Educating the Young Child 7
Advances in Theory and Research, Implications for Practice

Leslie Haley Wasserman
Debby Zambo *Editors*

Early Childhood and Neuroscience – Links to Development and Learning

Springer

Early Childhood and Neuroscience - Links to Development and Learning

EDUCATING THE YOUNG CHILD

VOLUME 7

This academic and scholarly book series will focus on the education and development of young children from infancy through eight years of age. The series will provide a synthesis of current theory and research on trends, issues, controversies, and challenges in the early childhood field and examine implications for practice. One hallmark of the series will be comprehensive reviews of research on a variety of topics with particular relevance for early childhood educators worldwide. The mission of the series is to enrich and enlarge early childhood educators' knowledge, enhance their professional development, and reassert the importance of early childhood education to the international community. The audience for the series includes college students, teachers of young children, college and university faculty, and professionals from fields other than education who are unified by their commitment to the care and education of young children. In many ways, the proposed series is an outgrowth of the success of Early Childhood Education Journal which has grown from a quarterly magazine to a respected and international professional journal that is published six times a year.

Leslie Haley Wasserman • Debby Zambo
Editors

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Editors
Leslie Haley Wasserman
School of Education
Heidelberg University
Tiffin, OH, USA

Debby Zambo
Department of Leadership and Innovation
Arizona State University
Glendale, AZ, USA

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Preface

Educational Neuroscience and the Double Entendre

As you read the following words, jot down or at least notice the meanings that automatically come to your mind. Ready? Here is the list: *attention, plastic, enrichment*, and *concept*. If you are a teacher, you may think of attention as a socially mediated process or of moments in a classroom when children lack it due to either pathology or boredom. Like a tax, it must be minded and paid. If you are a neuroscientist, you are likely to wonder what kind of attention (spatial, selective, orienting, or perceiving) and related to which cognitive process (response inhibition, cognitive control) are we talking about? The word “plastic” may bring images of picnic silverware or possibly your ID. Plastic is a noun, an adjective, and an artificial and sometimes toxic substance but also a fundamental functional characteristic of the body’s most precious and necessary organ, the brain.

“Enrichment” is a word used to describe some programs for gifted students or something extra that teachers add to curriculum when the basics are mastered. It also describes the means by which Marian Diamond discovered that the brains of rats grew more robust dendritic connections when allowed to live in more physically complex environments, and that these connections change dramatically and quickly under different circumstances. Teachers hear the word “concept” and seek to link fact-based information in one domain (the quadratic equation, the parts of speech, cycles of war, photosynthesis, iambic pentameter, harmony) to another using “system” or “pattern” to link them and create higher-level meaning and deeper, more persistent learning. Neuroscientists hear the same word (“concept”) and think of “chair,” “face,” “tool,” and “house,” which are some of the most basic functional elements detected in areas of the brain’s visual system by the early application of functional magnetic resonance imaging (fMRI). Herein lies the story. The fields of education and neuroscience are crossing paths on the street, starting to dance, stopping to stare in each other’s windows, and even looking for the occasional blue light special. We’re interested, intrigued, nervous, and cautiously aware that we are in the age where we can observe learning and performance from the outside and from the inside.

These four seemingly simple words (attention, plastic, enrichment, concept) cascade in one's mind toward vastly different meanings depending on whether you are an educator or a neuroscientist. Fortunately, due to the early crossings of these fields and exchanges between and among renowned and hearty scholars such as Michael Posner, Stanislas Dehaene, Usha Goswami, Brian Butterworth, and others, we find ourselves, today, in this place of unintended *double entendre*. Here, the real work begins. The coin flips. Are there useful concepts within domains such as reading and mathematics that readily lend themselves to examination by neuroscience? How do you represent the true nature of learning in an artificial setting like a laboratory? The complexity of a classroom is daunting to the cognitive neuroscientist wanting to pare down a process to its ramparts. The restraints of this exercise to an educator are wholly unrecognizable as learning. What are we to do?

This volume is an attempt to enter the space of this *double entendre* between neuroscience and education on behalf of learners in the earliest parts of life, the time where informal processes of learning (imitation, emotional attachment and security, and social interaction) shape an individual and turn them toward the formal processes of school. In essence, early childhood is time of free-range learning and discovery. School, at its best, retains these qualities while introducing the structures, skills, and knowledge of disciplines. As fast as neuroscience is making discoveries in the lab, we, as humans, are eager to understand new knowledge and attempt ways to apply it to better the human condition. Education is a natural consumer. The fact that this knowledge advances at such a breathtaking pace, and that in our enthusiasm it ends up extended far beyond itself, challenges us to simultaneously negotiate ourselves out of the *double entendre*. We need to access each other's vocabulary and begin to establish a shared vocabulary. We need a set of ethics, knowledge, and first principles (OECD-CERI, 2007; Tomlinson & Kalbfleisch, 1998) that will keep us from the early adoption of myth and understand that nearly every new finding will be vulnerable to this possibility due to the subjective nature of our own minds and natural tendencies to predict and pattern-find.

Indeed, early cognitive neuroscience research aimed at education and the attempt to remediate basic processes such as how the brain reads (Temple et al., 2003) or multitasks (McNab et al., 2009) show that intervention changes the brain and changes behavior. The brain is plastic; it is designed to respond to experience. One would hope to observe changes in these instances, and science has shown that we do. The gold standard of this plastic change, however, has yet to be measured. Do these changes lead to higher achievement, social success, and quality of life? What are the gains beyond increased metabolism in specific areas of the cortex and a better response time from the learner? Will these technologies become the heart of enrichment, remediation, or cognitive enhancement (Kalbfleisch, 2012)?

Yet, neuroimaging has already given us confirmation of a few ways in which contributions from these methods will spur paradigm shifts across education, society, and medicine. First, exercise is one of the single best things we can do for ourselves; it influences the efficiency of autonomic and neurochemical processes in the body and preserves the life and function of gray matter in certain parts of the brain that support memory across life (Erickson et al., 2011). Second, neuroimaging has shown us that the brains of bullies experience basic emotional processes differently (Viding, McCrory, Blakemore, & Frederickson, 2011) but also that a picture of a pathological process in a single individual predicts nothing (a neuroscientist who studies psychopaths measured that identical functional profile in himself despite the fact that he experienced a good upbringing and lives a productive, well-respected life). Finally, neuroimaging has also shown us that comatose individuals can and do respond in their minds to requests to imagine themselves performing different types of tasks (Coleman et al., 2007). Like Alice through the looking glass, we can measure the differential nature of the biological systems that give rise to behavior. In a 2008 article designed as a neuroprimer for education researchers, I call the nervous system an "endogenous heuristic," our template for understanding the nature of learning that is present in each one of us (Kalbfleisch, 2008).

The issues of learning in early childhood, how nature and nurture contribute to early skill development and individual differences, and the impact of extreme environmental factors on learning (poverty, emotional neglect) are just some of the questions being tackled by public policy, programming, education, and neuroscience research alike. Approaching from separate paradigms, we are interested in the same issues and the same gains in young lives. As much as the vocabularies of neuroanatomy and the methods of neuroscience are important to understand, so, too, are the research methodologies and the nature of the statistics used to examine the noisy signal in the brain. Most people do not realize that most of the computational power leveraged for data analysis is designed to quiet the irrelevant and prominent noise in the signal data we acquire during a brain scan more than to enhance meaningful signal. We seek simply to detect it. Most neuroscientists do not realize that teachers also seek to optimize the signal-to-noise ratio in a classroom to optimize learning. Teachers are engineers and experimentalists every day, but how they are currently trained does not propel them to see the profession in that regard. The methods of education researchers (action research, ethnography, and other qualitative methods) properly paired with neuroscience in the research enterprise will give deeper explanatory power and avenues for translation and application. Educators and neuroscientists have the same goal, to better understand both individual and social levels of learning and to master the transformative power to assess and characterize meaningful learning. The advent of educational neuroscience provides a new way to storyboard our efforts into the same space and onto the same page. This volume provides several avenues into that space and onto that page on behalf of learning in early childhood.

Krasnow Institute for Advanced Study and
College of Education and Human Development
George Mason University, Fairfax, VA, USA

Layne Kalbfleisch, M.Ed., Ph.D.

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We would like to thank Mary Renck Jalongo for the opportunity to be a part of this amazing series. Her vision has made it possible for us to reach educators, researchers, and parents alike and set the record straight about neuromyths.

This volume would also not have been possible without its contributors. When this volume was conceived, there was a clear call to be scientific and realistic and to temper the glorious views of neuroscience too often seen. Revealing the truth and reality of applying neuroscience to education were the challenges, and to meet these, the contributors researched the best ideas and used their common sense and practical knowledge to ground neuroscience in the realities and needs of teachers, parents, and young children. Each contributor answered challenging questions, made multiple revisions, and met time demands. As editors, we remain in awe of the bounty and depth of their knowledge, appreciate their collegial spirit, and appreciate the hard work they did to turn a vision into reality.

I would like to thank my parents (James and Joan Haley), husband (David Wasserman), and children (Timothy-TJ, Haley, and Sarah) for their continued support as I follow my educational journey.

I would also like to thank Debby Zambo for her expertise and encouragement throughout this endeavor.

Leslie Haley Wasserman

I would like to thank my husband (Ron Zambo) and my family (Nikki and Perry Parmely). You are always there to listen, challenge, and support me.

I would also like to thank Leslie Haley Wasserman who out of the blue contacted me and asked if I would like to coedit a text on young children and neuroscience. How could anyone say no?

Leslie has been the driving force of this volume because of her vision to make things better for young children. Leslie's caring nature, commitment, and knowledge have been inspiring. It has been an honor to work with her.

Debby Zambo

Contents

Chapter 1
Introduction

Leslie Haley Wasserman and Debby Zambo

How Does a Volume Such as This Come Together?

The authors and editors of this book also have this same goal and believe that findings from neuroscience can become an additional layer of understanding. Each one of us wants to foster the learning of children and help them fit and be successful in the world, and each one of us is passionate and hopeful that findings from neuroscience can help us accomplish these goals. By using this passion, we will broaden our knowledge and discover things that were once unknown. Our passion will help us make a difference.

Importance of This Book for Educating Today's Children

As neuroscientists learn more about brain development, chemistry, and structures, their findings are seeping into the education and care of young children. Teachers and caregivers are reading about brain development in magazines and watching television shows that explain how the brain learns. What was once a specialized field with technical jargon is being disseminated, yet some of this information is more reliable than others. Neuroscience can be used to create false hopes. The field of education needs conciliations of ideas, and this volume *Early Childhood and Neuroscience: Links to Development and Learning* will do just this.

L.H. Wasserman (✉)
School of Education, Heidelberg University, Tiffin, OH, USA
e-mail: lwasserm@heidelberg.edu

D. Zambo
Department of Leadership and Innovation, Arizona State University, Glendale, AZ, USA
e-mail: debby.zambo@asu.edu

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This volume fits with Springer's *Educating the Young Child* series and contributes to it by bringing together a group of 15 distinguished authors writing on an array of interrelated educational topics and practices. Authors were sought based on their cutting-edge research and/or expertise in the field of neuroscience and early childhood education. Authors were invited because they knew neuroscience and understood how it could and could not be applied to early childhood education. Each author is well respected in the field. They have published their works in many different venues such as books, peer-. Given this expertise, the authors have blended research, theory, and practice, in an attempt to provide proven and effective strategies educators and caregivers can use to shape the learning, emotional, social, and behavioral needs of all young children, including those with exceptionalities. Chapters in this volume focus on the ethics of neuroscience, brain development, best practices including good curricula, healthy environments, reliable information, and assessment strategies to use to ensure young brains are educated appropriately.

This volume is necessary and timely. We hope it will become a valuable resource for you and offer strategies that help you affect children today and influence the adults they will become tomorrow.

Overview of Book

This volume dispels neuromyths and gives insight into how to use neuroscience to understand and utilize the information gleaned to educate young children. Each chapter discusses a different topic that is intertwined with neuroscience and how it impacts young children.

In Chap. 2, you will find information about the practical and ethical concerns of using neuroscience to teach young children. In Chap. 2, Dr. Debby Zambo raises questions that can be used when neuroscience is involved in educational decisions. These questions are posed because even though information from neuroscience is growing, and becoming part of our daily conversations, we must not lose sight of the fact that it is a new and quickly evolving field. As educators, parents and caregivers we need to be fascinated of neuroscience and skeptical of it at the same time and we need to understand the types of moral decisions we make, how we make them, and what this means to the children in our care. In many ways Chap. 2 brings more questions than answers, but it has been written to provoke thought and reflection and, when necessary, encourage preemptive actions to preserve the identities, destinies, and development of young children in our care.

Chapter 3 discusses how everyone is unique and how sharpening each of our perspectives on child development and learning is important. This chapter written by Dr. Diane Connell and Ms. Jena Van Stelton, M.Ed., applies selected strategies to the field of early childhood education and strategies that are designed for diverse and inclusion-based early childhood education classrooms. An in-depth focus on hereditary and environmental influences on learning is discussed. From a genetic perspective, it appears individual neurological strengths and weaknesses develop in utero; from an environmental perspective, it is clear that a child's early home and school experiences affect his/her brain growth and development over his/her lifetime. To help readers find ways to reach every learner, this chapter intersperses mind, brain, and education research along with recent observations of older preschool students.

Well-known authors of books on reading, Drs. Nancy Frey and Douglas Fisher, have been widely read by educators everywhere. In Chap. 4, these authors share their wealth of knowledge about reading and the young brain. They discuss how neuroscience confirms and extends our understanding of reading development in young children and raise further questions that are not yet answerable. They help educators realize their work functions as a bridge builder. As teachers we seek to utilize the findings that allow us to create instructional environments that work. And while the field of educational research has long been conversant with psychological research, the more recent body of knowledge coming from the neurosciences has posed a challenge. How can educators incorporate findings from neuroscience into their work? Are there findings that confirm what is already known? Are there any findings that shed new light on compelling issues that matter to early childhood education? As reading researchers, these authors pose these questions to wrestle with as the participatory theories of neuroscience are transferred into the action theories of education.

Chapter 5 written by Drs. Valeri Farmer-Dougan and Larry Alferink compares recent educational curricula that purport to utilize research findings from neuroscience to promote improved learning and retention with the actual neuroscience findings. The authors note that much of the reasoning behind these new curricula is based on misinterpretation or oversimplification of neuroscience findings and/or is just not supported by the actual data. Even though the chapter is critical, it is also optimistic and informative. It concludes neuroscience does have much to say about the developing brain and how it learns.

Chapter 6, written by Dr. William Mosier provides an overview of the existing literature on how the affective domain impacts learning during early childhood. Developmental concepts are presented that have emerged from many decades of research. A consensus of what is understood about the emotional and social development of young children is presented for critique and exploration. A framework is offered within which the emotional needs of young children can be optimally addressed. The goal is to promote a clearer understanding of the science of early childhood development and its underlying neurobiology.

Learning about how early literacy trends for children identified as at risk for school failure and how they are consistent with contemporary neuroscience and learning theory is discussed in Chap. 7 by doctoral candidate, Rae Ann Hirsch, M. Ed. Current trends in early childhood curriculum for children identified as at risk for academic school failure need to embrace current neuroscience and learning theory to fully provide a strong cognitive foundation for learning and literacy. Healthy emotional development is a powerful building block in the brain and needs to be addressed in policy and practice as a necessary conduit to cognition is discussed.

Chapter 8 discusses autism spectrum disorder (ASD) and was written by Dr. Diane Branson. This chapter contributes much because advances in neurocognitive testing have established that ASD is a neurodevelopmental disorder affecting many different brain areas. There is evidence that ASD is a disorder of underconnectivity among brain regions that would typically work together in cortical networks to accomplish higher-order cognitive tasks, including language processing and production and social interactions, and goal-directed planning and monitoring are discussed.

Throughout Chap. 9, Dr. Leslie Haley Wasserman reveals the complexities of students identified as twice exceptional and the implications of this complexity in classrooms today. A brief overview of gifted education and special needs is provided as background for the reader so that the information provided is clear and leads to identification and understanding of just who twice-exceptional students really are. The relationship between twice-exceptional young learners and the role neuroscience plays in making their lives and the lives of those who live and work with them more successful will also be discussed.

Chapter 10 written by Dr. Niamh Stack, examines government and local intervention programmes designed to augment the development of children from at risk populations through a developmental neuroscience lens. From this work Dr. Stack discusses how advances neurobiological issues might be used to inform policy and practice.

Chapter 11, written by Drs. Billie Enz and Jill Stamm, concentrates on effective strategies to help teachers learn about brain development. Sharing new understandings about the brain and brain function has become essential to the preparation of teachers. There is little doubt that the organ of learning should be a staple in teacher education. A close examination of what learning principles motivate these teacher actions shows that there are solid, well-researched principles that underlie the behaviors. The real reason however why effective teachers do what they do is actually because of the ways in which the brain works. They discuss how knowing some brain basics helps us, as teachers, to look deeper than our behaviors to then be able to understand *why* learning occurs more successfully when we behave in one way versus another.

Chapter 12, written by Dr. George Hruby, discusses metaphors of developmental processes for brain-savvy teachers. He argues that to make good use of educational neuroscience and to contribute effectively to the conversation about its application in schools, teachers require more than a smattering of brain facts, hackneyed rhetoric, and overconfident commandments supposedly authorized by "hard" science. Teachers need to know a lot more about science itself, and about the dynamics of biological development, to make sense of brain transformation through instruction. But, to begin, teachers and teacher educators need a cohering metaphor to make sense together of the brain, brain processes, student learning, and effective teaching. From such a metaphor, easily grasped narratives of how such things work and work together can emerge to inform high-quality teacher professional development. From this, a compelling picture of what student achievement and effective instruction look like from the purview of educational neuroscience should emerge to direct teacher professionalization.

Conclusion

As you, the reader, can see, this volume covers many of the important topics in early childhood today. It is our hope that each chapter will help you understand that each child brings his/her own unique strengths and needs to us. We, as educators and caregivers, need to have an understanding of children's diverse backgrounds such as their differing ethnic cultures, religious views, family structure, and prior knowledge. This is an obvious statement that teachers already are aware of and are putting into practice. Teachers also follow best practices and allow for children to use their particular intelligences within the classroom. Teachers understand and apply various theories such as Vygotsky's social learning theory or Piaget's cognitive development theory that we learned in our methods' courses in higher education. But when, where, and how do teachers and caregivers learn about brain development and the importance of the windows of opportunity within the brain to teach our students to the best of their abilities? This volume is a wonderful addition for this knowledge and how to reach your potential as an educator by inspiring and teaching your students how to reach their own potential to achieve success.

Chapter 2
The Practical and Ethical Concerns of Using Neuroscience to Teach Young Children and Help Them Self-Regulate

Debby Zambo

Introduction

In the 1990s, neuroscience was burgeoning because of technological advances. As technology developed, neuroscientists began to glimpse brain development and see brains functioning as they learned and performed tasks. However, with technological innovations come challenges, and nowhere is this more evident than early childhood education. Neuroscientists and others are attempting to translate what was once a specialized field filled with technical jargon and findings into understandable information teachers of young children can use. And teachers are interested in this information. Educational neuroscience (or the intersection between mind, brain, and education) is seeping into the textbooks teachers are reading, the curriculum they are receiving, and the products they are purchasing. This information has the power to help teachers understand how young children learn, self-regulate, and think, but it also has the power to radically alter how children are nurtured and taught (Stein, Chiesa, Hinton, & Fischer, 2010).

As a teacher of young children (grades K-3) with learning and self-regulation challenges, I came to value neuroscience when I took an educational psychology course for my Master's degree. My teacher was Dr. Jill Stamm (a contributor to this volume), and in her class I learned about brain structures and functions, and this helped me understand how different and unique the brains of my young students were and how this difference translated into their actions. In Dr. Stamm's class I learned about the amygdala, and how it worked with other structures to activate the fight or flight response. When I learned this, I came to understand why David, a young boy in my classroom who had been neglected and abused as an infant, hid under his desk every time he heard a loud noise. When Dr. Stamm showed our class a picture of a brain with fetal alcohol syndrome and one without it, I was able to see

D. Zambo, Ph.D. (✉)
Department of Leadership and Innovation, Arizona State University, Glendale, AZ, USA
e-mail: debby.zambo@asu.edu

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the size and structural differences in these brains. Seeing these images helped me understand why Matthew, a boy in my class with fetal alcohol syndrome, struggled so hard to learn. Neuroscience helped me understand the biology of my students' learning and behaviors, and I'm sure it has done the same for countless teachers, parents, and caregivers like you.

Thanks to a teacher like Dr. Stamm, the good information she supplied, and my own experience, I came to understand the usefulness of educational neuroscience. However, when I moved from teaching young children to teaching educational psychology and child development to preservice and in-service teachers, I began to see another side of neuroscience. Even though our textbooks had chapters on brain development and talked about the limitations of neuroscience for educators and even though I provided information on brain structures and functioning in class lectures and discussions, I always heard students misusing or overextending ideas from neuroscience. Students were telling me about the hemispheric strategies they were using to remedy complex learning problems like dyslexia and autism, and they were standing by Ritalin and Adderall as the only means to help young students with attention problems learn to self-regulate. Worried about these practices, I began to wonder why so many of my students were buying into neuromyths or ideas with only a nugget of scientific truth. My students were misreading, misquoting, and overextending ideas from neuroscience and using these to confirm the biases they had. Instead of opening their minds to the valid information in their textbooks and from my lectures, my students were only paying attention to what aligned with their beliefs, forming their own folk theories, and building narratives based on the telling and retelling of their beliefs. This behavior concerned me because I knew it could have both educational and ethical implications (Farah, 2005; Organization for Economic Cooperation and Development [OECD], 2007). Fallacious beliefs about neuroscience and education could cause the students in my classes to waste valuable instructional time, treat young children unfairly, set low expectations, and spend their hard-earned money on worthless products and programs that did little good. Howard-Jones (2010) notes that neuromyths have a major influence on shaping the perceptions and views of educators, and this seemed to be the case with my students.

Realizing this, I became concerned but knew I needed data. So in 2006 a colleague and I began to investigate what preservice and in-service teachers at varying stages of their careers and other college students knew, thought, and believed about neuroscience and education. Since 2007, we have gathered data from approximately 850 individuals, and this data leads to some interesting insights. Our data from educators shows that they are interested in neuroscience and are using the Internet, television, workshops, and courses to gain information from it. Educators believe neuroscience should be a part of their training, and they believe that it will make them better teachers especially when dealing with students with special needs. Many of the teachers we surveyed believe that the products and strategies they are using help learning because there is a link to neuroscience (e.g., *Baby Einstein*, *Your Baby Can Read*, and *Brain Gym*®). For too many teachers, fads take precedence over research and facts (Zambo, 2008; Zambo & Zambo, 2009a, 2009b, 2012).

However, when it comes to believing in the value of neuroscience for teachers, our research told us not all teachers are the same. Many believe wholeheartedly, some hold reservations, and others, although few in number, see no use for neuroscience at all.

Believers see neuroscientists as experts and accept neuroscience because of its reliance on new technologies. Believers think neuroscientists can tell them what and how to teach, and because of this they want this information. Believers attend workshops, take courses, and buy DVDs to help them learn about the brain, and they share this information with each other. Believers see neuroscience as the most current and up-to-date information teachers can receive. They believe neuroscience is especially valuable to help them know how to teach students with special needs. To this group, neuroscience can be used to diagnose learning problems and understand how to differentiate instruction for different learning styles.

Believers with reservations were fewer in number than believers. These teachers always started saying something positive about neuroscience and education but stopped midstream and changed their mind. Believers with reservations thought information from neuroscience was useful, but as they began to articulate their reasoning, they always became less sure. Believers with reservations accepted neuroscience but felt it was only part of the information they needed. When it came to teaching and learning, they wanted information from educational psychology, psychiatry, and child development as well.

Whereas the believers saw neuroscientists leading them in the right direction, believers with reservations did not believe they were capable of understanding the vocabulary and technical ideas neuroscience posed. They said things like: "Teachers are not neuroscientists or doctors. They need someone to help them sort ideas out." Believers with reservations would not mind learning about neuroscience, but they wanted this information to be focused on their students' needs.

In contrast to these groups, nonbelievers were cautionary and hesitant. These teachers were not going to accept information from neuroscience without evidence and facts. Nonbelievers wanted results from carefully controlled studies, and they wanted to know how conclusions were drawn. Nonbelievers saw neuroscience as a cult-like fad and advocated for the human side of teaching. To them children were more than what was captured in brain scans. This group believed the interactions between teachers and students mattered more than an image on a screen (Zambo & Zambo, 2011).

Our data told us teachers were interested in neuroscience, but not all teachers were the same and this had implications. It told us that many preservice and in-service teachers were interested in neuroscience, consuming this information, and had hopes that it would make them better at their work. Wanting to understand the differences between believers and nonbelievers and what was so alluring about neuroscience to so many preservice teachers, we replicated one of McCabe and Castel's (2008) experiments. Like these researchers we gave students a fallacious passage about the positive effects of television on mathematical learning and supplied evidence for this claim with an fMRI (functioning resonance magnetic imaging) image, a graph, or nothing at all. With these three conditions we found that the students both in and out of education, in our college like McCabe and Castel's, could be misled with information from neuroscience, especially when an image was involved. From this work we found our participants, like McCabe and Castle's, thought the article with the fMRI image was more credible than the articles with a graph or no image. Participants also linked fallacies about learning to neuroscience. They believed neuroscience confirmed the reality of learning styles, the importance of multisensory learning, and the fact boys were active hands-on learners. This study helped us understand the neuromyths that can be perpetrated when the direct implications of neuroscience for educators are "oversold" (Zambo, Zambo, & Sidlik, In press).

Being intrigued by the fact our respondents felt that neuroscience was especially useful to understand and teach students with special needs, we investigated what a group of preservice teachers knew about attention deficit hyperactivity disorder (ADHD) and what they thought about medical science and neuroscience in terms of helping them educate students with this disorder. In this study we had a general questionnaire and manipulated the type of information participants received. Half of our participants saw an fMRI image and read about ADHD from a neuroscience perspective (e.g., faulty neuroreceptors responding to the neurotransmitter dopamine). And the other half saw an image of a premature infant and read about ADHD from a medical perspective (e.g., infants being born prematurely and weighing less than 3.3 lb often develop ADHD).

Data from this study showed that preservice teachers really know a lot about the students with ADHD. They know children with ADHD are hyperactive, excitable, impulsive, irritable, and seldom tired, and that medication suppresses some of these symptoms for some children. They also know these characteristics inhibit a student's learning. They know children with attention challenges are distractible, have trouble focusing/concentrating, are off task much of the time, struggle to process information, and have social and family problems. When asked where they learned this information, they said they, their friends, or their family members have ADHD, celebrities on television talk about it, and it is discussed in their courses (especially special education courses).

Data from the two conditions (neuroscience and medical science) showed slight differences. Participants who saw the fMRI image and read information from neuroscience believed it was useful to help them. These participants felt neuroscience could help them identify students with ADHD earlier, advocate for their needs, understand how their brain works, and understand why they behave in certain ways. Participants in the neuroscience condition also thought neuroscience would help them teach these students. They thought neuroscience could help them learn how to create learning environments conducive to these students' needs, create and teach better lessons, and know how to redirect students so they would remain on task.

In comparison, participants who saw the image of the premature infant and read information from medical science also saw it as useful but in slightly different ways. Participants in this group thought medical science would help them understand the cause, signs, and symptoms of ADHD, if medications were working, and know how to manage students.

This work over the years maps a trend in educators' thinking and beliefs about neuroscience. It is safe to say that students in teacher preparation programs and teachers working in schools are being exposed to information from neuroscience. When it comes to believing in the benefits of neuroscience, however, educators fall along a continuum such that some accept unquestioningly that neuroscience can offer ways to improve their instruction (particularly for students with special needs) and manage students in the classroom, while others view brain research with considerable skepticism. While there is little doubt that neuroscience—particularly when it is combined with other disciplines like human development, cognitive science, and behavioral science—can illuminate the biological basis of learning, confirm developmental differences, and help educators, parents, and caregivers understand how a brain learns; it is also clear that for many educators, how to use this information, where it fits, and what is valid are not totally clear (della Chiesa, Christoph, & Hinton, 2009). Neuroscience can be used to create false hopes and market products that have little or no salutary effects (Dubinsky, 2010; Howard-Jones, 2010; Stamm, 2007; Wolfe, 2001; Willis, 2006). Calling it "a bridge too far," long-time critic John T. Bruer (1999, 2006) has warned educators to take a cautionary stance in applying neuroscience to their field. Likewise, Bear, Connors, and Paradis (2007) note that when it comes to neuroscience, educators are often overzealous. Others echoed similar sentiments and conducted research as to why neuroscience is so alluring. In their work, McCabe and Castel (2008) and Weisberg, Keil, Goodstein, Rawson, and Gray (2008) found fMRI images to be persuasive and lead to misunderstandings. To these researchers, images appeal to intuitive, reductionist notions of learning, and educators need to be careful when they think about the complex process of learning. More recently, Sylvan and Christodoulou (2010) found neuroscience being used to create learning theories and principles, develop strategies to change behaviors, and create products that claim to have explicit brain links. These researchers concluded that each of these uses of neuroscience makes sense if they match the educational needs of children, are cost-effective, align with other scientifically based research, and produce observable behavioral effects. Hruby and Goswami (2011) offer solutions to the problems facing the neuroscience education interface by calling for varied disciplines (brain, social, cognitive, cultural) to converge. Neuroscientists can help educators understand how the brain decodes and comprehends language if methodological and conceptual challenges are aligned. Given these potentials and concerns, it is important that teachers and other caregivers realize that:

- Some information from neuroscience is being overextended, misinterpreted, and oversimplified, and this has implications.
- There are curricula, books, and products that purport to use findings from neuroscience to promote improved learning without any scientific backing.
- Emotional catch phrases are being used to pose quick and easy answers to complex learning and behavioral challenges.
- Testimonials are not the same as empirical facts gathered by researchers with reliable and valid tools.