 22: On average boys have stronger visual-spatial skills than girls (True)	No revision
Final Item 23: Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic) (True)	No revision
Final Item 24: Girls tend to be verbal learners (False)	**No revision**
Final Item 25 Boys tend to be visual learners (False)	**No revision**
Final Item 26: Boys tend to be kinesthetic learners (False)	**No revision**
Final Item 27: Boys tend to learn abstract concepts better than girls (False)	**No revision**
Final Item 28: Girls tend to learn concrete concepts better than boys (False)	**No revision**
Final Item 29: Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic) (False)	**No revision**
Final Item 30: There are specific periods in childhood when it is easier for boys and girls to learn certain things (True)	Deleted: This item was deleted on recommendation of an expert reviewer. This item was not included in the initial list sent to the expert reviewer.

Final Item 31: Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains (True)	No revision
Final Item 32: Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain (True)	No revision

APPENDIX H

FINAL SEX-SPECIFIC LEARNING DIFFERENCES IVENTORY

Table H.1: Final Sex-Specific Learning Differences Inventory (SSLDI)

Question	Item	Correct Answer
FQ16.1	The brains of boys and girls develop at different rates	True
FQ16.2	On average the brains of boys are bigger than the brains of girls	True
FQ16.3	Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)	True
FQ16.4	Girls' brains finish growing at an earlier average age than boys'	True
FQ16.5	On average girls acquire language skills before boys	True
FQ16.6	Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain	True
FQ16.7	Boys are more likely to be color blind	True
FQ16.8	The brains of males and females are more alike than they are different	True
FQ16.9	The right and left hemispheres work together in boys' and girls' brains	True
FQ16.10	Extended rehearsal of some mental processes can change the structure and function of boys' and girls' brains	True
FQ16.11	Boys are more likely to be diagnosed with dyslexia	True
FQ16.12	On average boys have stronger visual-spatial skills than girls	True
FQ16.13	Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking)	False
FQ16.14	Girls tend to be better at multi-tasking	False
FQ16.15	Boys and girls can be classified as "left-brained" or "right-brained" thinkers	False
FQ16.16	Girls tend to hear better than boys	False
FQ16.17	Boys tend to learn better when a teacher uses a loud voice	False
FQ16.18	Most human brains can be classified as "male-brains" or "female-brains"	False

FQ16.19	The eyes of boys are more attuned to motion than the eyes of girls	False
FQ16.20	The eyes of boys are naturally drawn to cool colors (black, blue, grey, and brown)	False
FQ16.21	The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)	False
FQ16.22	Boys tend to learn better under stress	False
FQ16.23	Girls tend to learn better in warmer ambient temperatures	False
FQ16.24	Boys tend to learn better in cooler ambient temperatures	False
FQ16.25	Girls tend to be verbal learners	False
FQ16.26	Boys tend to be visual learners	False
FQ16.27	Boys tend to be kinesthetic learners	False
FQ16.28	Boys tend to learn abstract concepts better than girls	False
FQ16.29	Girls tend to learn concrete concepts better than boys	False
FQ16.30	Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)	False

APPENDIX I

FINAL STUDY SURVEY INSTRUMENT

Teacher Beliefs District A and E

Thank you for your interest in participating in my study. The results from this study will be used in my doctoral research. Your complete and honest answers are essential for the success of my research.

As a thank you for your time and participation, you will be entered into a drawing for one of five **$50.00 Amazon Gift Cards.**
Please Note: Only **___________** School District teachers are eligible to participate and be entered in the Amazon Gift Card drawing.

You will have to provide your name and district email address to be entered in the gift card drawing. Your contact information will be collected after you have completed the research survey and will not be linked to your responses. **Your responses will remain anonymous.**

Before you proceed to the first question, please complete the reCAPTCHA below.

Section One: Background Information and Teaching Experience

FQ1. Are you a full time or part time classroom teacher?

Start of Block: Not Teacher

You are not eligible to participate. The survey is only open to certified classroom teachers. Thank you for your time and consideration. Please close your browser to exit the survey.

Start of Block: Background Information

FQ2. Which statement best describes your current certification status?

FQ3. What level(s) are you certified to teach? Select all that apply.

FQ4. Which of the following grade levels do you currently teach? Select all that apply.

FQ5. Which subjects or areas are you certified to teach? Select all that apply.

FQ6. What is the highest degree you have earned?

FQ7. Are you or have you ever been a National Board Certified Teacher?

FQ8. How many undergraduate or graduate level neuroscience related courses have you completed?

FQ9. What is your self-identified gender?

FQ10. What is your age?

FQ11. How many years of classroom teaching experience do you have?

FQ12. How many years have you taught in South Carolina?

FQ13a. Have you ever taught single-gender **classes** (classes with only boys or classes with only girls) OR **in a school** that offered single-gender classes?

Start of Block: Single-Gender

FQ13b. How many years of teaching experience do you have **teaching in a school** that offered single-gender classes?

FQ13c. How many years of teaching experience do you have **teaching in single-gender classes?**

FQ13d. How many years of teaching experience do you have **teaching in co-educational** (classes with both boys and girls) classes?

Start of Block: Experience Reflection

Section Two: Professional Experiences and Activities Related to Gender Learning Differences

Please reflect on the experiences and activities you have engaged in as part of your certification program (traditional and alternative) and during your career as an educator. This includes college course work, teacher preparation training, on-line modules, internships, workshops, conferences, faculty meetings, district in-services, school in services, professional learning communities, book studies, etc. It also includes your personal professional learning activities such as reading books, magazines, journal articles, websites, blogs, news articles, etc.

FQ14a. Did any of your past experiences or activities include information about gender/sex learning differences?

Start of Block: Experience and Time

FQ14b. Which of the following experiences or activities included information about gender/sex learning differences? Select all that apply.

FQ14c. How many hours of time would you estimate that you spent learning about gender/sex learning differences?

Start of Block: 60+

FQ14d. You indicated the amount of time you spent learning about **gender/sex learning differences was 60+ hours**. Please provide a more accurate estimate of the time you spent learning about gender/sex learning differences.

End of Block: 60+

Start of Block: Agency Author

FQ15. If known, please list any specific agencies, authors, individuals, organizations, consultants, or companies that provided/sponsored/authored any of your experiences and activities that included information about gender/sex differences in which you participated.

Start of Block: True False Knowledge Intro

Section Three: Gender Learning Differences

In this section of the survey, you will be asked to respond to a series of true and false questions related to gender/sex learning differences. At the end of the true and false items, you will have an opportunity to rate your confidence in your responses.

Start of Block: True or False

FQ16.1 The brains of boys and girls develop at different rates

FQ16.2 On average the brains of boys are bigger than the brains of girls

FQ16.3 Boys and girls show a preference for the mode in which they receive information (auditory, visual, kinesthetic)

FQ16.4 Girls' brains finish growing at an earlier average age than boys'

FQ16.5 On average girls acquire language skills before boys

FQ16.6 Information is stored in the brains of boys and girls in networks of cells distributed throughout the brain

FQ16.7 Boys are more likely to be color blind

FQ16.12 On average boys have stronger visual-spatial skills than girls

FQ16.13 Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking)

FQ16.14 Girls tend to be better at multi-tasking

FQ16.15 Boys and girls can be classified as "left-brained" or "right-brained" thinkers

FQ16.16 Girls tend to hear better than boys

FQ16.17 Boys tend to learn better when a teacher uses a loud voice

FQ16.18 Most human brains can be classified as "male-brains" or "female-brains"

FQ16.19 The eyes of boys are more attuned to motion than the eyes of girls

FQ16.20 The eyes of boys are naturally drawn to cool colors (black, blue, grey and brown)

FQ16.21 The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)\

FQ16.22 Boys tend to learn better under stress

FQ16.23 Girls tend to learn better in warmer ambient temperatures

FQ16.24 Boys tend to learn better in cooler ambient temperatures

FQ16.25 Girls tend to be verbal learners

FQ16.26 Boys tend to be visual learners

FQ16.27 Boys tend to be kinesthetic learners

FQ16.28 Boys tend to learn abstract concepts better than girls

FQ16.29 Girls tend to learn concrete concepts better than boys

FQ16.30 Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)

Start of Block: Confident

FQ17. How confident are you in your responses to the previous true and false items?

Start of Block: Knowledge of Gender/Sex Learning Differences

FQ18. Which statement best describes your knowledge of gender/sex learning differences?

FQ19. How would you characterize gender/sex learning differences?

FQ20. What is your general understanding of gender/sex learning differences?

Start of Block: Instructional Strategies

Section Four: Instructional Strategies

FQ21. Indicate whether you believe each instructional strategy would meet the needs of primarily girls, primarily boys, or both boys and girls.

FQ21.1 Participating in collaborative activities

FQ21.2 Participating in competitive activities

FQ21.3 Working independently

FQ21.4 Working with a partner

FQ21.5 Observing a teacher led demonstration

FQ21.6 Participating in teacher led direct instruction

FQ21.7 Participating in student led instructional activities

FQ21.8 Participating in an activity that requires movement

FQ21.9 Participating in student led inquiry

FQ21.10 Solving problems using manipulatives

FQ21.11 Participating in hands-on activities

FQ21.12 Working in a small group

FQ21.13 Participating in problem/project-based learning

FQ21.14 Participating in sustained silent reading

FQ22. How would you characterize the **instructional needs of boys and girls**?

FQ23. What is your general understanding and/or belief about the differing instructional needs of boys and girls?

Start of Block: Survey Feedback

Comments and Gift Card Drawing

FQ24. Do you have any comments about this survey, or the topics covered in this survey that you would like to share?

FQ25. Would you like to be entered into a drawing for one of five $50.00 Amazon Cards?

APPENDIX J

FINAL STUDY EMAIL INFORMED CONSENT AND COMMUNICATION

DISTRICT A

From: **District A Research Director** < >
Date: Fri, Feb 21, 2020 at 3:28 PM
Subject: Teacher Knowledge and Beliefs Survey
To: District Principals < >

Principals,

The District A Research Committee has approved a request to invite teachers and administrators to participate in a brief survey about teacher knowledge of gender/sex learning differences and teacher beliefs about instructional strategies. We are attempting to limit the number of surveys teachers are asked to complete, particularly from outside researchers, but the results of this survey will provide meaningful insights and help with our professional development efforts. Please forward the message below to your teachers.

As with all surveys conducted for research, **teacher participation is strictly voluntary**.

Thanks,

District Research Director

Dear District A Classroom Teacher,

My name is Marriah Schwallier. I am a doctoral candidate in the Instruction and Teacher Education Department, College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Teaching and

Learning, and I would like to invite you to participate in my survey study (link and password below).
If you choose to participate in the study, you will be entered into a drawing for one of five $50.00 Amazon Gift Cards.

The survey is divided into four sections and should take **only 10 - 15 minutes to complete.** The survey will open on **Monday February 24, 2020** and close on **Monday March 9, 2020.**

Only one survey attempt will be allowed, so please ensure you have ample time to complete the survey at one time. You must complete and submit the survey to be entered in the gift card drawing.

I am studying teacher knowledge of gender/sex learning differences and teacher beliefs about instructional strategies. If you decide to participate, you will be asked to complete an electronic survey about your teaching experience, professional learning related to gender/sex differences, knowledge of gender/sex learning differences, and your beliefs about instructional strategies.

Participation is anonymous, which means that no one (not even the research team) will be able to identify your responses. So, please do not include your name or other identifying information on any of the study items. Participation is voluntary and there will be no negative consequences if you choose not to participate.

We will be happy to answer any questions you have about the study. You may contact me at schwallm@email.sc.edu or my faculty advisor, Dr. Christine Lotter, 803-777-6593, and lotter@mailbox.sc.edu.

Thank you for your consideration. If you would like to participate, please open the link to complete the survey. When you are done, submit the survey and follow the instructions for entering the drawing for a $50.00 Amazon Gift Card.

With kind regards,

Marriah Schwallier

University of South Carolina
Instruction and Teacher Education
College of Education
schwallm@email.sc.edu

If you are ready to complete the survey, please click the link below.

Password: XXXXX
Survey Link: https://uofsc.co1.qualtrics.com

Survey Window: Monday February 24, 2020 (12:01 a.m.) - Monday March 9, 2020 (11:50 p.m.)
On Fri, Feb 28, 2020 at 8:25 AM Marriah Schwallier <mschwallier@gmail.com> wrote:

Good Morning,

I am wondering if you will send any survey reminders. So far, I have participation by 15 schools with 66 completed teacher responses.

I find it interesting that teachers who are participating are taking the time to write *detailed open responses.* The teachers appear to have strong beliefs and ideas about the survey topics. While the qualitative data is rich and interesting, I really need numbers for my factorial analysis (ideally 300 respondents). The data is revealing that some teachers have misconceptions and, in some cases, stereotypical beliefs about the influence of gender in the classroom.

I assume I am not allowed to follow up with schools. Will you send reminders? The survey closes March 9th.

As always, I appreciate your support of my research.

Have a great weekend! Marriah

On Wed, Mar 4, 2020 at 12:19 PM Marriah Schwallier <mschwallier@gmail.com> wrote:

Hello,

I am sorry to bother you again. I need to know if you will send out a reminder email before the survey closes on Monday. There are still about 20 schools who appear to have not sent it to their faculty.

Thank you, Marriah

District Research Director < >
Wed, Mar 4, 1:12 PM
to me:

Marriah,

I just sent another email to the principals asking them to forward your email if they had not already done so.

District Research Director

DISTRICT E

From: SCHWALLIER, MARRIAH <schwallm@email.sc.edu>
Sent: Tuesday, February 18, 2020 6:51 PM
To: Principal District E < >
Subject: Dissertation Research Request – Your School
Dear School Principal District E,

My name is Marriah Schwallier. I am a doctoral candidate in the Instruction and Teacher Education Department, College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Teaching and Learning, and I would like to invite your teachers to participate in my survey study. Attached is my approved District E Application Request for Research Project.

The survey will only take **10 - 15 minutes to complete.** If your teachers choose to participate in the study, they will be entered into a drawing for one of five $50.00 Amazon Gift Cards. The survey window is scheduled for February 26 – March 11.

I am studying teacher knowledge of gender/sex learning differences and teacher beliefs about instructional strategies. If your teachers decide to participate, they will be asked to complete an electronic survey about their teaching experience, professional learning related to gender/sex differences, knowledge of gender/sex learning differences, and beliefs about instructional strategies.

Participation is anonymous and voluntary and there will be no negative consequences if you or your teachers choose not to participate. District and school names will be reported with pseudonyms to maintain anonymity.

We will be happy to answer any questions you have about the study. You may contact me at schwallm@email.sc.edu or my faculty advisor, Dr. Christine Lotter, 803-777-6593, and lotter@mailbox.sc.edu.

Thank you for your consideration. If you are willing to allow your teachers to participate, I will send an email that can be forwarded to your teachers. **The email to teachers will contain an introduction to my study, the survey link, and survey password.**

With kind regards,

Marriah Schwallier

University of South Carolina
Instruction and Teacher Education
College of Education
schwallm@email.sc.edu

On Feb 24, 2020, at 7:04 PM, SCHWALLIER, MARRIAH <schwallm@email.sc.edu> wrote:

Dear School Principal,

I recently shared my approved District E Research Application with you in the hope that you would be willing to allow your teachers to participate in my doctoral research survey. If you are willing to allow your teachers to participate, please forward the following invitation and informational email. There is a link to the survey at the end of the email message below. There is a $50.00 gift card drawing incentive for participating teachers. The survey will close on Wednesday March 11, 2020.

I would greatly appreciate your school's participation in my research study. Thank you for your time and consideration.

With gratitude, Marriah Schwallier

Dear District E Teacher,

My name is Marriah Schwallier. I am a doctoral candidate in the Instruction and Teacher Education Department, College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Teaching and Learning, and I would like to invite you to participate in my survey study (link and password below).

If you choose to participate in the study, you will be entered into a drawing for one of five $50.00 Amazon Gift Cards.

The survey is divided into four sections and should take **only 10 - 15 minutes to complete.** The survey is open now and will **close on Wednesday March 11, 2020.**

Only one survey attempt will be allowed, so please ensure you have ample time to complete the survey at one time. You must complete and submit the survey to be entered in the gift card drawing.

I am studying teacher knowledge of gender/sex learning differences and teacher beliefs about instructional strategies. If you decide to participate, you will be asked to complete an electronic survey about your teaching experience, professional learning related to gender/sex differences, knowledge of gender/sex learning differences, and your beliefs about instructional strategies.

Participation is anonymous, which means that no one (not even the research team) will be able to identify your responses. So, please do not include your name or other identifying information on any of the study items. Participation is voluntary and there will be no negative consequences if you choose not to participate.

We will be happy to answer any questions you have about the study. You may contact me at schwallm@email.sc.edu or my faculty advisor, Dr. Christine Lotter, 803-777-6593, and lotter@mailbox.sc.edu.

Thank you for your consideration. If you would like to participate, please open the link to complete the survey. When you are done, submit the survey and follow the instructions for entering the drawing for a $50.00 Amazon Gift Card.

With kind regards,

Marriah Schwallier

University of South Carolina
Instruction and Teacher Education
College of Education
schwallm@email.sc.edu

If you are ready to complete the survey, please click the link below.

Password: XXXXXX
Survey Link: https://uofsc.co1.qualtrics.com

Survey Window: The survey will close on Wednesday March 11, 2020 (11:59 p.m.)

School Principal < >

Feb 24, 2020, 8:11 PM

to MARRIAH

Hello Marriah. Any research study needs to be approved at the district level first. Contact for that is District E Research Director.

Good luck with your research

From: SCHWALLIER, MARRIAH <schwallm@email.sc.edu>
Sent: Thursday, February 27, 2020 7:19:42 PM
To: District E Research Director < >
Subject: Question about my research survey
District E Research Director,

I understand that participation by principals and teachers is totally optional. However, I am wondering if the lack of clarity on my research approval is affecting survey distribution by schools. So far, I have had only 5 schools participate.

What is interesting is that teachers who are participating are taking the time to write detailed open responses. They seem to have strong beliefs and ideas about the survey topics. While the qualitative data is rich and interesting, I really need numbers for my factorial analysis. It is also interesting that all the teachers who have attempted the survey, have taken the time to complete it!!

I am wondering if it is possible for you to send out the survey link with a statement that the project is approved and that principals can *choose* to share the survey if they are willing. Or if there is some other way to let them know that I was in fact approved. The survey closes on March 11th. I desperately need this data; I only have until this summer before my time limit to graduate expires.

I understand if this is not possible but needed to ask.

Thank you, Marriah

From: SCHWALLIER, MARRIAH <schwallm@email.sc.edu>
Sent: Friday, March 6, 2020 7:21 AM
To: District Research Director and Principals

Dear District Research Director and School Principals,

This email serves as my final request and reminder for your teachers' participation in my doctoral research survey.

I believe there was some confusion about whether or not my study was approved by School District E. I have included District Research Director on this email as confirmation in the event you need further verification of approval (see previous email for approved research request pdf attachment).

School District E teachers from schools who have chosen to participate, are providing insightful data and have varied knowledge and beliefs about the survey topics. I believe this information is of interest and benefit to School District E. I hope to collect adequate responses from School District E to draw meaningful inferences about the survey topics. The aggregate results of my study will be shared with the district.
If you are willing to give your teachers an opportunity to participate, please forward the email message below containing survey information, link, and password. The survey will only take 10 - 15 minutes to complete.
If you have already forwarded my request, thank you!!! I have collected responses from 25 teachers representing 5 schools. Please remind teachers that the survey will close on **Wednesday March 11, 2020 at 11:59 p.m.**

APPENDIX K

PARTICIPATION BY DISTRICT AND SCHOOL AND ESTIMATED RESPONSE RATES

Table K.1 Participation by District and School and Estimated Response Rates

	Total Attempts	Teacher Respondent Attempts	Teacher Completed Surveys	Estimated 2019 - 2020 Teacher Population for Participating Schools
School District E Total	**41**	**39**	**36**	**293**
Early Childhood Center		1	0	**
Elementary School 1		12	11	33
Elementary School 2		6	6	77
Elementary School 3		2	2	33
Elementary School 4		6	6	32
Middle School 1		6	6	50
Middle School 2		4	3	36
Middle School 3		2	2	32

School District E as 22 early childhood centers/elementary schools, six middle schools, six high schools, three K-8 programs/schools, and three specialty schools (adult education, alternative program, virtual program, charter, CTE, etc.). The number of certified teachers is between 1600 – 1700.

	Total Attempts	Teacher Respondent Attempts	Teacher Completed Surveys	Estimated 2019 - 2020 Teacher Population for Participating Schools
School District A Total	**208**	**181**	**155**	**1498**
Early Childhood Center		2	2	*

Elementary School 2		10	8	45
Elementary School 3		1	1	35
Elementary School 4		6	3	42
Elementary School 5		3	3	45
Elementary School 6		4	3	*
Elementary School 7		2	2	*
Elementary school 8		4	3	*
Elementary School 9		5	4	72
Elementary School 10		1	1	63
Elementary School 11		2	2	31
Elementary School 12		6	4	32
Elementary School 13		2	2	37
Elementary School 14		1	1	41
Elementary School 15		7	7	50
Elementary School 16		1	1	52
Elementary School 17		5	4	44
Elementary School 18		7	5	48
Elementary School 19		5	5	38
Middle School 1		3	3	44
Middle School 2		12	11	86
Middle School 3		11	10	85
Middle School 4		10	7	54
Middle School 5		2	2	62
High School 1		4	4	75
High School 2		12	12	113
High School 3		20	17	101
High School 4		16	13	95
Specialty School 1		13	12	93
Specialty School 2		3	3	15
School District A has 21 early childhood centers/elementary schools, seven middle schools, five high schools, and four specialty schools (adult education, alternative program, virtual program, charter, CTE, etc.). The number of certified teachers is between 1900 – 2000.		1	0	**
Combined Total	250	220 12.3%	191 10.7%	1791

*These schools are programs located on elementary or middle school campuses. SCDE includes these teachers in the teacher count for the school campus where the program is located.
**Only one teacher attempt with zero surveys completed, therefore these teacher populations were excluded from response rate estimates.

APPENDIX L

DATA ORGANIZATION AND CODING FOR POTENTIAL

QUANTITATIVE VARIABLE ANALYSIS

Table L.1: Data Organization and Coding for Potential Quantitative Variable Analysis

Final Survey Question	**Demographic and Experience Predictor Variable**	**Values and Codes**
Q2	Certification Status	South Carolina (1) Another State (2) Alternative (3) International (4)
Q3	Certification Level (grouped for analysis)	Early Childhood/Elementary (1) Middle (2) High (3) Multi (4)
Q4	Current Teaching Level 1 (grouped for analysis)	Early Childhood/Elementary Middle High
Q5	Certification Category (grouped for analysis)	STEM (1) NON-STEM (2)
Q6	Education Level (grouped for analysis)	Bachelor’s Degree (1) Master’s Degree (2) Doctorate Degree (3)
Q7	National Board Certification	Yes (1) No (2)
Q8	Neuroscience Courses (grouped for analysis)	No (0) Yes (1)

Q9	Gender	Male (1) Female (2)
Q10	Age (grouped for analysis)	20 – 29 (1) 30 – 39 (2) 40 – 49 (3) 50 – 59 (4) 60 – 69 (5)
Q11	Total Years Teaching Experience	Scale not recoded
Q12	Years Teaching in SC	Scale not recoded
Q11 divided by 12	Percent Time Teaching in SC (grouped for analysis)	Less than 100% (1) 100% (2)
Q13a	Teaching in Single-Gender School/Classroom	No (0) Yes (1)
Q13b	Years in Single-Gender/Sex School	Scale not recoded
Q13c	Years in Single-Gender Classroom	Scale not recoded
Q14a	Professional Experiences/Activities	No (1) Yes (2)
Q14b	Number of Different Types Professional Learning Experiences	Count not recoded
Q14c	Amount of Time Learning Experiences	Scale not recoded

Question	**Likert Scale Variables**	**Coded Values**
Q17	Confidence in True False Responses	Not Confident (0) Slightly Confident (1) Somewhat Confident (2)

		Moderately Confident (3) Very Confident (4) Extremely Confident (5)
Q18	Knowledge of Gender/Sex Learning Differences	Not Knowledgeable (0) Slightly Knowledgeable (1) Somewhat Knowledgeable (2) Moderately Knowledgeable (3) Very Knowledgeable (4) Extremely Knowledgeable (5)
Q9	Beliefs about Sex Learning Differences	Not Different (0) Slightly Different (1) Somewhat Different (2) Moderately Different (3) Very Different (4) Extremely Different (5)
Q22	Beliefs about Gender-Specific Instructional Strategies	Not Different (0) Slightly Different (1) Somewhat Different (2) Moderately Different (3) Very Different (4) Extremely Different (5)

Item **Q16**	**Neuromyth Scale Variables**	**Neuromyth Factor Score**
16.1 – 16.12	True Score	0-12 (reported as percent correct)
16.16 16.17 16.19	Senses	0 – 3 (reported as percent incorrect)
16.14 16.25 16.27	Learning Styles	0 – 3 (reported as percent incorrect)
16.28 16.29	Concepts	0 – 2 (reported as percent incorrect)

16.13 – 16.30	False Score	0-18 (reported as percent incorrect)
16.1 – 16.30	Overall Accuracy/Percent Accuracy	0-30 (reported as percent incorrect)
Strategy Item Q21	**Instructional Strategy Scale Variables**	**Instructional Strategy Factor Score**
21.2 21.3 21.5 21.14	Passive Learning	0 – 4 (reported as percent different)
21.4 21.12	Collaboration	0 – 2 (reported as percent different)
21.7 21.9	Inquiry	0 – 2 (reported as percent different)
21.1 21.8 21.1 21.11	Active Learning	0 – 4 (reported as percent different)
21.1 – 21.12	Instructional Score	0-14 (reported as percent different)

APPENDIX M

EXPLORATORY AND CONFIRMATORY FACTOR ANALYSIS

NEUROMYTHS

Table M.1: Eigenvalue for Exploratory Factor Analysis Neuromyths

Factor	Eigenvalue
1	3.840
2	1.335
3	1.269
4	1.216
5	1.163
6	1.018
7	0.997
8	0.914
9	0.889
10	0.818
11	0.787
12	0.739
13	0.645
14	0.579
15	0.509
16	0.459
17	0.428
18	0.396

Table M.2: Rotated Factor Loadings Neuromyths

		Factor				
Neuromyth Item		**1**	**2**	**3**	**4**	**5**
Q16.13 Boys tend to use one hemisphere of the brain at a time (compartmentalized thinking)	F1	0.084	0.028	0.147	0.170	0.283
Q16.14. Girls tend to be better at multi-tasking	F2	0.032	-0.112	-0.025	0.377*	0.220
Q16.15 Boys and girls can be classified as "left-brained" or "right-brained" thinkers	F3	-0.074	0.054	0.071	0.132	0.215
Q16.16 Girls tend to hear better than boys[c]	F4	-0.051	0.332*	0.01	0.113	0.099
Q16.17 Boys tend to learn better when a teacher uses a loud voice[c]	F5	0.010	0.507*	-0.009	-0.018	0.014
Q16.18 Most human brains can be classified as "male-brains" or "female-brains"	F6	-0.003	0.260	-0.030	-0.030	0.278
Q16.19 The eyes of boys are more attuned to motion than the eyes of girls[c]	F7	0.049	0.332*	0.085	0.100	0.110
Q16.20. The eyes of boys are naturally drawn to cool colors (black, blue, grey, and brown)	F8	-0.004	-0.015	1.051	-0.003	-0.010
Q16.21. The eyes of girls are naturally drawn to warm colors (yellow, red, and orange)	F9	0.028	0.186	0.394	0.009	0.024
Q16.22 Boys tend to learn better under stress	F10	-0.018	0.332*	0.165	-0.047	0.109
Q16.23 Girls tend to learn better in warmer ambient temperatures	F11	1.642	0.002	-0.001	-0.003	0.005

Q16.24 Boys tend to learn better in cooler ambient temperatures	F12	0.198	0.247	0.052	0.156	-0.025
Q16.25 Girls tend to be verbal learners	F13	0.036	0.387*	-0.05	0.339*	-0.061
Q16.26 Boys tend to be visual learners	F14	-0.071	0.113	0.107	0.299*	-0.009
Q16.27 Boys tend to be kinesthetic learners	F15	-0.016	0.018	0.006	0.838*	0.014
Q16.28 Boys tend to learn abstract concepts better than girls	F16	-0.008	0.012	-0.044	-0.067	0.624*
Q16.29 Girls tend to learn concrete concepts better than boys	F17	0.013	0.008	0.059	0.064	0.521*
Q16.30 Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)	F18	0.024	-0.126	0.058	0.155	0.111

Table M.3: Model Summary Exploratory Factor Analysis Neuromyths

Chi-Square Test of Model Fit	
Value	74.833
Degrees of Freedom	73
P-Value	0.4186
RMSEA (Root Mean Square Error of Approximation)	
Estimate	0.011
90 Percent C.I.	0.000 (0.044)
Probability RMSEA <= .05	0.984
Comparative Fit Index	0.995
Tucker-Lewis Index	0.991
Chi-Square Test of Model Fit for the Baseline Model	
Value	559.876

Degrees of Freedom	153
P-Value	0
SRMR (Standardized Root Mean Square Residual)	
Value	0.034

Table M.4: Exploratory Factor Analysis Neuromyths Goemin Factor Correlations Matrix

Factors	**1**	**2**	**3**	**4**	**5**
1	1				
2	0.197	1			
3	0.129	0.299*	1		
4	0.194	0.345*	0.314	1	
5	0.172	0.331	0.338*	0.288*	1

* significant at 5% level

Table M.5: Model Summary for Confirmatory Factor Analysis for Neuromyths (Senses, Learning Styles, and Concepts)

Chi-Square Test of Model Fit	
Value	21.022
Degrees of Freedom	17
P-Value	0.225
RMSEA (Root Mean Square Error of Approximation)	
Estimate	0.035
90 Percent C.I.	0.000 (0.078)
Probability RMSEA <= .05	0.665
Comparative Fit Index	0.950
Tucker Lewis Fit Index	0.910
Chi-Square Test of Model Fit for the Baseline Model	
Value	102.423
Degrees of Freedom	28

P-Value	<0.001
SRMR (Standardized Root Mean Square Residual)	0.086

Table M.6: Confirmatory Factor Analysis Neuromyths (Senses, Learning Styles, and Concepts) Factor Loadings

	Estimate	**S.E.**	**Est./S.E.**	**P-Value**
Senses				
F4 Girls tend to be better at multi-tasking	0.361	0.128	2.824	0.005
F5 Boys tend to learn better when a teacher uses a loud voice	0.989	0.213	4.631	<0.001
F7 The eyes of boys are more attuned to motion than the eyes of girls	0.480	0.153	3.144	0.002
Learning Styles				
F2 Girls tend to be better at multi-tasking	0.451	0.146	3.096	0.002
F13 Girls tend to be verbal learners	0.663	0.158	4.109	<0.001
F15 Boys tend to be kinesthetic learners	0.355	0.138	2.580	0.010
Concepts				
F16 Girls tend to hear better than boys	0.611	0.164	3.732	<0.001
F17 Boys and girls learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic)	0.468	0.138	3.395	0.001
Learning with Senses	0.631	0.205	3.081	0.002
Concepts with Senses	0.605	0.193	3.134	0.002
Concepts with Learning Styles	0.774	0.242	3.199	0.001

APPENDIX N

EXPLORATORY AND CONFIRMATORY FACTOR ANALYSIS

INSTRUCTIONAL STRATEGIES

Table N.1: Eigenvalue for Exploratory Factor Analysis Instructional Strategies

Factor	Eigenvalue
1	4.686
2	1.567
3	1.135
4	1.108
5	0.892
6	0.761
7	0.687
8	0.583
9	0.523
10	0.494
11	0.472
12	0.394
13	0.376
14	0.323

Table N.2: Rotated Factor Loadings Instructional Strategies

		Factor			
Instructional Strategy		**1**	**2**	**3**	**4**
Q21.1 Participating in collaborative activities	T1	0.036	0.364	-0.217	0.491*
Q21.2 Participating in competitive activities	T2	0.401*	0.134	-0.024	0.254
Q21.3 Working Independently	T3	0.499*	-0.137	0.486*	0.045
Q21.4 Working with a partner	T4	0.162	0.692*	0.003	-0.043

Q21.5 Observing a teacher led demonstration	T5	0.705*	0.062	0.014	-0.144
Q21.6 Participating in teacher led direct instruction	T6	0.743*	-0.196	-0.025	-0.018
Q21.7 Participating in student led instructional activities	T7	-0.013	0.335*	0.432*	0.075
Q21.8 Participating in an activity that requires movement	T8	0.246*	0.091	0.042	0.493*
Pa Q21.9 Participating in student led inquiry	T9	0.009	0.072	0.809*	-0.113
Q21.10 Solving problems using manipulatives	T10	0.121	0.282	0.109	0.318*
Q21.11 Participating in hands-on activities	T11	-0.088	-0.085	0.075	0.771*
Q21.12 Working in a small group	T12	-0.115	0.688*	0.106	0.031
Q21.13 Participating in problem/project-based learning	T13	0.181	0.079	0.213	0.084
Q21.14 Participating in sustained silent reading	T14	0.433*	0.064	0.348*	0.088

* significant at 5% level

Table N.3: Exploratory Factor Analysis Factor Correlations Instructional Strategies

Factors	**1**	**2**	**3**	**4**
1	1.000			
2	0.352*	1.000		
3	0.222	0.379*	1.000	
4	0.350*	0.352*	0.514*	1.000

*significant at 5% level

Table N.4: Model Summary Explanatory Factor Analysis for Instructional Strategies

Chi-Square Test of Model Fit	
Value	62.5
Degrees of Freedom	41
P-Value	0.0169
RMSEA (Root Mean Square Error ff Approximation)	
Estimate	0.052

90 Percent C.I.	0.023 (0.077)
Probability RMSEA <= .05	0.415
CFI (Comparative Fit Index)	0.97
TLA (Tucker-Lewis Fit Index)	0.933
Chi-Square Test of Model Fit for the Baseline Model	
Value	806.9
Degrees of Freedom	91
P-Value	<0.001
SRMR (Standardized Root Mean Square Residual)	0.029

Table N.5: Confirmatory Factor Analysis Neuromyths (Active Learning, Passive Learning, Inquiry, and Concepts)

Chi-Square Test of Model Fit	
Value	81.955
Degrees of Freedom	48
P-Value	0.0016
RMSEA (Root Mean Square Error ff Approximation)	
Estimate	0.061
90 Percent C.I.	0.037 (0.083)
Probability RMSEA <= .05	0.204
CFI (Comparative Fit Index)	0.98
TLA (Tucker-Lewis Fit Index)	0.97
Chi-Square Test of Model Fit for the Baseline Model	
Value	1526.93
Degrees of Freedom	66
P-Value	<0.001
SRMR (Standardized Root Mean Square Residual)	0.073

Table N.6: Confirmatory Factor Analysis Instructional Strategies (Active Learning, Passive Learning, Inquiry, and Collaboration) Factor Loadings

	Estimate	**S.E.**	**Est./S.E.**	**P-Value**
Passive Learning				
T2 Participating in competitive activities	0.686	0.058	11.88	<0.001
T3 Working Independently	0.808	0.055	14.825	<0.001
T5 Observing a teacher led demonstration	0.568	0.07	8.063	<0.001
T14 Participating in sustained silent reading	0.896	0.047	18.912	<0.001
Collaboration				
T4 Working with a partner	0.869	0.06	14.451	<0.001
T12 Working in a small group	0.812	0.059	13.775	<0.001
Inquiry				
T7 Participating in student led instructional activities	0.885	0.056	15.825	<0.001
T9 Participating in student led inquiry	0.816	0.058	14.089	<0.001
Active Learning				
T1 Participating in collaborative activities	0.726	0.064	11.35	<0.001
T8 Participating in an activity that requires movement	0.879	0.054	16.299	<0.001
T10 Solving problems using manipulatives	0.79	0.052	15.134	<0.001
T11 Participating in hands-on activities	0.696	0.057	12.237	<0.001
Collaboration with Attention	0.669	0.076	8.81	<0.001
Inquiry with Passive Learning	0.736	0.074	9.928	<0.001
Inquiry with Collaboration	0.746	0.083	8.961	<0.001

APPENDIX O

MULTIPLE REGRESSION ANALYSIS PREDICTORS OF BELIEFS TABLES

Table O.1: Multiple Regression Results Predicting Respondent Self-Rated Confidence on the True and False Items

	B (SE)	**Beta***	**p-value**
Age[a]			
20 – 29	-0.240 (0.398)	-0.085	0.548
30 – 39	-0.164 (0.368)	-0.067	0.657
40 – 49	-0.333 (0.365)	-0.140	0.363
50 – 59	-0.449 (0.374)	-0.166	0.232
Gender[b]	0.063 (0.213)	0.022	0.768
Education[c]			
Bachelor	0.544 (0.401)	0.205	0.177
Masters	0.883 (0.366)	0.356	0.017
Current Teaching Level[d]			
Elementary	-0.290 (0.191)	-0.134	0.130
Middle	0.102 (0.221)	0.040	0.645
Certification Area[e]	0.046 (0.198)	0.018	0.816
Single-Gender[f]	0.161 (0.195)	0.064	0.41
Neuroscience Courses[g]	-0.108 (.155)	-0.049	0.485
Total Hours[h]	0.016 (0.004)	0.304	<0.001
Adjusted R2		0.104	
p-value		0.002	

Dependent variable: self-rated confidence in performance on the true and false items
*Beta refers to the standardized beta estimate

[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[c]continuous Scale = estimated hours in professional learning related the sex difference

Table O.2: Multiple Regression Results Predicting Respondents self-rated Knowledge of Learning Differences

	B (SE)	Beta*	p-value
Age[a]			
20 – 29	-0.606 (0.343)	-0.229	0.079
30 – 39	-0.477 (0.317)	-0.209	0.135
40 – 49	-0.587 (0.314)	-0.263	0.063
50 – 59	-0.234 (0.322)	-0.092	0.469
Gender[b]	-0.055 (0.184)	-0.021	0.767
Education[c]			
Bachelor	0.280 (0.345)	0.112	0.418
Masters	0.556 (0.315)	0.239	0.079
Current Teaching Level[d]			
Elementary	0.032 (0.164)	0.015	0.848
Middle	0.297 (0.191)	0.124	0.121
Certification Area[e]	0.303 (0.171)	0.126	0.078
Single-Gender[f]	-0.094 (0.168)	-0.040	0.575
Neuroscience Courses[g]	-0.102 (0.133)	-0.049	0.444
Total Hours[h]	0.022 (0.004)	0.427	<0.001
Adjusted R2		0.245	
p-value		<0.001	

Dependent variable: self-rated knowledge of gender learning differences
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school

[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex difference

Table O.3: Multiple Regression Results Predicting Respondent Belief in Sex-Specific Learning Differences

	B (SE)	**Beta***	**p-value**
Age[a]			
20 – 29	-0.355 (0.382)	-0.134	0.354
30 – 39	-0.286 (0.353)	-0.125	0.419
40 – 49	-0.037 (0.350)	-0.016	0.916
50 – 59	-0.077 (0.359)	-0.030	0.830
Gender[b]	0.227 (0.205)	0.086	0.268
Education[c]			
Bachelor	0.081 (0.385)	0.032	0.834
Masters	0.292 (0.351)	0.125	0.406
Current Teaching Level[d]			
Elementary	0.295 (0.183)	0.144	0.109
Middle	0.257 (0.212)	0.107	0.227
Certification Area[e]	-0.029 (0.190)	-0.012	0.881
Single-Gender[f]	-0.173 (0.187)	-0.073	0.356
Neuroscience Courses[g]	-0.122 (0.149)	-0.059	0.412
Total Hours[h]	0.011 (0.004)	0.216	0.007
Adjusted R2		0.067	
p-value		0.020	

Dependent variable: belief in gender learning difference
*Beta refers to the standardized beta estimate
[a]Reference = male [b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex difference

Table O.4: Multiple Regression Results Predicting Respondent Belief in Gender-Specific Instructional Strategies

	B (SE)	Beta*	p-value
Age[a]			
20 – 29	-0.317 (0.400)	-0.118	0.428
30 – 39	-0.142 (0.370)	0.061	0.702
40 – 49	-0.106 (0.367)	-0.047	0.773
50 – 59	0.286 (0.376)	0.111	0.447
Gender[b]	0.295 (0.214)	0.109	0.170
Education[c]			
Bachelor	-0.006 (0.403)	-0.003	0.987
Masters	0.012 (0.367)	0.005	0.973
Current Teaching Level[d]			
Elementary	0.257 (0.192)	0.124	0.181
Middle	0.360 (0.222)	0.148	0.107
Certification Area[e]	-0.034 (0.199)	-0.014	0.865
Single-Gender[f]	-0.113 (0.196)	-0.047	0.564
Neuroscience Courses[g]	-0.148 (0.156)	-0.070	0.344
Total Hours[h]	$-2.812E^{-5}$ (0.004)	-0.001	0.995
Adjusted R2		0.009	
p-value		0.340	

Dependent variable: belief in gender-specific instructional strategies
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex difference

APPENDIX P

MULTIPLE REGRESSION ANALYSIS PREDICTORS OF SEX-SPECIFIC NEUROMYTHS

Table P.1: Multiple Regression Results Predicting Total Neuromyth Score

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	0.244 (7.926)	0.005	0.975
30 – 39	1.678 (7.330)	0.037	0.819
40 – 49	-1.514 (7.268)	-0.034	0.835
50 – 59	0.781 (7.446)	0.015	0.917
Gender[b]	0.364 (4.245)	0.007	0.932
Education[c]			
Bachelor	9.998 (7.983)	0.200	0.212
Masters	6.518 (7.277)	0.14	0.372
Current Teaching Level[d]			
Elementary	3.558 (3.798)	0.087	0.350
Middle	7.695 (4.404)	0.160	0.082
Certification Area[e]	-4.72 (3.949)	-0.098	0.234
Single-Gender[f]	0.855 (3.891)	0.018	0.826
Neuroscience Courses[g]	2.095 (3.085)	0.050	0.498
Total Hours[h]	0.146 (0.083)	0.144	0.081
Adjusted R2		-0.001	
p-value		0.472	

Dependent Variable: all neuromyth items average percent incorrect
*Beta refers to the standardized beta estimate
[a]Reference = male

[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex difference

Table P.2: Multiple Regression Results Predicting Senses Neuromyth Factor Score

	B (SE)	**Beta***	**p-value**
Age[a]			
20 – 29	-4.597 (12.667)	-0.054	0.717
30 – 39	-2.775 (11.715)	-0.038	0.813
40 – 49	-10.113 (11.616)	-0.141	0.385
50 – 59	-5.058 (11.900)	-0.062	0.671
Gender[b]	-3.193 (6.784)	-0.038	0.638
Education[c]			
Bachelor	9.580 (12.758)	0.120	0.454
Masters	5.237 (11.630)	0.070	0.653
Current Teaching Level[d]			
Elementary	-1.597 (6.070)	-0.024	0.793
Middle	13.293 (7.039)	0.173	0.061
Certification Area[e]	-2.177 (6.311)	-0.028	0.731
Single-Gender[f]	1.546 (6.218)	0.020	0.804
Neuroscience Courses[g]	-1.772 (4.931)	-0.027	0.731
Total Hours[h]	0.161 (0.133)	0.099	0.227
Adjusted R2		-0.003	
p-value		0.498	

a. Dependent Variable: senses neuromyth CFA factor items average percent incorrect
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM

[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex difference

Table P.3: Multiple Regression Results Predicting Concepts Neuromyth Factor Score

	B (SE)	**Beta***	**p-value**
Age[a]			
20 – 29	10.620 (14.711)	0.107	0.471
30 – 39	13.056 (13.605)	0.152	0.339
40 – 49	9.130 (13.490)	0.109	0.499
50 – 59	5.512 (13.820)	0.058	0.690
Gender[b]	4.957 (7.878)	0.050	0.530
Education[c]			
Bachelor	19.861 (14.816)	0.212	0.182
Masters	7.598 (13.506)	0.087	0.574
Current Teaching Level[d]			
Elementary	10.228 (7.049)	0.134	0.149
Middle	5.730 (8.174)	0.064	0.484
Certification Area[e]	-12.176 (7.330)	-0.135	0.098
Single-Gender[f]	-5.593 (7.222)	-0.063	0.440
Neuroscience Courses[g]	-5.378 (5.727)	-0.069	0.349
Total Hours[h]	-0.133 (0.154)	-0.070	0.388
Adjusted R2		0.015	
p-value		0.262	

Dependent variable: concepts neuromyth CFA factor items average percent incorrect
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex differences

Table P.4: Multiple Regression Results Predicting Learning Styles Neuromyth Factor Score

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	-4.793 (11.206)	-0.063	0.669
30 – 39	1.873 (10.364)	0.029	0.857
40 – 49	4.466 (10.276)	0.070	0.664
50 – 59	-1.770 (10.527)	-0.024	0.867
Gender[b]	8.857 (6.001)	0.117	0.142
Education[c]			
Bachelor	8.530 (11.286)	0.120	0.451
Masters	6.752 (10.288)	0.102	0.512
Current Teaching Level[d]			
Elementary	10.174 (5.369)	0.175	0.060
Middle	8.070 (6.227)	0.118	0.197
Certification Area[e]	-8.824 (5.583)	-0.129	0.116
Single-Gender[f]	-0.235 (5.501)	-0.003	0.966
Neuroscience Courses[g]	2.137 (4.362)	0.036	0.625
Total Hours[h]	0.129 (0.118)	0.089	0.275
Adjusted R2		0.014	
p-value		0.275	

Dependent variable: learning styles neuromyth CFA factor items average percent incorrect
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex differences

APPENDIX Q

MULTIPLE REGRESSION ANALYSIS PREDICTORS OF GENDER-SPECIFIC INSTRUCTIONAL SCORES (WITH NEUROMYTH ENDORSEMENT AS INDEPENDENT VARIABLE)

Table Q.1: Multiple Regression Results Predicting Total Gender-Specific Instructional Strategy Score (total neuromyth)

	B(SE)	**Beta***	**p-value**
Age[a]			
20 – 29	-0.158 (9.379)	-0.002	0.987
30 – 39	10.449 (8.675)	0.168	0.230
40 – 49	7.717 (8.601)	0.127	0.371
50 – 59	7.911 (8.811)	0.114	0.370
Gender[b]	3.574 (5.023)	0.049	0.478
Education[c]			
Bachelor	1.958 (9.488)	0.029	0.837
Masters	-6.516 (8.630)	-0.103	0.451
Current Teaching Level[d]			
Elementary	-8.952 (4.505)	-0.161	0.048
Middle	0.570 (5.256)	0.009	0.914
Certification Area[e]	0.768 (4.692)	0.012	0.870
Single-Gender[f]	-3.649 (4.605)	-0.056	0.429
Neuroscience Courses[g]	-6.053 (3.656)	-0.107	0.100
Total Hours[h]	-0.110 (0.099)	-0.080	0.268

Total Neuromyth[i]	0.654 (0.089)	0.481	<0.001
Adjusted R2		0.243	
p-value		<0.001	

Dependent variable: total instructional score strategy item average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex differences
[i]Total Neuromyth = % items incorrect from all neuromyth, false items

Table Q.2: Multiple Regression Results Predicting Active Learning Instructional Strategy Score (total neuromyth)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	-2.190 (11.955)	-0.025	0.855
30 – 39	4.655 (11.058)	0.061	0.674
40 – 49	6.324 (10.964)	0.084	0.565
50 – 59	10.573 (11.231)	0.124	0.348
Gender[b]	-4.505 (6.403)	-0.051	0.483
Education[c]			
Bachelor	0.712 (12.094)	0.008	0.953
Masters	-4.744 (11.001)	-0.061	0.667
Current Teaching Level[d]			
Elementary	-15.841 (5.743)	-0.232	0.006
Middle	0.707 (6.700)	0.009	0.916
Certification Area[e]	-3.295 (5.981)	-0.041	0.582
Single-Gender[f]	-5.529 (5.869)	-0.069	0.347
Neuroscience Courses[g]	-5.552 (4.660)	-0.080	0.235
Total Hours[h]	-0.156 (0.127)	-0.092	0.218

Total Neuromyth[i]	0.636 (0.114)	0.380	<0.001
Adjusted R2		0.186	
p-value		<0.001	

Dependent variable: active learning strategies CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Total Neuromyth = % items incorrect from all neuromyth, false items

Table Q.3: Multiple Regression Results Predicting Collaboration Instructional Strategy Score (total neuromyth)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	-32.562 (14.883)	-0.309	0.030
30 – 39	-17.173 (13.767)	-0.190	0.214
40 – 49	-18.577 (13.650)	-0.210	0.175
50 – 59	-16.250 (13.982)	-0.161	0.247
Gender[b]	5.192 (7.971)	0.049	0.516
Education[c]			
Bachelor	9.165 (15.056)	0.093	0.544
Masters	-4.840 (13.696)	-0.052	0.724
Current Teaching Level[d]			
Elementary	-6.726 (7.149)	-0.083	0.348
Middle	1.967 (8.341)	0.021	0.814
Certification Area[e]	-10.723 (7.445)	-0.113	0.152
Single-Gender[f]	1.281 (7.307)	0.014	0.861
Neuroscience Courses[g]	-8.090 (5.801)	-0.098	0.165
Total Hours[h]	-0.028 (0.158)	-0.014	0.859

Total Neuromyth[i]	0.558 (0.142)	0.282	<0.001
Adjusted R2		0.097	
p-value		0.004	

Dependent variable: collaboration strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex differences
[i]Total Neuromyth = % items incorrect from all neuromyth, false items

Table Q.4: Multiple Regression Results Predicting Inquiry Instructional Strategy Score (total neuromyth)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	10.14 (14.632)	0.100	0.489
30 – 39	23.673 (13.534)	0.271	0.082
40 – 49	19.381 (13.419)	0.227	0.150
50 – 59	20.097 (13.746)	0.207	0.146
Gender[b]	-2.111 (7.836)	-0.021	0.788
Education[c]			
Bachelor	-12.867 (14.802)	-0.135	0.386
Masters	-18.431 (13.465)	-0.207	0.173
Current Teaching Level[d]			
Elementary	-0.489 (7.029)	-0.006	0.945
Middle	8.169 (8.201)	0.089	0.321
Certification Area[e]	2.956 (7.320)	0.032	0.687
Single-Gender[f]	-4.861 (7.184)	-0.054	0.500
Neuroscience Courses[g]	-0.447 (5.703)	-0.006	0.938
Total Hours[h]	-0.225 (0.155)	-0.117	0.148

Total Neuromyth[i]	0.520 (0.139)	0.273	<0.001
Adjusted R2		0.060	
p-value		0.033	

Dependent variable: inquiry strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Total Neuromyth = % items incorrect from all neuromyth, false items

Table Q.5: Multiple Regression Results Predicting Passive Learning Instructional Strategy Score (total neuromyth)

	B(SE)	**Beta***	**p-value**
Age[a]			
20 – 29	9.821 (12.165)	0.103	0.421
30 – 39	21.571 (11.252)	0.262	0.057
40 – 49	15.409 (11.157)	0.192	0.169
50 – 59	10.811 (11.428)	0.118	0.345
Gender[b]	8.423 (6.515)	0.088	0.198
Education[c]			
Bachelor	5.629 (12.307)	0.063	0.648
Masters	-3.412 (11.194)	-0.041	0.761
Current Teaching Level[d]			
Elementary	-9.518 (5.843)	-0.130	0.105
Middle	2.081 (6.818)	0.024	0.761
Certification Area[e]	4.740 (6.085)	0.055	0.437
Single-Gender[f]	-1.153 (5.972)	-0.013	0.847
Neuroscience Courses[g]	-12.694 (4.742)	-0.170	0.008
Total Hours[h]	-0.110 (0.129)	-0.060	0.394

Total Neuromyth[i]	0.887 (0.116)	0.494	<0.001
Adjusted R2		0.269	
p-value		<0.001	

Dependent variable: passive learning strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Total Neuromyth = % items incorrect from all neuromyth, false items

Table Q.6: Multiple Regression Results Predicting Total Gender-Specific Instructional Strategy Score (neuromyth factors)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	0.213 (9.898)	0.003	0.983
30 – 39	9.728 (9.159)	0.156	0.290
40 – 49	5.732 (9.105)	0.094	0.530
50 – 59	8.693 (9.284)	0.125	0.350
Gender[b]	1.561 (5.341)	0.022	0.770
Education[c]			
Bachelor	2.808 (10.001)	0.041	0.779
Masters	-5.396 (9.079)	-0.085	0.553
Current Teaching Level[d]			
Elementary	-10.061 (4.815)	-0.181	0.038
Middle	1.447 (5.547)	0.022	0.795
Certification Area[e]	1.528 (4.983)	0.023	0.759
Single-Gender[f]	-2.480 (4.856)	-0.038	0.610
Neuroscience Courses[g]	-4.232 (3.859)	-0.075	0.274
Total Hours[h]	-0.045 (0.105)	-0.033	0.667

Senses Myth[i]	0.120 (0.064)	0.141	0.064
Concepts Myth[j]	0.133 (0.053)	0.183	0.012
Learning Styles Myth[k]	0.223 (0.072)	0.234	0.002
Adjusted R2		0.161	
p-value		<0.001	

Dependent variable: total instructional score strategy items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related the sex differences
[i]Senses Myth = % items incorrect from senses factor
[j]Concepts Myth = % items incorrect from senses factor
[k]Learning Styles Myth = % items incorrect from senses factor

Table Q.7: Multiple Regression Results Predicting Active Learning Instructional Strategy Score (neuromyth factors)

	B(SE)	**Beta***	**p-value**
Age[a]			
20 – 29	-1.830 (12.358)	-0.021	0.882
30 – 39	3.945 (11.435)	0.052	0.731
40 – 49	4.461 (11.368)	0.060	0.695
50 – 59	11.357 (11.591)	0.133	0.329
Gender[b]	-6.432 (6.669)	-0.072	0.336
Education[c]			
Bachelor	1.421 (12.486)	0.017	0.910
Masters	-3.706 (11.335)	-0.047	0.744
Current Teaching Level[d]			
Elementary	-16.914 (6.012)	-0.247	0.005
Middle	1.449 (6.925)	0.018	0.835
Certification Area[e]	-2.522 (6.221)	-0.031	0.686

Single-Gender[f]	-4.390 (6.063)	-0.055	0.470
Neuroscience Courses[g]	-3.747 (4.818)	-0.054	0.438
Total Hours[h]	-0.094 (0.131)	-0.055	0.474
Senses Myth[i]	0.125 (0.081)	0.119	0.122
Concepts Myth[j]	0.132 (0.066)	0.148	0.046
Learning Styles Myth[k]	0.215 (0.090)	0.183	0.018
Adjusted R2		0.135	
p-value		<0.001	

Dependent variable: active learning strategies CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Senses Myth = % items incorrect from senses factor
[j]Concepts Myth = % items incorrect from senses factor
[k]Learning Styles Myth = % items incorrect from senses factor

Table Q.8: Multiple Regression Results Predicting Passive Learning Instructional Strategy Score (neuromyth factors)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	10.787 (12.800)	0.113	0.401
30 – 39	21.149 (11.844)	0.257	0.076
40 – 49	13.732 (11.775)	0.171	0.245
50 – 59	12.309 (12.006)	0.134	0.307
Gender[b]	6.238 (6.907)	0.065	0.368
Education[c]			
Bachelor	6.823 (12.933)	0.076	0.598
Masters	-1.903 (11.740)	-0.023	0.871
Current Teaching Level[d]			

	B(SE)	Beta*	p-value
Elementary	-10.424 (6.227)	-0.142	0.096
Middle	2.698 (7.172)	0.031	0.707
Certification Area[e]	5.411 (6.444)	0.063	0.402
Single-Gender[f]	0.183 (6.280)	0.002	0.977
Neuroscience Courses[g]	-10.189 (4.990)	-0.136	0.043
Total Hours[h]	-0.033 (0.135)	-0.018	0.809
Senses Myth[i]	0.231 (0.083)	0.205	0.006
Concepts Myth[j]	0.155 (0.068)	0.162	0.023
Learning Styles Myth[k]	0.279 (0.093)	0.222	0.003
Adjusted R2		0.195	
p-value		<0.001	

Dependent variable: passive learning strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Senses Myth = % items incorrect from senses factor
[j]Concepts Myth = % items incorrect from senses factor
[k]Learning Styles Myth = % items incorrect from senses factor

Table Q.9: Multiple Regression Results Predicting Collaboration Instructional Strategy Score (neuromyth factors)

	B(SE)	Beta*	p-value
Age[a]			
20 – 29	-33.342 (15.363)	-0.317	0.031
30 – 39	-18.340 (14.216)	-0.203	0.199
40 – 49	-20.904 (14.132)	-0.236	0.141
50 – 59	-16.259 (14.410)	-0.161	0.261
Gender[b]	3.785 (8.290)	0.036	0.649

Education[c]			
Bachelor	10.344 (15.522)	0.104	0.506
Masters	-3.338 (14.091)	-0.036	0.813
Current Teaching Level[d]			
Elementary	-7.375 (7.474)	-0.091	0.325
Middle	3.936 (8.609)	0.041	0.648
Certification Area[e]	-10.415 (7.734)	-0.110	0.180
Single-Gender[f]	2.581 (7.537)	0.027	0.732
Neuroscience Courses[g]	-6.258 (5.989)	-0.076	0.298
Total Hours[h]	0.053 (0.162)	0.027	0.744
Senses Myth[i]	0.041 (0.100)	0.033	0.681
Concepts Myth[j]	0.154 (0.082)	0.146	0.061
Learning Styles Myth[k]	0.110 (0.112)	0.080	0.325
Adjusted R2		0.043	
p-value		0.093	

Dependent Variable: collaboration strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Senses Myth = % items incorrect from senses factor
[j]Concepts Myth = % items incorrect from senses factor
[k]Learning Styles Myth = % items incorrect from senses factor

Table Q.10: Multiple Regression Results Predicting Inquiry Instructional Strategy Score (neuromyth factors)

	B(SE)	**Beta***	**p-value**
Age[a]			
20 – 29	11.053 (14.898)	0.109	0.459
30 – 39	23.433 (13.786)	0.269	0.091

40 – 49	17.761 (13.705)	0.208	0.197
50 – 59	20.968 (13.974)	0.216	0.135
Gender[b]	-4.090 (8.040)	-0.040	0.612
Education[c]			
Bachelor	-11.873 (15.053)	-0.124	0.431
Masters	-17.609 (13.665)	-0.198	0.199
Current Teaching Level[d]			
Elementary	-1.619 (7.248)	-0.021	0.823
Middle	8.74 (8.348)	0.096	0.297
Certification Area[e]	3.617 (7.500)	0.040	0.630
Single-Gender[f]	-4.104 (7.309)	-0.045	0.575
Neuroscience Courses[g]	0.660 (5.808)	0.008	0.910
Total Hours[h]	-0.184 (0.157)	-0.095	0.244
Senses Myth[i]	0.085 (0.097)	0.071	0.385
Concepts Myth[j]	0.069 (0.079)	0.068	0.382
Learning Styles Myth[k]	0.237 (0.108)	0.177	0.031
Adjusted R2		0.031	
p-value		0.157	

Dependent variable: inquiry strategy CFA factor items average percent different
*Beta refers to the standardized beta estimate
[a]Reference = male
[b]Reference = 60 – 69
[c]Reference = doctorate
[d]Reference = high school
[e]Reference = non-STEM
[f]Reference = no single-gender experience
[g]Reference = no neuroscience courses
[h]Continuous Scale = estimated hours in professional learning related to sex differences
[i]Senses Myth = % items incorrect from senses factor
[j]Concepts Myth = % items incorrect from senses factor
[k]Learning Styles Myth = % items incorrect from senses factor

APPENDIX R

CONVERGENT VALIDITY CORRELATION TABLES

Table R.1: Learning difference Likert score and Neuromyth False Score Correlation

		False Score
Learning Differences	Pearson Correlation	.370**
	Sig. (2-tailed)	.000
	N	190

**Correlation is significant at the 0.01 level (2-tailed)

Table R.2: Instructional needs Likert score and Instructional Score Correlation

		Instructional Score
Instructional Needs	Pearson Correlation	.456**
	Sig. (2-tailed)	.000
	N	190

**Correlation is significant at the 0.01 level (2-tailed)