Teachers' Beliefs about Neuroscience and Education

Debby Zambo & Ron Zambo, Arizona State University

Information from neuroscience is readily available to educators, yet instructors of educational psychology and related fields have not investigated teachers' beliefs regarding this information. The purpose of this survey study was to uncover the beliefs 62 teachers held about neuroscience and education. Results indicate there were three types of views: believers, believers with reservations, and nonbelievers. Believers believed neuroscience was applicable and that they were using information from neuroscience in their classrooms. Believers with reservations believed in the benefits of neuroscience but were hesitant to commit wholeheartedly. Nonbelievers saw no use for neuroscience and perceived it to be a passing fad. From these findings, ideas that focus on sound information and critical thinking are offered for those who teach educational psychology and related subjects.

As instructors in a college of education, we began investigating teachers' beliefs about neuroscience in 2007 because our students were talking so much about it. Our students were coming to class and telling us about the brain-based strategies they were using in their field placement classrooms. One student told us about the brain exercises she was performing with third grade children to wake up their brains. Another spoke about the classical music she was playing in her classroom to calm the brains of adolescents and get them ready to learn. Students were openly and eagerly providing testimonials about their use of neuroscience, and this captured our attention. From our observations, it seemed that students were willing to try any idea if it was linked to neuroscience. Our students never considered that these strategies might be a waste of valuable classroom time. When it came to the usefulness of neuroscience for educators there was an unquestioning atmosphere. Our students truly believed that they were applying ideas from brain research to help the children in their classrooms.

At the same time, we also noticed that some students were purchasing products based on neuroscience and they were bringing these products to class to share with their peers. One student purchased a DVD of brain relaxation techniques to help focus the brains of children with attention-deficit/hyperactivity disorder (ADHD). Another bought a six-CD set with strategies to connect brain structures and enhance children's memory. A student working with children with dyslexia purchased a movement program guaranteed to help them read fluently. Our students were buying into the claims being made by the manufactures. The mere mention of neuroscience or brain enhancement convinced them that a product was worth the price.

Manufacturers and experiences were influencing our students' beliefs about neuroscience, but these were not the only sources. The textbooks the first author was using in her educational psychology and child and adolescent development courses contained information about the brain, and with each new edition the amount of information was growing. What began as a few pages in one chapter grew into 15 pages on brain development, neurons, and brain structures. As teacher educators, we felt this surge of information was important because it stemmed from neuroscience, but as we discussed the brain in our classes and heard

conversations like those mentioned earlier we began to see how reliable facts were being twisted with unwarranted claims. Even though our students were learning reliable information from their textbooks, they continued to believe in brain-based strategies and products without questioning, and as teacher educators we knew this could have consequences. We knew our students' beliefs would influence their perceptions of children, how they learn, and how they should be taught.

Teachers' Beliefs

Most teachers enter teaching because they believe they can and will make a difference in students' lives (Fang, 1996; Levin & He, 2008). Teachers' beliefs are important because they influence their interactions with students, the expectations they set, the instructional decisions they make, and the lenses they use to interpret classroom events (Good & Nichols, 2001; Kagan, 1992). Teachers' beliefs about teaching and learning come from:

- *personal experience*—activities events and understandings from everyday life.
- *experience with school*—instructional experiences gained as students themselves.
- *experience with formal knowledge*—knowledge gained from courses in teacher preparation programs. (Richardson, Anders, Tidwell, & Lloyd, 1991)

The beliefs teachers hold stem from their experience in the classroom and have become a prominent field of inquiry (e.g., Levin & He, 2008; Luft & Roehrig, 2007). Researchers have found that teachers hold both *peripheral* and *core beliefs* (Kagan, 1992). Peripheral beliefs are individual and isolated ideas and given their lack of connection they are easy to change. Core beliefs, on the other hand, are connected with other beliefs, and often used. Because of the frequency of their use core beliefs get ingrained, are resistant to change, and are self-perpetrating. Teachers see what they believe, and they believe what they see when it aligns with their beliefs and this applies to instruction. Holt-Reynolds (1992) found that teachers are more willing to use pedagogical approaches when they are consistent with their beliefs. Likewise, Errington (2004) argued that teachers' beliefs are the most influential factor in determining the success or failure of a new teaching approach. Beliefs have a powerful influence, even when they are flawed. It takes time and hard work to alter beliefs, but with instruction and convincing evidence they can be changed (Levin & He, 2008).

Research on teachers' beliefs is growing, but there is one area, neuroscience, where beliefs have been mostly ignored. Our experience and observations tell us that teachers, like the rest of us, are being exposed to strategies and products based on neuroscience and buying into them even if they are make unjustified claims. Building brains with exercises and using products deemed to change brains quickly could be a waste of energy and valuable instructional time. Varma, McCandliss, and Schwartz (2008) contend that the application of neuroscience to the classroom is in its infancy. Sound information is being discovered, but this information still needs to be validated outside the laboratory. As it currently stands there is much misinformation and no regulatory agency scrutinizing claims being made in the name of neuroscience (Willis, 2006). Our observations were convincing us that without direction education students' beliefs could go astray and their students could be affected.

Concerns about the Applicability of Neuroscience

Wanting to help our students understand the best way to interpret and use neuroscience we turned to the literature and found varying views. In one corner was long-time critic, John T. Bruer (1999, 2006), saying we need to take a cautionary stance because many claims being made in the name of neuroscience are nothing more than a repackaging of what cognitive scientists have known for years. Others echoed similar sentiments. For example, Stamm (2009) and Willis (2006) noted that many products being marketed in the name of neuroscience are little more than profit-making schemes and the number of these schemes is growing. Since the 1990s, pseudoscientific information and products have become more plentiful, and books, videos, CDs, and DVDs that make promises to improve learning, teaching, and behavior are being sold to parents and teachers everyday (Willis, 2006). Teachers can purchase books and programs with brain-based strategies and parents can purchase programs to develop the female brain. Racine, Bar-Ilan, and Illes (2005) argued that *neurorealism,* a phenomenon making research findings uncritically real and objective, has become the norm and our experience was telling us this was true.

However, what was it that was making this information so believable? Why were our students enthusiastically talking about strategies and purchasing products simply because neuroscience was linked? Could the mere mention of neuroscience or fMRI images be enough to persuade? As we conducted our search we found that McCabe and Castel (2007) asked similar questions. These researchers gave undergraduate students articles with incorrect information and found that students perceived them to be credible if they contained an image of the brain. These researchers contend that fMRI images are perceived as evidence because they provide a tangible physical explanation of thinking. To them, images appeal to intuitive reductionist notions even though thinking and learning are difficult to capture even with the most sophisticated tools. In a follow-up study, Weisberg, Keil, Goodstein, Rawson, and Gray (2008) found that the mere mention of neuroscience, even without brain images was enough to sway judgment and reasoning.

To help educators gain a realistic perspective of the applicability and usefulness of neuroscience, Sylvan and Christodoulou (2010) explained how it is being used. These researchers pose that neuroscience is being used to (a) create educational theories that explain learning, (b) develop principles and techniques to guide practice, (c) develop training to change behavior, and (d) create products that claim to have explicit brain-behavior links. Each of these uses makes sense if there is scientific backing. For example, the International Dyslexia Association and Florida Center for Reading Research promote techniques and products that were used in neuroimaging studies and aligning to scientifically based research. Sylvan and Christodoulou also provided a framework to evaluate each of their ideas and use neuroscience properly. To be useful, a theory, strategy, or product must match educational goals and the needs and background of the students. It is also important that the theory, strategy, or product be backed with evidence. Scientists have empirically investigated the idea and published their findings in peer-reviewed journals. Teachers, principals, and others who use brain-based products or strategies should also weigh their benefits and costs. In budget-strapped times, programs that demand time and money investments should be worth the price. If a less expensive process or product gives equal benefit it may

be worth using even if there is no neuroscience link. Teachers, principals, and others who use products and ideas based on neuroscience must be critical consumers. They should demand evidence not only theoretical but behavioral as well. Documentation of observable behavioral changes should be included with any ideas or product being sold. Sylvan and Christodoulou believed that this framework should be applied to any theory, strategy, or product being used in the name of neuroscience. Students in teacher preparation programs and teachers must think critically about information and products being sold to them in the name of neuroscience (Willis, 2006). If they do not they will be wasting valuable instructional time and their own money.

Neuroscience can be alluring, and given that it was to our students, we began to investigate their beliefs about neuroscience. In our first investigation, *What Future Teachers Think about Brain Research* (Zambo & Zambo, 2009), we used a survey to investigate the beliefs of 215 preservice teachers. In this work we found that preservice teachers believe information from neuroscience would make them better teachers and should be part of their training. The preservice teachers in our study had few concerns about neuroscience and education. They neither agreed nor disagreed that neuroscience could be misunderstood or misapplied to classrooms.

These results, although interesting, did not help us gain deep insight into the beliefs of practicing teachers. Novice teachers were interested in neuroscience and unquestioningly believed in its promises. However, would practicing teachers hold the same interests and beliefs? The purpose of this second study was to delve deeper with a population already in the field. In this study we investigate the beliefs of practicing teachers' in an open and qualitative way.

Method

This study took place in a college of education at a large state university located in the southwestern United States. The university is typical of most across our country. It provides a sound, basic curriculum, but because it is not affiliated with a hospital or neuroscience laboratory it offers no courses that focus on the applicability of neuroscience to education. At the master's level there are a few courses (e.g., child and adolescent development, educational psychology, special education) where textbooks provide information about the brain and its development.

Participants

In this study participants were enrolled in this program. They were master's level students enrolled in a child development or educational psychology course during spring or summer and fall of 2009. The participants were a purposive sample chosen because they had recently been exposed to ideas from neuroscience in their course readings, discussions, or both.

The sample was composed of 56 female and 6 male participants ($N = 62$). Even though female participants outnumbered male participants, we felt this is a representational sample. Most teachers in schools today are women; therefore it was reasonable that women would comprise a major portion of the group surveyed. The ethnicity of participants included 51 Caucasians, 7 Hispanics, 2 African Americans, 1 American Indian, and 1 Asian American. The teachers in this study taught varied grade levels. Fifty-three taught preschool–primary grades (Pre-3), 6 taught the middle grades (4–8), and 3 taught at the high school level. The years of experience of this group included 21 new to the profession (1–4 years of experience), 27 with 5–9 years of experience, and 14 with 10+ years of experience.

Data Collection Tools and Procedures

Participants were solicited in their classes, and those who gave consent completed an electronic version of the *Opinion of Neuroscience for Educators Questionnaire*. The first page of the questionnaire asked participants to provide demographic information. Page two began with a brief introduction to neuroscience and a few of the new imaging tools scientists use.

The questionnaire then asked participants to answer this question: What do you think about neuroscience and education? The questionnaire can be found in the Appendix.

The questionnaire was housed in course shells. Participants accessed the questionnaire, downloaded it, and answered on a voluntary basis outside of class. Completed questionnaires were sent to the first researcher in an e-mail. As questionnaires were received answers were downloaded and assigned a number. E-mails with identifying information were deleted.

Data Analysis

Data collected were intended to reveal teachers' beliefs about neuroscience and education. With this in mind, we used constant and comparative in our analysis (Glasser & Strauss, 1967). We progressed inductively. To build an explanatory framework we moved between data, codes, and theory as data were amassed and analyzed. To ensure credibility we explain each phase of our process.

Phase 1: Summarizing and packaging the data. Both researchers read and reread the questionnaires independently. After this reading, we made an analytic choice to place the data into a partially ordered matrix checklist (Miles & Huberman, 1994). The matrix contained the raw data separated by question in the left column and initial key words horizontally on top. Our choices in creating keywords at this phase were careful and inductive.

After creating keywords for the entire corpus of data we began to move idea units. This sorting began our evidence path. Keywords with data were revisited, and words became our codes. Codes with support were created, codes with no support were removed, and data without codes were reevaluated. After coding was completed, we began to take notes on preliminary linkages to make initial interpretations.

Phase 2: Repackaging, aggregating data, and developing propositions. Our goal in this phase was to uncover the nuances the data contained, how they fit together, and what if any gaps remained. We began searching for relationships and writing detailed analytical memos. We returned to our matrix and looked for linkages among the individual codes and across the entire data set (Erikson 1986). We then broke apart the matrix and created a conceptual map. We fit codes together in an attempt to show relationships and hierarchies. Codes that connected were linked into larger categories and conceptual frames. As we did this the salient, repeated beliefs began to emerge and allow us to formulate theories; beliefs mentioned less often were rethought or put aside.

In mapping, we began to move from the empirical to the conceptual, and this allowed us to begin memoing (Miles & Huberman, 1994). We began to write our impressions to make our thoughts visible. Doing this at this phase helped to verify, check rival ideas, and reflect on surprises and data that did not seem to fit.

Phase 3: Creating an explanatory framework. During Phase 3 we used the conceptual map's nodes and connections to create an explanatory framework. Themes were articulated and assertions were made with evidence from participants' words (Erikson, 1986). As we wrote, we

consistently checked the effects of our collection methods and analysis on our findings. We reviewed our analysis and went back to the original corpus of data numerous times to make sure our findings were inclusive, trustworthy, and credible. As a result of this we claim process validity. We maintain the process was performed in an analytical, dependable, and competent manner. We claim credibility with reflectivity, detailed procedures, and a clear and comprehensive audit trail. We do not, in any way, claim generalizability nor do we present our findings as a true or the only perspective known.

Phase 4: Analyzing by years of experience. The purpose of this study was to uncover what a group of teachers believed about neuroscience, education, and themselves in their own words. However, after an inspection of the demographics of our participants we began to realize that they were fairly homogenous in most ways except years of experience. Therefore, we began to wonder if years of experience mattered to teachers' beliefs. Specifically, we wondered whether teachers with more or less experience would hold similar or different beliefs.

To answer this question we returned to the initial corpus of data. We coded each questionnaire with the assumptions made. These were then sorted into a new matrix that contained each participant's years of experience and a holistic overall rating of the data the participant supplied. Doing this allows us to present additional these findings by experience.

Results

When the entire data set was analyzed we discovered that the beliefs of teachers in our study fell along a continuum that included *believers*, *believers with reservations*, and *nonbelievers*. Each of these groups held very different views of neuroscience. We begin with the believers.

Believers

Fifty-seven percent of the teachers in our study believe neuroscience has value for education. When asked about neuroscience they used words like "it absolutely should be given to teachers," "certainly," "definitely," and "of course," as if there could be no doubt. To them this information is legitimate, noteworthy, and true and provides them with what they need. In one participant's words, "Findings from neuroscience provides us with what we need to do our job." Another noted, "Neuroscience should be taught to every teacher and every parent in every school."

Teachers who believe in the benefits of neuroscience for education think there is "scientific evidence" to the claims being made. They put their faith in programs and ideas because they stem from science, medicine, and new technologies:

> With the way technology is today and all of the amazing things happening in the medical field teachers need to recognize that neuroscientists are creating programs that help brains learn. If doctors say they are okay teachers should use them.
>
> Neuroscientists and doctors have access to tools that provide hard evidence. They image a child's brain preintervention and then after intervention has been done. This gives indisputable evidence that is not easy to dismiss.

Teachers who believe in neuroscience think it is their duty as teachers to use ideas from neuroscience in their classrooms. To them, teachers must do

"whatever it takes" to help students learn, and to this group, whatever it takes includes neuroscience.

Believers in neuroscience also think it can be used to settle some of the debates surrounding education:

> As teachers learn more about the brain they can use this information to understand how children learn and what they need to do. Brain research can change how we teach and possibly put to rest many of the debates that surround education today. Neuroscience is what the field of education needs to finally settle its arguments.

Given these strong beliefs it became evident that believers also thought information from neuroscience should be part of their training and the more information they receive the better. This group believes the growth of neuroscience is a "normal part of scientific progress and can be used to advance the teaching profession." They see neuroscience as the most current and up-to-date information teachers can receive. One participant said

> Teachers need to be trained in this information because all day long they are giving students information to process in their brains. Teachers need to know how brains take this information in. Teachers want to take classes and receive professional development on the brain.

Participants in this group believe neuroscience has value. However, they also believe that the information can be especially valuable for teachers working with students with special needs. To this group neuroscience can be used to diagnose students and provide a rationale for differentiated instruction that focuses on particular learning styles:

> Neuroscience is a more concrete way to diagnose learning problems. Neuroscientists and teachers can see brain differences. There are also programs and strategies that focus on learning styles. Information likes this helps teachers differentiate instruction and this makes students with learning, behavior, and social problems succeed.

In addition to believing in the scientific and medical backing of neuroscience, believers also believed because of the testimonials their colleagues supplied. Colleagues who had attended workshops brought back information and spread the word. Teachers who were the recipients of this information saw this as a pay-it-forward situation. One believer said,

> When teachers go to workshops they see the benefits and they want others at their schools to know what they learned, so they hold trainings. They hold workshops or spread information by word of mouth. Teachers have to spread the word.

Teachers are teaching each other about how to apply neuroscience in their classrooms but they are also watching television shows to understand their students and the important role the environment plays on students' brains:

> Shows like the Oprah Winfrey show and Dr. Phil talk a lot about the brain and

> this helps teachers understand children, especially those who have been abused or have learning problems. The Oprah show recently showed a girl who had been deprived of all experiences and stimulation early in her life. This girl's doctor said she had the mental maturity of a one-year-old. Her doctor felt her brain had missed some critical learning experiences so he gave her an enriched environment. This story helps teachers understand the importance of their job. There are abused and neglected students in our classrooms, and we create environments that help their brains thrive.

Others believers thought ideas aligned with their personal experience with children, how they learn, and what they need. One participant said, "Children have a lot of energy so if brain-based programs harness that energy and cure that itch to move they sound wonderful." Another noted,

> The brain of a child who is upset cannot learn because they are functioning in the brain stem. I use music and breathing to help students calm down. This calms the neurons and gets them to a state where they can think and learn.

Several comparisons were also made. One believer said, "Just like a flower needs sunlight and water to grow the brains of children need stimulation to support the growth of neurons." Another noted, "The brain is like a muscle. The more children exercise it the stronger it will grow!"

Yet, even with these strong beliefs these teachers also recognize that there are colleagues who do not share their beliefs. They likened this hesitation to other scientific discoveries:

> Neuroscience provides teachers with new information and tools. Brain research is the most current and accurate research any teacher can use. There is real science behind it. Unfortunately, some teachers choose not to use it. Just like other discoveries, paradigm shifts are hard to make. It's like when computers first came out. Some teachers thought they didn't need computers in the classroom. They thought students would become illiterate if they used a word processing program to write. Of course it's evident these individuals were wrong. It is as important for teachers to use neuroscience as it is for them to use computers.

Teachers who believe neuroscience can and should be applied to the classroom believe wholeheartedly and without any doubt. They put their faith in neuroscience, seek it out, and think they are applying it properly because it aligns with their beliefs about teaching and learning even though some of their uses are not backed by research. Believers think information from neuroscience should be taught to them because it is current, helps them understand students with special needs, and provides insight into students' needs. Believers want information and seek it from each other and the media. Believers have no concerns about neuroscience. They liken doubters of neuroscience to those who failed to see the relevance of other discoveries.

Believers with Reservations

Twenty-four percent of the participants in our study held cautionary or reserved beliefs about neuroscience and education. When asked to state their beliefs about neuroscience these teachers always started saying something positive but then, midstream, they began to change their mind. Teachers with Reservation thought information from neuroscience was valid but always added a caveat, hesitation, or contradiction. They started out positively but as they began to articulate their reasoning they became less sure.

Participants with reserved beliefs accepted neuroscience but felt it was only part of what they needed to know. To provide answers for them neuroscience would need to be combined with other information and other disciplines. Even though teachers in this group believe information could be useful they also believe it is not complete. There was an air of caution in their words. Participants said, "Teachers *wish* neuroscience would give them answers but it's only part of the answer. Other disciplines like psychiatry, child development, and educational psychology also help."

Believers with reservations thought neuroscience, when combined with other findings, offers insights they can use but they also thought that they needed to be protected from unfound claims. Whereas the believers saw neuroscientists and doctors leading them in the right direction, this group did not see themselves as knowledgeable enough to interpret their results. Believers with reservations said, "Neuroscience is great and gives ideas but teachers need to keep their eyes open. There are a lot of complicated terms and ideas. Teachers are not neuroscientists or doctors so they need someone to help them sort ideas out."

It is also interesting to note that even though this group did not see themselves as totally capable of understanding neuroscience they suggested teachers should give it a try. Teachers in this group saw no harm in using information from neuroscience, but they specified when and where this information should be applied. Even though believers with reservations would use ideas from neuroscience they would not expect miraculous results. Believers with reservations said, "Teachers should give brain-based activities a try but use them as fillers, when a class is waiting in line or during transition times. It's okay to use brain-based activities but not to learn. Teachers should not expect miracles."

Believers with reservations would not mind participating in training focused on neuroscience, but they want this training to be on their own terms. As noted earlier, these teachers do not see themselves as knowledgeable as neuroscientists so they do not want complicated or drawn-out training sessions. They do not want complex terminology and unusable facts. These teachers wanted scientific information in digestible terms. They wanted strategies to raise achievement scores. They wanted strategies they could implement immediately:

> Teachers need training about the brain but keep it short and make sure it's not the same information every year. Teachers should not be expected to sit through long and boring workshops with a lot of complex terminology. Nor should they be expected to learn a large amount about the brain. Teachers don't need to know this structure does this and that one does that. Teachers need to learn what this translates

> to in everyday terms. What does this mean in the classroom? What can they do to help students learn?

The believers with reservations were fewer in number than those who believed. Teachers in this group believed in the value of neuroscience, but they consistently had reservations. They stated a positive idea but then changed their mind. Believers with reservations noted neuroscience should not be the only filter used to understand students nor be theoretical and devoid of their needs.

Nonbelievers

Nineteen-percent of the teachers in this study believed that neuroscience was of no use to them at all. Nonbelievers were negative and cautionary. These teachers were not going to accept secondhand information. They wanted to see the data for themselves and investigate the validity of claims. One participant acted on this by doing some research on the Internet:

> I had not heard much about the application of neuroscience to education so I decided to look into it a bit. I Googled brain-based strategies for the classroom and Brain Gym came up as one of the most popular programs being used in schools. So I decided to check into this. Wikipedia was my best source, and they had much to say. According to an article published in *Nature* by Professor Usha Goswami on Brain Gym, she said this program is based on neuromyths and needs to be eliminated. She attributes the success of the brain-based learning industry to inspirational marketing. Teachers are getting sold on the supposed benefits of programs and beginning to see placebo effects.

Nonbelievers think harm could occur if research dealing with an organ as complex as the brain moves too quickly or is unsupervised. They paralleled new research to harmful studies conducted in the past.

> Teachers need to be aware of the research behind the claims. They need to be aware of how scientists test certain things. Consider little Albert, the baby Watson worked with and caused to fear anything with fur. This experiment should make teachers cautious. It was abusive and likely had long-term effects on the baby. Neuroscientists and teachers need to keep Albert in mind. Kids being scanned are unique. They have emotions and thoughts, as well as brains. It would be a mistake for teachers to want more and more brain scans without knowing the effects of these scans on children. Moving too fast could cause harm.

These participants believe that neuroscientists need to be ethical. They need to recognize they are dealing with children who could be harmed if their research is not conducted with the child in mind. Nonbelievers did not like the idea of using neuroscience to understand students. Even though information from neuroscience is appealing to their colleagues, they felt it was impractical and did not address their immediate needs. One nonbeliever said,

> Neuroscience, as it stands today, is too removed from classrooms. Right now

> teachers would be hard-pressed to find any information they could use. Teachers want to research to help them teach. They want to see results but neuroscience is not there yet.

Nonbelievers do not want training in brain-based strategies. In fact, they saw this training as cult-like. They believe teachers who use this information are brainwashed into thinking a certain way. One nonbeliever said, "There are brainwashed teachers using brain-based strategies and products. Go into any teacher store you'll see shelves of books based on the brain. It's just the latest fad teachers are following. It's like a cult."

Nonbelievers are not buying into the claims being made by sellers of neuroscience. Instead they are asking questions and stating strong viewpoints:

> Findings from neuroscience are allowing manufacturers of trash science to make a lot of money. But what do they really provide? Do they give teachers concrete strategies and tell them the content children need to know? Right now these programs are quick fixes. They make teachers feel like they are doing something. They make them feel good for a while. However, in the long run teachers using them will come up empty.

Nonbelievers question findings being made and at the same time see neuroscience as a threat to their professionalism:

> If products and curricula based on the neuroscience help students learn teachers will lose their jobs. If brain tricks made a difference anyone can be hired in our place. What happens to our judgments? Where do our observations fit in? What if our beliefs and data conflict with neuroscience? Will the public believe a teacher's ideas over scientific/medical evidence?

Others did not focus on their professionalism but instead focused on the children they teach. They believe there is more to children than what can be seen in images of their brains. This group believes it is the interactions between teachers and students that matter most:

> The brain is a multifaceted and individual organ that is a small piece of a complex system. Anyone who works with children recognizes this. Even if neuroscientists are able to provide colorful images they will never be able to help teachers understand how to read the expression on a child's face or understand what a child needs. Brain scans will never tell teachers if a child is feeling sad and needs comforting. Children need humans who know this.

Nonbelievers were fewer in number and did not believe in the benefits of neuroscience even though they felt the field has made advances. Nonbelievers were not going to accept secondhand information: They wanted to see the data themselves and investigate the validity of the claims.

Years of Experience

Although this study was designed to reveal what a group of teachers believed about neuroscience in their own words, as we analyzed our data we began to realize

that our participants were fairly homogenous except in their years of experience. Therefore, we began to wonder whether their years of experience mattered to their beliefs. Specifically, we wondered whether teachers with more or less experience would hold similar or different beliefs. To answer these questions we used each of the categories we had discovered (believers, believers with reservations, and nonbelievers) to rate each data source holistically. We then were able to separate these by teacher's years of experience. These results are provided in Table 1.

Table 1. *Examining Data By Years of Experience*

Years experience	No.	Believers	Believers with reservations	Nonbelievers
1–4 years	18	13/18 = 72%	2/18 = 11%	3/18 = 17%
5–9 years	23	11/23 = 70%	2/23 = 13%	4/23 = 17%
10+ years	13	4/13 = 31%	7/13 = 54%	2/13 = 15%

Table 1 allows us to see that 72% of the teachers with 1-4 years of experience and 70% of the teachers with 5–9 years of experience were believers in the value of neuroscience. The majority (54%) of teachers with 10 or more years of experience were believers with reservations. Implications of this and the overall analysis are discussed below.

Discussion and Implications

Given our experience as researchers and teacher educators we believe that neuroscience is seeping into the lives of teachers. Teachers are interested in the brain and their beliefs about neuroscience are changing. The brain is being discussed in informal conversations and course discussions, and this discourse is showing that there are various levels of knowledge and beliefs. This has implications because the beliefs teachers hold influence the curriculum they provide, how they teach, and what their students learn (Good & Nichols, 2001; Kagan, 1992). Beliefs come from experience, and core beliefs can be self-perpetrating and difficult to change especially when information, like information from neuroscience, is perceived to be scientific even if it is wrong. Given the persuasiveness of neuroscience and the importance of beliefs, we set out to understand what teachers believe.

Analyzing the beliefs a group of teachers posed in an open-ended questionnaire and essay we found three groups (believers, believers with reservations, and nonbelievers). With further holistic analysis we were able to describe the percentage in each of these groups by their years of experience. The majority of the teachers in this study believe wholeheartedly in neuroscience, and these teachers are in the earlier years of their careers. Most of the believers had been teaching 1–9 years. Believers with 10+ years of experience were few.

Teachers who believe in neuroscience hold an absolute and positive view. Believers think neuroscience stems from new technologies and because of this they see credibility in the information they receive. Believers accept ideas without evidence. They believe in the benefits of neuroscience, and they are learning about it through each other, workshops, and courses. Believers think information from neuroscience should be part of their training and want the most information they can get.

Believers are doing more than just talking; they are applying ideas from neuroscience to their classrooms. Their students are breathing, crossing hemispheres, hydrating their brains, and taking brain breaks because believers think these actions help students relax, become

attentive, and get ready to learn. Believers have personal experience with neuroscience, and these become core beliefs. For most of the teachers in this study the application of neuroscience to their classrooms was not believed to be a bridge too far (Bruer, 1999, 2006). Unfortunately, when one looks carefully at what believers are saying it becomes evident that their bridge has structural flaws. The words that believers provide give few specific links to research and the ideas they are trying seem to be wasting valuable instructional time. Teachers posing quick and easy fixes would be hard pressed to find research to support their use of crossing hemispheres, hydrating brains, or focusing on learning styles as valid ways to help children learn. Having enough water and a good breakfast to think clearly makes sense, but the question is, does this information come from neuroscience, or is it an overextension of ideas neuroscience provides? There is no doubt that new and important insights from neuroscience are being discovered, but as McCabe and Castel (2007) and Weisberg et al. (2008) found, this information can be misconstrued. Core beliefs can be difficult to change, and teachers would benefit from Sylvan and Christodoulou's (2010) understanding of what theories, strategies, and products have been empirically investigated and published in peer-reviewed journals.

A smaller group of the teachers in this study accept findings from neuroscience but with reservations. It is interesting to note that the majority of teachers in this group had 10+ years of experience. Teachers in this group are hesitant to accept neuroscience wholeheartedly. Instead of wanting the most information they can get, they focused on information that is pragmatic and leads to students' success. Teachers with reservations believe neuroscience should be used in conjunction with other disciplines and filtered by those more knowledgeable. Strategies from neuroscience have a proper place and time in the school day, but this is not during content area time. Given that most of the teachers in this group had 10+ years of experience, it seems that perhaps it is their experience that is contributing to their hesitancy. Perhaps more-seasoned teachers are aware of new ideas, including those from neuroscience, but are wary of applying these to their classrooms. This may be a good way of thinking according to Sylvan and Christodoulou's (2010) frame. Perhaps seasoned teachers recognize that a theory, strategy, or product must match the educational goals they set for their students and their students' needs and backgrounds.

The nonbelievers were fewest in number and the teachers in this group were evenly distributed by their years of experience. These teachers want to see the research for themselves and are willing to question it and find the validity of claims being made. So even though information from neuroscience is appealing to their colleagues, they raise questions about it. They believe that as it now stands it is impractical and does not address their needs. When it comes to professionalism, nonbelievers and believers hold opposite views. Believers think neuroscience increases their professionalism, whereas nonbelievers see it as a threat. Nonbelievers think their experience and judgment could be challenged with technology and by the views of outsiders.

It is amazing how nonbelievers seem to be using the ideas of Sylvan and Christodoulou (2010). They want evidence that a theory, strategy, or product has a behavioral link. They also want to know that ideas and products have been empirically investigated and results published findings in peer-reviewed journals. They want to be sure the benefits outweigh the costs; costs to

them were not monetary but connections and bonds.

So the question for those of us who are teaching educational psychology is, what does this mean for us? When we hear our students enthusiastically talking about strategies and products what can we do and where do we begin? First, we believe teachers need the best and most up-to-date information, but like Sylvan and Christodoulou (2010), we believe they need a framework, and the one they provide is a good place to start along with information in educational psychology textbooks. However, when beliefs focus on quick and simple fixes teachers need to understand that their beliefs are wrong. When they use theories, strategies, or products they believe are making a difference they should be asked to supply the following:

1. Who published–posted the theory, strategy, or product? What are their credentials? Why should they be believed–trusted? Are there financial gains to be made if the idea is tried?
2. Is the information written clearly? Is jargon used? Are complex terminology and facts made understandable to hide the facts? Is there valid evidence the theory, strategy, or product really changes terminology and facts made understandable to hide the facts? Is there valid evidence the theory, strategy, or product really changes the brain quickly and easily? Is there behavioral and other evidence? Does it converge and align with other disciplines (e.g., psychology, child development)? Are claims logical or are broad and overstated claims being made? Does it confirm or disconfirm practical sense? Will observable evidence be available to share with parents?

Those of us who teach educational psychology know it is our job to help teachers understand how students think, learn, and feel and today this information is intertwined with neuroscience. These are exciting times, and it is up to help teachers think critically, use valid information from both educational psychology and neuroscience, and sort out fallacies from facts.

References

Bruer, J. T. (1999). In search of . . . brain-based education. *Phi Delta Kappan, 80,* 649–657.

Bruer, J. T. (2006). Points of view: On the implications of neuroscience research for science teaching and learning: Are there any? A skeptical theme and variations: The primacy of psychology in the science of learning. *CBE-Life Sciences Education, 5,* 104–110.

Erikson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., 119–161). New York, NY: Macmillan.

Errington, E. (2004). The impact of teacher beliefs on flexible learning innovation: Some practices and possibilities for academic developers. *Innovations in Education and Teaching International, 41,* 39–47.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research 38,* 47–61.

Glasser, B., & Strauss, A. (1967). *Discovery of grounded theory*. Chicago, IL: Aldine.

Good, T. L., & Nichols, S. L. (2001). Expectancy effects in the classroom: A special focus on improving the reading performance of minority

students in first-grade classrooms. *Educational Psychologist, 36,* 113–126.

Holt-Reynolds, D. (1992, April). Preservice teachers and coursework: When is getting it right wrong? Paper presented at the 73rd annual meeting of the American Educational Research Association, San Francisco, CA.

Kagan, D. M. (1992). Professional growth among beginning and preservice teachers. *Review of Educational Research, 62,* 129-169.

Levin, B., & He, Y. (2008). Investigating the content and sources of teacher candidates' personal practical theories (PPTS). *Journal of Teacher Education, 59,* 55–68.

Luft, J. A., & Roehrig, G. H. (2007). Capturing science teachers' epistemological beliefs: The development of the teacher beliefs interview. *Electronic Journal of Science Education, 11,* 38–63.

McCabe, D. P., & Castel, A. D. (2007). Seeing is believing: The effect of brain images on judgments of scientific reasoning. *Cognition, 107,* 343–352. doi: 10.1016/j.cognition,2007.07.017

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

Racine, E., Bar-Ilan, O., & Illes, J. (2005). fMRI in the public eye. *Nature Reviews Neuroscience, 6,* 159–164. DOI: 10.1038/nrn1609

Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension instruction. *American Educational Research Journal, 28,* 559–586.

Stamm, J. (2007). *Bright from the start: The simple science-backed way to nurture your child's developing mind, from birth to age 3.* New York, NY: Gotham Books.

Sylvan, L. J., & Christodoulou, J. A. (2010). Understanding the role of neuroscience in brain based products: A guide for educators and consumers. *Mind, Brain, and Education, 4,* 1–7.

Varma, S., McCandliss, B. D., & Schwartz, D. L. (2008). Scientific and pragmatic challenges for bridging education and neuroscience. *Educational Researcher, 37,* 140–152. DOI: 10.31102/0013189X8317687

Weisberg, D. S., Keil, F. C., Goodstein, E. R., Rawson, & Gray, J. R. (2008). The seductive allure of neuroscience explanations. *Journal of Cognitive Neuroscience, 20,* 470–477.

Willis, J. (2006). *Research based strategies to ignite student learning: Insights from a neurologist and classroom teacher*. Upper Saddle River, NJ: Association for Supervision and Curriculum Development.

Zambo, D. & Zambo, R. (2009) What future teachers think about brain research. *Teaching Educational Psychology, 2(5),* 39-49.

Debby Zambo is an Associate Professor at Arizona State University in Mary Lou Fulton Teachers College. Her research interests include the applicability of educational psychology and neuroscience for educators and the value of action research.

Ron Zambo is an Associate Professor at Arizona State University in Mary Lou Fulton Teachers College. His research interests include mathematics education and the value of neuroscience for educators.

Appendix

Opinion of Neuroscience for Educators Questionnaire

This survey is designed to help us understand what you believe about brain research and its implications for education. Your responses are important and we appreciate your help!

To answer please place an X in the boxes.

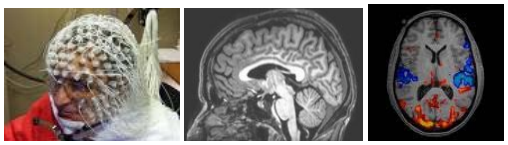
Gender:
☐ Male
☐ Female

Ethnicity:
☐ American Indian or Alaskan Native
☐ Asian or Pacific Islander
☐ Biracial or Bicultural
☐ Black or African American
☐ Hispanic or Latino
☐ White - Caucasian
☐ Other

Current assignment:
☐ Preschool
☐ Primary grades (K-3)
☐ Intermediate grades (4-5)
☐ Middle school (6-8)
☐ High School (9-12)
☐ Older

Years experience working with children:
☐ 0 – 2 years
☐ 3 - 5 years
☐ 6 – 10 years
☐ over 10 years

Introduction and Directions:
The rapid development of brain imaging tools is allowing neuroscientists to peer inside the brain and see how it functions as it performs a task. Some of the ways neuroscientists gather information include:



ERP - measure changes in the brain's electrical activity
EEG - measure brain waves
MRI - uses magnets and radio waves to image soft tissue
fMRI - measures oxygen use in brain structures

As a result of these new technologies, an abundant amount of information about the brain is being published in the media and marketed to teachers. Teachers can read about how specific brain areas process information and they can purchase products to help the brains of their students become motivated and learn easier. But what do you, as a prospective teacher/teacher think about all of this?
Please take your time to explain your beliefs as thoroughly and honestly as you can. Type your answer in the box (save along the way). When you are finished please e-mail your replies to the name listed in the consent letter.

What do you think about neuroscience and education?