Brain Science and Teaching: A Forty-Year Personal History

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Abstract

This paper is the sharing of a record, the personal history of an educator pursuing an interest in knowledge of the brain. Over the years, this fascination sparked the idea to create a course for teachers based on brain science, with a twist. Certain course assignments would require teachers to interpret knowledge of the brain in the context of their individual classes. In 2006, I completed a dissertation entitled "The Impact of a Brain Research Course on Knowledge of the Brain and Teacher Efficacy." Over the past ten years, I have continued to teach brain science research to master's level teachers.

In this article, I share my observations and insights into the teaching of brain anatomy and function to teachers. The article focuses on the growing attraction of brain science research to educators. In it, I seek to illustrate how learning about the brain has created a positive force in the teaching lives of enrolled students, the learning of their students, the accommodations of curricular requirements, and the culture of the schools in which they operate. I conclude with observations regarding the utility, viability, and desirability of a course in brain research within other teacher preparation programs.

Introduction

This story begins some forty years ago and includes a personal history of my experiences, reflections, and explorations of a relationship between educational goals and brain research findings. Significant in that narrative is my formal return to PhD studies in what I referred to as a Neuropedagogy Major and Biological Psychology Minor at George Mason University. This effort provided an opportunity to further my understanding of the universe that is the brain formally and systematically, with particular attention to how it learns. Those findings have fueled the past ten years of teaching brain science courses to teachers, and so I begin.

In 1973, while working on a Master's Degree in Reading at the University of Virginia, I encountered early research on reading disability from the perspective of brain science (Orton 1937; Robbins 1967; Liberman et al. 1971; Smith 1971). These brain function and performance findings seemed to have a message for teachers. The brain's processing of reading, movement, memory, and attention correlated with educators' interest in understanding student learning,

Commensurate with Hart (1983), Howard Gardner published *Frames of Mind: The Theory of Multiple Intelligences* in 1983. This information from neuropsychology created a stir in education. It was a theory, certainly. But to any teacher Gardner's book was a useful way to get a new perspective on how children learn. In 1991, Renata and Geoffrey Caine published *Making Connections: Teaching and the Human Brain* (1994, rev ed). This book was so helpful, so insightful, and so inspirational that I began using it in a five-hour field-based undergraduate course entitled The Social and Psychological Conditions of Learning. Students enthusiastically shared my love of this little book and its messages about the brain, how it learns, and teaching.

Soon the Caines' book was joined by others by educators such as David Sousa (2011, orig pub in 1995), Robert Sylwester (1995), Eric Jensen (1996), Pat Wolfe (2001), Virginia Berninger and Todd Richards (2002), and James Zull (2002). Generally, the first chapter of such texts was devoted to brain anatomy and function. Subsequent chapters contained a little brain science knowledge with explanations for how to strategize this information into classroom operations. I tried using a few of these offerings and was happily surprised when my young teachers requested more science.

While experimenting with how to teach brain science to potential teachers, I struggled to educate myself. I began reading Richard Restack (1979) early on and then added to him more specifically with Carla Hannaford (1995), William Calvin (1996), Candice Pert (1997), Marian Diamond and Janet Hopson (1998), Robert Sapolsky (1998), and Susan A. Greenfield (2000). But even with all my reading, I was still very frustrated with the growth of my understanding. It seemed I was digging around in the shallow end of the rabbit hole.

By the close of the ’90s, the Caines (1994) had created a summer think tank in the California mountains. It worked through a mix of science, education, good food, excellent fellowship, and little oxygen. One morning at the close of one of these experiences, the word *Neuropedagogy* came to mind. *Pedagogy* is my favorite way to describe what I do—the method, practice, and art of teaching. *Neuro* was easy to incorporate, for other disciplines had usurped this prefix as well—neuroanatomy, neurophysiology, neurobiology, and neuropsychology—really so many. I like Neuropedagogy too because of the wiggle room the name suggests.

In 2000, the National Research Council of the National Academies published *How People Learn: Brain, Mind, Experience, and School*. This culminated work adopted the same approach as previous texts, a little bit of brain science and a lot of interpretation and suggestions. Additionally, the National Institute of Health (2000) weighed in on such education problems as Attention Deficit/Hyperactive Disorder.

It seems that education in the United States swings like a pendulum anchored to current fashions in teaching with their accompanying accessories. Especially embedded are the packages of new methodologies to learn and tests to take. And so by the 2000s, the flood gates were open, and neuroscience research had entered the debate. Educators sought to educate teachers about how the brain works (Given 2002; Sylwester 2005), and neuroscientists were publishing their work about targeted student populations: Barkley (1998, ADHD), Grigorenko (2001, dyslexia), Ratey (2001, function), Baddeley (2002, memory), Eden and Moats (2002, dyslexia), and Shaywitz (2003, dyslexia). This confluence of brain science, education, and research findings sparked my interest in how neuroscience might inform teacher training, teacher behaviors, and classroom outcomes. Simultaneously John T. Bruer (1997) began his urging of a cautionary approach to these links, suggesting it was *A Bridge Too Far* from neuroscience to education.

In 2002, while this conversation between educators and neuroscience was evolving, I began a PhD program in Education at George Mason University. My major was Neuropedagogy, which Mason graciously allowed me to create and combine with a minor in Biological Psychology. This combination allowed me to enroll in courses like The Neuron and enter the universe of brain function and anatomy, foreign climes for me and most educators.

Not long after beginning coursework, I noted how much of the brain is concerned with motor movement. From this and many other encounters, I began incubating the idea of an entire course in brain research directed to practicing teachers. This inspiration undergirded my studies at George Mason. During the dissertation pilot, it was easy to see that efficacy would play a role in teachers’ ability to turn information into action. Bandura (1997) set the stage for these considerations when discussing the sources of self-efficacy: modeling, mastery experiences, verbal persuasion, and psychological arousal (Shaughnessy, 2004). My thinking is best articulated by Tschannen-Moran, Hoy and Hoy (1998, 22): “the teacher’s belief in his or capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context.” The context for each teacher then would determine his or her activities.

To inform the quantitative evaluation of the course, two pre/post assessments were developed with the aid of several faculty members, fellow students, and a pilot study involving teaching brain science to teachers.

The first assessment was called the Brain Science Knowledge Test (BSKT), which assessed knowledge of basic brain anatomy and function. The second was the Brain Science Teacher Efficacy Scale (BSTES), which used (a) Barbara Given's (2002) theory of the brain's natural learning systems (emotional, social, cognitive, motor, and reflective) in five sections and (b) Bandura's (2001) model and ideas for the stem questions revolving around teacher efficacy for classroom practices. The results were not only statistically significant; they were also stunning.

I ran three *t*-tests on the BSKT for my dissertation (Kirby 2006). In the first, run on Section I, teachers demonstrated a good recall of the specifics of brain science ($M = 89.75$; Kirby 2006). Section II scores, which measured their ability to apply that knowledge to the classroom, were more impressive ($M = 97.38$), $t(7) = -3.042$, $p < .05$ (Kirby 2006). The final *t*-test investigated how the averaged post-course scores on Sections I and II might compare with the pre-course Section I score. The pre-course scores were low ($M = 10.36$), and the averaged post-course score was high ($M = 93.63$), $t(7) = -23.84$, $p < .01$, reflecting a positive and significant difference in participants' knowledge of the brain before taking the course and after taking the course (Kirby 2006, 79–80).

To test the hypothesis that there would be significant differences in teacher's efficacy for brain systems related to teaching practices, paired *t*-tests were used. The results revealed that teacher's initial scores on all subscales of the Brain Systems Teacher Efficacy Scale (BSTES), including the total BSTES score, were significantly different following completion of the master's level course focusing on knowledge of the brain, Neuropedagogy (all ps. = .05; Kirby 2006, 87).

With their high significance levels, both quantitative measures demonstrated the positive effects of the course. The interviews and artifacts were equally supportive. Teacher comments from assignments and interviews formed the voice of the qualitative assessment.

> I think it has just opened up my mind to different ways of thinking on how the brain can be beneficial in teaching us how to be better teachers in a sense so that I really opened up a whole new world for me. Being able to go from a course where before I didn't know anything really about the brain to now I can really think of different parts of the brain and how they impact us and our actions and the way we interact with each other and think that's so important in the classroom. So from a teacher's standpoint I feel like I have a lot more knowledge where I can go in and be more effective as a teacher. Which I think is excellent, the main point of teaching, being effective. (Kirby 2006, 159-60)

> I think it will greatly impact my teaching. This is the one class that has sort of unlocked a lot of secrets to me….Ah, okay, now I get why this happens in my classroom or how this could be helped. (Kirby 2006, 160)

Because the pilot course and the dissertation's brain science course were successful, I began teaching introductory Neuropedagogy courses at my local university. Over the past decade, many teachers have taken the elective course (EDUC 599A, Neuropedagogy: Brain Science and Teaching), and the approval ratings have been impressive. Because it is an elective course, the fact that students enroll is reinforcing. Some even continue down the rabbit hole for a few more specific courses focusing on a subject of interest, like motor movement or special disabilities (EDUC 599B or EDUC 599C, respectively).

The Neuropedagogy course has evolved as my experience has grown, but it retains some fundamental principles of the original dissertation course. The first part of the course concentrates on brain anatomy and function. During course assignments, teachers use this knowledge to meet curricular goals in their individual classrooms. Finally, teachers reflect on the applications and strategies developed for course assignments.

In this dialogue with neuroscience research and the development of a related course for teachers, certain questions continue to shape the conversation. Which pieces of this knowledge are worthwhile for teachers? What difference would it make to a teacher to know this information? Having acquired some brain works fundamentals, how would teachers respond to teaching-related prompts? The languages of education and neuroscience share some similarities (memory, emotion, behaviors, motor movement, and even creativity) and provide the references for this cross talk between the fields.

Genetics, experiences, birth, childhood, adolescence, adulthood, and old age—all of these features are deeply affected by learning. Every experience influences every new experience. However, unconscious processing predominates, and making meaningful connections is a cognitive imperative (Gazzaniga, 2011). The teachers from the dissertation course had much to say about what difference the knowledge of brain science made to them in their classrooms. Since then and throughout subsequent course evaluations, students have echoed those original comments as they explore the original hypotheses. My observations suggest that introducing brain science during teacher training coursework will increase teacher knowledge of student learning and memory and will improve teacher efficacy for related classroom practices and thus enhance classroom outcomes through teacher education. So what did teachers say about taking a course that focused on brain science and allowed them to develop their own classroom applications?

> Well, it's just. Why we haven't been learning this all along is where I'm kind of…Why wouldn't you just keep learning how every kid is different or every student is different and all of this, but yet you're not putting the component about your brain in there…Ok, everyone learns differently but there never has really, to me, been a connection between what we're doing and how the brain is part of that. Now that I've seen this class, I'm thinking, how could you even teach without that? (Kirby 2006, 157)

The Neuropedagogy course content has changed over the years, as have the textbooks. Currently, the core texts are Nobel Prize winner Eric Kandel's *In Search of Memory* (2006), educator Barbara Given's *Natural Learning Systems of the Brain* (2002), and Rita Carter's visually stunning *The Human Brain* (2014). Additionally recommended is Schoonover (2010), who provides a visual romp through the history of neuroscience. Students complete ten journal entries from prompts about their classroom applications of the brain science research. They take eight or more quizzes and an online midterm on brain science content. They select a brain science/education related special project to pursue, and they generate a Fun with the Brain Project (FWTB), which encourages their creativity and playfulness around their topic. Lastly, the final exam requires them to apply this new perspective on learning to their future activities in the classroom. A roundtable format encourages in-class discussions and the sharing of their responses to assignments, readings, and personal connections.

Teaching students brain anatomy and function was important, but how would they use this knowledge? A kindergarten teacher, or an eighth grade math teacher, chemistry, fifth grade, gym, music—what would knowledge of brain science mean to them operationally? Describing connections they make to the context of their teaching assignments is always revealing of the distinctive nature of their individual settings. Then, too, their personalized connections to neuroscience are also revelatory and unique. What do the teachers say about their experiences in this course? Their comments remain similar to those expressed in the original dissertation and continue to support the approach to instruction that allows them to interpret and apply this knowledge as they deem appropriate. Each student describes the effects and connections differently, again reflecting the individual nature of their classroom settings, requirements, and objectives.

> To get attention… use novelty, movement, making connections, smells, manipulatives…these strategies connect to the right hemisphere, motor strip, basal ganglia, hippocampus and amygdala, olfactory bulb as well as the frontal parietal and temporal lobe, as well as working memory. (Kirby 2006, 85)

> When I learned about the nucleus accumbens I got it. We humans like to be rewarded. We need to know we are doing the right thing or that we are on the right path. How silly of me not to connect the two and the importance of my feedback to my students and their self-confidence, not to mention their learning. (Kirby 2006, 96)

For many reasons, this course has never been integrated into the Department of Education's catalogue of courses at my university. It is not required for a degree in education. After ten years, however, students continue to enroll from virtually every department on campus. Even as legislative and administrative course requirements have eaten away at elective options, this course still manages to attract students. As each semester begins, I commend my enrollees on their selection of a science course as an elective. Interestingly word of mouth from both faculty and former students encourages enrollment. This warms my heart and fuels my desire to share this knowledge with teachers. Likewise, the participating teachers never fail to embrace the content with enthusiasm, dedication, and creativity—every time.

> I realized through this course that I don't repeat material enough. I learned this from understanding long-term potentiation (LTP). (Kirby 2006, 116)

> I wanted them to sit in their seats by golly, sit there and be quiet and do what I tell you to do. That has changed. (Kirby 2006, 157)

> It was sort of making my brain hurt, and for once I thought I really am using some new ways to think of things and connect things. (Kirby 2006, 161)

So students will voluntarily enroll in an elective course about brain science and teaching. They enjoy taking the course, learning the content, and applying what they learn to their classrooms. How do they feel about the desirability of incorporating such a course into the menu of teacher training? One student says, "I really think this needs to be taught to the undergraduates" (Kirby 2006, 157).

Comments from students during course evaluations, responses to a journal entry prompt that asked "what will I do differently in my class due to the influence of my Neuropedagogy course?" and discussions online and in-class indicate teacher fascination with and appreciation of the new course content. Two of the most pervasive of their observations continue to be "why haven't I learned this sooner?" and "applying this knowledge to my classroom is easy, effective, and students benefit from the results."

> But with that knowledge and seeing that it's different pieces, I can understand now more how the kids can get confused easily, and each child can remember something differently, even if it's happened to those children at the same time and they're both experiencing the same thing, they're not experiencing the same thing. (Kirby 2006, 151)

> I believe these changes will enable me to better serve my students. To teach them skills that will improve overall performance the whole year. (Kirby 2006, 151)

A three-point paper for extra credit requires the student to examine brain science and education metaphorically. Interestingly, the Fun with the Brain (FWTB) project is also often conceived as a metaphor. One of my favorite projects was created by a high school math teacher who sculpted in his free time. He sculpted a clay image of one brain head coming out of another brain head. They were facing two directions and some very long-fingered hands were helping the interior brain head to arise through the center. This was no amateur's creation. He called it Unconscious to Conscious.

A fifth grade teacher baked a red velvet cake with peach icing. It had neurons connecting around its exterior circle. On the top she created a coronal slice mid-brain. It was stunning, and delicious. Another Neuropedagogy FWTB project was a crib-sized quilt made with brain-related patches. Quilting is an important part of the history and culture of West Virginia where I teach, and this biology teacher used her quilting knowledge along with the language of brain science to represent axons, neurons, and lobes along with children and learning systems. In describing her quilt she wrote, "we can wrap-up and take comfort in our new knowledge" (Kirby 2006, 127).

For certain journals and the final exam in the dissertation class, I applied qualitative methods to students' writings. The discussion that followed was always insightful and enthusiastic. At the conclusion, we used the essence of their data to create a sentence that summarized their efforts. Representing the final exam responses, the dissertation class wrote, "we are the tech crew behind the stage of the theatre of the mind in the company of the conscious" (Kirby 2006, 147).

Conclusion

Three overarching observations emerge from these years of study. First, teachers are looking for new perspectives that help them interpret what is happening in their classrooms. Second, knowledge of brain science changed teachers' beliefs and their behaviors in the classroom. Third, teachers were thankful and hopeful. They were thankful for the brain science information and hopeful that having such knowledge would positively influence their classroom learning environment.

From my years of experiences, I see three major implications. First, brain science provides a different language for, and window on, understanding what has been the purview of teachers—what is happening in their classrooms. Second, teachers find knowledge of brain science useful and can develop numerous strategies for every brain science concept. Finally, schools of education, and teacher education in general, need to include brain science course work in their teacher education programs.

Utility

My experiences over the past decade lead me to conclude that teachers would benefit from a course in fundamental brain anatomy and function. For instance, memory has a deeper meaning for them. Declarative memory, nondeclarative memory, working memory, episodic memory, semantic memory, habituation, sensitization, classical conditioning, emotional memory, procedural memory, even reflex memory—each concept adds to their understanding of the many ways that exist to make long-term memories. When they understand mirror neurons, modeling becomes more important. When they see the vast amount of territory devoted to motor movement, physicality in their classrooms becomes more essential. When they understand that we are a social species and how our visual systems can dominate so much of our sensory input, classroom activities change. When they grasp concepts like priming, feedback loops, long-term potentiation, and neuroplasticity, their conceptualization of how to encourage learning expands. So the utility of such a course is evident. What about the viability?

Viability

It has been my experience that once teachers are exposed to brain science research, they easily integrate it with their coursework in education as well as their classroom activities. There is a fascination with the knowledge certainly, but the usefulness calls to them. One teacher said, “overall, I find myself taking good activities that I like and making them more dynamic. Overall, I find myself thinking more. Thinking about me, thinking about teaching, thinking about learning, and thinking about thinking” (Kirby 2006, 149).

Educators like Jensen (2006), Tileston (2011), and Sousa (2011) continue to inform teachers about the latest from neuroscience/education related findings. The popular Learning and the Brain conferences, institutes, and workshops produced by Public Information Resources, Inc. (2016), have focused on connecting educators with neuroscience research since 1999. Neuroscientists and science writers continue to write books that spark educators’ interest (Ratey 2008; Dahaene 2009; Sousa 2010; Eagleman 2015; Carey 2015). These measures fall shy of the long-term effects inherent in coursework, but their ongoing popularity demonstrates teachers’ fascination with the topics. So such courses are viable. What about their desirability?

Desirability

I do hope I have made the case for the desirability of neuroscience coursework in the education of teachers. My experiences have been overwhelmingly positive. Students in my classes tend to embrace this new knowledge like a new religion, with born-again enthusiasm. They share this knowledge at home, at school, and with friends at dinner parties, and they pursue it long after their course work is complete. Teacher enthusiasm for this new window on how learning happens and on how to use this knowledge in their roles as a teacher is encouraging and compelling. As we confront this new wave of digital natives (Greenfield 2015), we need to up our game. Some educators refer to such content as brain-friendly teaching (Tokuhama-Espinosa 2011; Jensen 2008). While this term is not one I embrace or encourage, the idea it suggests is a rich one. This is not just new content for teacher education programs; this is the injection of new life into our education of teachers.

The brain science for teachers’ course idea—stemming from my original fascination with knowledge of the brain, the PhD and specifically the dissertation, and the decade of teaching brain research content to teachers—is the subject of this reflection. I hope I have shared enough to illustrate how learning about the brain has been a positive force in the lives of enrolled teachers, the learning of their students, the accommodations of curricular requirements, and the sharing of these ideas within the culture of the schools in which they operate. My personal experiences and observations regarding the utility, viability, and desirability of a course in brain research within our teacher preparation program are suggestive of success at other institutions.

We are now in a struggle for life in our educational world. Students, technology, environment, and cultures struggle for our attention. When we introduce knowledge of brain science, we give teachers some insight into the science of learning and being human. How can we deny them this knowledge as we strive for best practices? One teacher described the experience by saying, “I believe that I am now seeing [the classroom] as a type of lab filled with rich experiences. Everyone should have the opportunity to take this class. It will change the way that we teach and will help so many teachers and students become who they are meant to be” (Kirby 2006, 163). I say, what a hopeful future that is.

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