Building Mind, Brain, and Education Connections: The View From the Upper Valley

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ABSTRACT—This article describes the efforts of a small group of educators and researchers to build a model for making connections across mind, brain, and education. With a common goal of sharing, strengthening, and building useable knowledge about child and adolescent learning and development, we focused on questions of mutual interest to educators and researchers. We describe our efforts to develop a common vocabulary and language and to create opportunities for dialogue and discussion, including classes and talks for in-service and preservice teachers, research laboratories open to in-service and preservice teachers, local conferences that provided a context for educator and researcher interactions, and researcher outreach in the local education community at the administrative, classroom, and student levels. These activities represent concrete mechanisms by which links might be forged between educators and researchers within the context of Mind, Brain, and Education.

INTRODUCTION

The purpose of this article is to share our experiences with building a model for making mind, brain, and education connections between schools and research laboratories. In part, our goal was to find ways to involve teachers integrally in the endeavor to make such connections, as we believe that the engagement of educators is crucial to the sustainability of the field of Mind, Brain, and Education. Although we recognize that this is not the only possible model for making such links (e.g., laboratory or research schools are another viable model; Hinton & Fischer, 2008) and we in no way offer our experiences as a blueprint, we chronicle our efforts in order to illustrate some ways to begin making meaningful connections across disciplines. These might be considered components in the development of "a fundamental infrastructure for connecting the work of researchers and practitioners" (Hinton & Fischer, 2008, p. 157). Overall, we write to provide ideas about how connections might be made on a small scale, given our joint efforts with three researchers and an administrator in a small region of northern New England.

The Upper Valley region encompasses portions of Vermont and New Hampshire, and the schools in this area are organized in a number of ways both educationally and geopolitically—which has a potential impact on building a mind, brain, and education model. Educationally, schools in the Upper Valley are generally small and rural, with many K–6 schools having fewer than 100 students. Elementary schools typically include Grades K–5, although some schools are K–2, K–3, K–4, 3–5, or 3–6. Middle school organizations also vary and can include Grades 5–8, 6–8, or 7–8. High schools usually include Grades 7–12 or 9–12. Some districts include Grades K–12 in a single building. Geopolitically, Vermont schools are organized into Supervisory Unions (SUs), whereas New Hampshire schools are organized into School Administrative Units (SAUs). The three SUs and SAUs with which we were directly associated (Michlovitz) had an average faculty size of about 300. Schools that belong to the SUs may each have their own school board that oversees many educational functions, including reviewing proposals for research in schools within the SU; approval of the board may be necessary but not sufficient for action to be taken on issues such as mind, brain, and education initiatives. In New Hampshire, the SAUs provide common services but the multiple school districts within an SAU essentially act as independent school districts, and individual district approval is needed to advance initiatives.

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Given these educational and geopolitical conditions in Upper Valley schools, creating a context for mind, brain, and education initiatives involves discussion with administrators at both the building and the SU/SAU levels. Connections between researchers and teachers and parents must be built through relationships with (not around) the administrative hierarchy, that is, the administration is a crucial component of the interaction between schools and research that is at the core of building mind, brain, and education connections.

Dartmouth College is also located in the Upper Valley and includes one of few undergraduate education departments that incorporate neuroscience as an integral piece of the curriculum. In a department focused on human development and learning, many of the courses offered reflect a science of learning approach, discussing multiple facets of development across multiple disciplines (including neuroscience) and challenging students to think about learning in new ways, on multiple levels (e.g., both the behavioral and the neural levels). The department also includes a small teacher education program (with an average cohort of about nine students over the past 7 years), through which undergraduate students can become certified to teach in the state of New Hampshire. One of the goals of the department is to develop new teachers who have not only begun to master the art of teaching but who are also thoroughly grounded in the research-based science of learning and are able to use that knowledge to better understand their students and, eventually, use that knowledge in their classroom practice. Our expectation is that such teachers will become leaders not only in their classrooms but also in their schools, school districts, and states.

We envision collaboration and cross talk between educators and researchers, between classroom and laboratory, to be at the center of the field of Mind, Brain, and Education. We believe that sharing expertise in learning and development across traditional boundaries, from the ivory tower to the trenches and back, will strengthen what we know about how children and adolescents learn. In turn, this will not only engender new research on learning but also contribute to the development of teaching practices and educational policy that are based on scientific evidence about learning, in a reciprocal process and in a responsible way (e.g., Huston, 2008). As in the research school model, we believe that "a bidirectional relationship between research and practice is needed to help teachers understand scientific findings and to steer researchers toward questions that are relevant to educational practice" (Hinton & Fischer, 2008, p. 158). Educators and researchers often have questions about learning and development that are of mutual interest, and much of our effort to create links across mind, brain, and education in the Upper Valley included attempts to develop a common vocabulary—across students, educators, and researchers—so that those questions could be addressed fruitfully at multiple levels.

TEACHING TEACHERS AND RESEARCHERS

Despite a high level of interest (cf. Pickering & Howard-Jones, 2007), teachers in the Upper Valley generally have little or no training in the neurosciences and typically little or none has been provided at either the in-service or preservice level. Teachers are generally exposed to opinion-based rather than research-based information and "silver bullet" merchandising of programs and products purportedly based on brain research. Indeed, so-called "brain-based" commercial programs and products are widely available, and many such popularized materials are based either on pure opinion or on the notion that the results of laboratory neuroscience experiments can be applied directly to classroom teaching, that is, that neuroscience can tell teachers what to do in the classroom (see, e.g., Goswami, 2006). We believe that such expectations for neuroscience-based, easy-to-follow recipes for practice are unrealistic; much of the brain-based learning material, upon closer inspection, often is based on very loose links and factually incorrect interpretations or gross generalizations of neuroscience data. Given that context and the need for teachers to understand that Mind, Brain, and Education must be based on careful and critical evaluation of rigorous and peer-reviewed research, the issues become how, where, when, and at what level to educate educators about the neurosciences.

In our experience, building the evolving interface between education and the brain sciences by teaching teachers in the Upper Valley began almost two decades ago when one of us (Michlovitz) began offering a graduate-level class at St. Joseph's College in Rutland, VT called *Learning in the Brain*. From 1998 through 2007, this course was offered on the Windsor Central Supervisory Union campus as a pass-through course with an average class size of about 11 students. Based on demand from students who took this first course, a second-level course was developed in 2004. In *Pathways to Brain-Based Learning*, with an average class size of about six students, teachers revisited the research ideas that they had written about in the first-level course and developed an action research experiment to conduct in a classroom setting. For example, one teacher designed a study examining classroom conditions that influenced performance on memory tasks, and another conducted longitudinal observations of an elementary school child with severe epilepsy in order to identify behaviors that predicted "teachable moments" for the child.

In both courses, teachers visited neuroscience laboratories (e.g., magnetic resonance imaging and event-related potential laboratories) at Dartmouth and interacted with cognitive neuroscience researchers in roundtable discussions. In the second-level class, the teachers discussed their research ideas with the neuroscientists. As many of the teachers involved in the classes were special educators, much of the discussion focused on potential connections among mind, brain, and

education in developmental clinical populations; this natural link in interest served as a fruitful starting point for engaging, multilevel discussion. Through such discussions, teachers became acutely aware of the rigor with which scientific studies need to be carried out in the classroom if the resulting data are to be useful to neuroscientists and other researchers. They also developed critical thinking skills with regard to neuroscience data, recognizing that brain images alone cannot be justifications for practice (see, e.g., Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). In addition, teachers began to understand the importance of isolating dependent, independent, and intervening variables in their studies and the crucial need for controls. Further, they became aware of fundamental differences between traditional educational research, with its often broad, sweeping generalizations based on opinion, and the slow, incremental manner in which scientific statements are corroborated with extensive data and replication in neuroscience research. These teachers who developed the ability to critically evaluate scientific results and popular media reports of scientific results (particularly those related to practices and products that claim to be brain based) were able to discount advice based on inaccurate data and pseudoscience and in the future may be able to force the producers of education-related literature on the brain to provide more sophisticated and accurate information. Overall, the teachers gained further insight into both the interface between neuroscience and education (in which they were actively participating) and the possible classroom implications that might arise from that interface.

In turn, the researchers involved in the discussions learned more about the constraints of the classroom and became more aware of the concrete problems and challenges that teachers face in their work. Listening to the teachers' insights about student behaviors helped the researchers to think about new projects that might build on that knowledge and elucidate some of the mechanisms underlying children's classroom behaviors, such as the kinds of errors that students make. These discussions also made researchers even more aware of the scope and variety of individual differences across children, which are often overlooked in quantitative research. Further, through these discussions, the researchers had to become better communicators about their own research and methods and neuroscience findings more generally. It was fascinating for the researchers to experience how teachers interpreted their data and how difficult it could be at times to find a common language and understanding on both sides of the discussion; just wading through the professional jargon of cognitive neuroscience (e.g., corrected *p* values in a VBM analysis in an fMRI study [translation: corrected statistical significance values in a voxel-based morphometry analysis in a functional magnetic resonance imaging study]) and education (e.g., an IEP for a child with NVLD [translation: an individualized education plan for a child with a nonverbal learning disability]) was at times challenging on both sides. Indeed, presenting empirical findings to educators requires communication skills that are quite different from those that researchers draw on during scientific meetings with their peers. These discussions with teachers forced the researchers to state their findings clearly, while at the same time not compromising the accuracy of their report. Communicating in this way and receiving feedback from teachers who interact with children every day helped the researchers to see their work in a different way. As has been noted previously, "without collaboration, neuroscientists are at risk of running naïve experiments informed by their personal experiences of how children come to learn" (Varma, McCandliss, & Schwartz, 2008, p. 148) rather than how children actually learn in the classroom. To extend the dialogue beyond these discussions, the researchers issued an open invitation to the teachers to collaborate on research in the Dartmouth education department laboratories.

The cognitive neuroscience laboratories in the education department at Dartmouth are not only open to in-service teachers in the community but also to preservice teachers in the teacher education program at the College. Although similar programs have been developed at the graduate level (see, e.g., Blake & Gardner, 2007), the conceptual link to brain sciences in an undergraduate education program is rare. The opportunity in an undergraduate program for hands-on experience in conducting and publishing developmental cognitive neuroscience research in domains crucial to education, such as the development of mathematical (e.g., Ansari & Dhital, 2006; Ansari, Garcia, Lucas, Hamon, & Dhital, 2005) and reading (e.g., Coch, George, & Berger, 2008; Coch, Hart, & Mitra, 2008) skills, is even more rare. Our expectation is that students who have been trained in the science of learning in both the classroom and the laboratory, who have developed the ability to think without or outside of traditional disciplinary boundaries, and who have the skills to critically evaluate and use any kind of information at any level of analysis that can inform their understanding of learning and development will become powerful and knowledgeable teachers. Part of our goal is to foster beginning teachers in appreciating their potential roles in building bridges in the new field of Mind, Brain, and Education; in understanding the developing minds and brains of their students at multiple levels; and in discovering how conceptualizations of learning and development offered by cognitive neuroscience can deeply inform, and be informed by, their own reflections and practice (Ansari & Coch, 2006).

In addition to these approaches to connecting mind, brain, and education with students and teachers in laboratories and classes, we have been involved in a larger biennial conference series called *Building the Interface*. The idea for this conference series arose from the roundtable discussions with teachers and researchers in the graduate-level classes; all participants agreed that it was important to gather together clinicians, neuroscientists, educators, and researchers periodically to discuss current research-based information coming from

the neurosciences as it pertained to improved pedagogy and student achievement. The ultimate goal would be to take findings from neuroscience studies and translate them into practical classroom pedagogy for the purpose of maximizing student achievement; however, all participants recognized that the relevant studies have yet to be completed or even, in many cases, conceived to address this outcome. So the interim goal was to create a forum aimed at presenting information to professional educators in the Upper Valley primarily about recent advances in developmental cognitive neuroscience that had potential implications for and relevance to education and a forum in which researchers and educators could discuss this information. This local conference series, begun in 2003, was designed for teachers, special educators, school counselors, paraprofessionals, administrators, neuroscientists, and psychologists to begin an active dialogue to mutually inform professions and practices. The promotional materials note that, "although we must be very cautious about applying the findings of neuroscience . . . to the complexities of classroom pedagogy and practice, we must continue to engage in formal conversation and exploration that interfaces our respective professions." About 100 participants have attended each of the three biennial conferences, showing a strong level of local interest in Mind, Brain, and Education.

REACHING OUT: SCHOOLS AND LABORATORIES

Although teachers and researchers may share common developmental and educational questions, collaborations between researchers and teachers to answer those questions are not always easy to establish. From an administrative perspective, research in the schools is complex and more often involves researcher requests for access to participants than requests for teacher–researcher collaborations. From the roundtable discussions between educators and researchers in the graduate-level classes, researchers gained insight into the students in the Windsor Central SU and were afforded the opportunity to access those students for research purposes. Through this mechanism, protocols were developed and a true partnership was established between the educators and the local neuroscience community. For example, given the messy geopolitical parameters of the SU system, one SU liaison was established who served as the go-between for researchers and building principals. In this way, schedules, number of requests for research participants, which schools would be involved in which research projects, and other logistical details were attended to and coordinated by one administrator.

In some cases, teachers and administrators might be resistant to the idea of having children in their classes participate in cognitive neuroscience research in part because the notion of brain scanning might seem daunting or potentially dangerous in some way. This is understandable, given that brain scanners are most commonly associated with hospitals where they are used for clinical and diagnostic purposes and associated with illness. However, many teachers in local districts had visited the cognitive neuroscience laboratories at Dartmouth, learned about the safety of the research procedures and the approval process for research studies through the institutional review board, and even volunteered to have their brains scanned and experience the research in action. This hands-on exposure to the research environment, perhaps a form of inquiry science, made the concept of brain scans less abstract for teachers, which helped them to communicate with parents and other teachers interested in the research. Teachers also got to take images of their brains back to their schools, which resulted in significant interest from their students. Throughout, teachers were encouraged to both ask questions and provide ideas about how the research experience could be optimized for child and adolescent participants. Essentially, the researchers strove to design a successful learning environment for teachers as well as child and adolescent participants as part of the research experience. Overall, protocols were developed to involve teachers, students, and parents in the students-as-research-subjects initiatives in order to facilitate the complicated steps required to make the research happen. The researchers involved in projects also made themselves generally available to students, faculty, and parents, both within and outside of school hours, to present the background material around the particular study that was being conducted, and to discuss educational neuroscience information of more general interest.

One example of the success of this type of reciprocal interaction is an intervention study aimed at reducing middle school girls' vulnerability to bullying. The idea for the study came from conversations between the researcher (Baird) and the teachers about what issues take the most time away from classroom time; a 7-week mentoring program to address bullying designed jointly by the researcher and teachers grew from these conversations. In close collaboration, Dartmouth undergraduate students and middle school teachers ran the mentoring program. Both brain and behavioral measures were taken before the start of the mentoring program and at the end of the program. One of the findings was that a behavioral intervention run by teachers and college students produced measurable increases in the activity of neural regions associated with cognitive regulation in some, but not all, of the adolescent girls who participated. In discussing the results of the study with teachers, one of the teachers noticed something about the girls who had not shown changes in neural activity and remarked, " . . . I know these girls, and they are all really tiny." This led the research team to take a second look at the data, which in turn led to the discovery that the intervention was only effective with girls who had reached menarche (Viner & Baird, 2005). This finding has meaningful research and practical applications and has inspired another

wave of empirical work. This research reflects a crucial piece of the neuroscience and education interaction: reciprocity. In our opinion, too many scientists simply collect their data, thank the schools, and move on. In contrast, sharing the raw data and listening to how educators think about it and what conclusions they draw from it—as the people who likely spend the most time with those whom we are studying—can give the research a certain ecological validity that many subdisciplines lack. Thus, we believe that it is the *integration* of perspectives from education, the neurosciences, and psychology that is potentially one of the greatest strengths of Mind, Brain, and Education.

The researchers were also involved with schools in other ways. For example, a local district was considering adoption of a new elementary mathematics curriculum and was struggling to choose between one instructional program focused on teaching "procedures" and another that claimed to enhance children's understanding of "mathematical concepts." The debate over which of these two methods was "best" became quite heated and was accompanied by the formation of factions within the educational community. Frustrated with this situation, the superintendent asked one of us (Ansari) to talk with the teachers about the differences between procedural and conceptual aspects of math learning from a research perspective. In an afternoon presentation and discussion with all the math teachers from the district present, behavioral and neuroscientific data on math learning were reviewed and the teachers' questions were addressed from a research-based viewpoint. Later, the superintendent reported that this event had lowered tensions and helped teachers in the opposing camps to recognize that a false dichotomy had been established; that rather than either/or, both instructional approaches had some value. Similarly, a local superintendent was struggling with one elementary school in the district that used a whole language approach to teach reading and another that used a phonics approach; discussions with one of us (Coch) led to the sharing of accessible scientific information on this issue (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001) with members of the school board and a movement toward a more balanced approach to teaching reading (e.g., Pressley, 2006) in the district. Historically, making connections between research and education in terms of both practice and policy has been difficult (e.g., Condliffe Lagemann, 2000; Hess, 2008) and this continues to be the case. However, such targeted discussions between educators and researchers can build a framework within which to begin forging links or at least kindling interest in making such links. As Hirsh-Pasek and Bruer (2007, p. 1293) have noted, "real dialogue starts when we address misconceptions and misunderstandings across the research/practice divide. Over time, these conversations can lead to a common vocabulary, informed engagement, meaningful applied research, and ideally, evidence-based practice. The conversation might even contribute to more informed policy discussions."

Getting teachers and students involved in the field of Mind, Brain, and Education does not only involve researchers reaching out to schools but also teachers reaching out to laboratories. Over the past few years, two local teachers have been members of our laboratories. One, a sixth-grade social studies and science teacher joined one of our laboratories through a summer externship program for teachers coordinated by the Upper Valley Business and Education Partnership. Through this program, teachers apply to intern in local businesses during the summer months with the goal of bringing their experiences back to the classroom. In her application, this teacher wrote that she was looking for "a placement related to brain function or cognition. In addition to the fact that the brain is a science unit I teach, as a teacher, the more one understands about the brain and learning, the more effective a teacher one can hope to become." In her time in the laboratory, she conducted an independent project reviewing evidence for brain-based gender differences in children, specifically in terms of spatial processing and mental rotation. She shared her findings with the laboratory, with her elementary school faculty, and with undergraduate students in the teacher education program at Dartmouth and their mentor teachers. In terms of her own practices in the classroom, she concluded that there was little convincing evidence for having nonequivalent performance expectations for tasks involving spatial processing for male and female elementary school students.

Another teacher-researcher was a fourth-grade teacher when she first joined one of our cognitive neuroscience laboratories and has since become certified as a reading specialist. She began in the laboratory as a Teacher-Scholar and, when that grant funding ended, remained in the laboratory of her own accord. At the same time as being a full-time teacher and reading specialist, she has slowly learned the techniques of the laboratory, has trained in data collection, and participates in and contributes to conceptual discussions at laboratory meetings and discussions with laboratory members outside of laboratory meetings. In her role as a teacher and reading specialist, she has observed behaviors in her students that have led her to wonder about the neural underpinnings of those behaviors. In collaboration with other laboratory members, she has spent many months researching and designing a project that will index neural processing related to specific phonological behaviors that she has observed in her students struggling to learn how to read. She is currently revising a grant proposal to support her own collaborative neuroscientific research project in the laboratory. This is just one example of an educator who worked to develop specialized knowledge based on her classroom experiences and was able to bring that knowledge into a research setting in a meaningful way; it is likely that she will in turn bring the results of her research back to her classroom.

In both of these cases, the reciprocal, iterative, looping nature of creating mind, brain, and education links is not quite closed with the teachers becoming part of the laboratories. In each case, researchers and undergraduate research assistants—including students in the teacher education program—have in turn made visits to these and other teachers' classrooms (brain specimens in hand) to talk to their students and answer questions about brains, brain development, and learning. Indeed, sometimes the loop began with a classroom visit, and conversations with teachers and administrators came later. For researchers, going into classrooms to teach about brain science and brain scanning was not only an educational opportunity in terms of teaching science (one elementary school student wrote a thank-you note that read, "Thank you for bringing the brains. My head hurt because I was learning so much. The brains were owesome." *[sic]*) but also a way to let students know about opportunities in the local area for them to actually get involved in brain science research. In addition, it was often a chance for the researchers to remember the wonder of what they do—to be able to confirm, in all honesty, that yes, brains and brain science are, as another student wrote, "really cool." Others have reported on the benefits of such classroom visits to students, teachers, and researchers (e.g., Cameron & Chudler, 2003; Peplow, 2004). This is yet another way of reaching out to schools—to teachers, to students—to involve them as an integral part of the mind, brain, and education endeavor. Such classroom visits also allow researchers to develop real-world questions in context and in collaboration, leading eventually to the design of more useful experiments.

CONCLUSIONS: BUILDING MIND, BRAIN, AND EDUCATION ON A SMALL SCALE

Developmental cognitive neuroscience studies can address many questions with practical importance to education and educators, but teachers need to be integrally involved in guiding this research to be useful and in making connections across mind, brain, and education. In this approach, the division between "basic" and "applied" research becomes blurred and yet another false dichotomy is revealed. Teachers conduct action research in their classrooms every day, asking questions and controlling variables to modify outcomes, "real" research with its own procedures and ethical considerations (e.g., Nolen & Vander Putten, 2007); many of those same questions can be scaled to the neural level, allowing for scientific investigation of not only behavioral change but also brain change with learning.

Forums for dialogue and conversation between teachers and researchers, new avenues for training researchers and teachers that emphasize potential connections between classrooms and laboratories, and opportunities for translation from research to practice and from practice to research are central to the field of Mind, Brain, and Education; these are all concrete, viable mechanisms by which to further construct an infrastructure for meaningfully connecting research and practice and sustain this new field (e.g., Ansari & Coch, 2006; Hinton & Fischer, 2008). We attempted to build a small model incorporating these pieces in the Upper Valley. Like any dynamic model, ours is subject to change. Indeed, one of us moved to a new school district and has since retired from the school system, and two of us have moved to new universities; but each has brought the model along, as a basis for finding new and creative ways to connect educators and researchers and further develop the field of Mind, Brain, and Education.

Although some of us no longer live and work in the Upper Valley, our goals for the future have not changed: Each of us is committed to developing the field through building multiple connections between teachers and researchers. We continue to make efforts to bring the brain sciences to the attention of educators at all grade levels and in all educational roles and to bring educational questions to the attention of neuroscience researchers. Proposals have been made at our new institutions for development of new Mind, Brain, and Education programs and for greater integration between faculty in Education and Neuroscience. We expect that building such programs and collaborations, balancing between traditional qualitative and quantitative approaches, and moving beyond a traditional university structure will be challenging but believe that the effort is worthwhile—for faculty, students, and the education community. Policy and funding bodies could make a significant contribution to these efforts by encouraging interdisciplinary and collaborative work and by requiring that some portion of funding be spent in connecting research with practice (e.g., by bringing researchers into schools and by bringing students and teachers into research laboratories).

Each of us continues to search for others locally who are willing to engage in multidisciplinary work and keep building a Mind, Brain, and Education community. We continue to support the hiring of candidates who are trained in such multidisciplinary work. We also continue to strive to build connections with members of our local education communities through workshops, classes, conferences, and opportunities to become involved in our laboratories. One obstacle is the time commitment that this requires from both teachers and researchers. However, even informal one-on-one interactions; brief discussions about child development, neuroscience, and pedagogy; and occasional sharing and co-analysis of research findings can help to advance both relationships and the field. This is particularly true in a climate in which we believe that there will be an increasing demand for quantitatively grounded research on what works and what does not work for schools and students. Overall, one challenge that we encounter repeatedly is showing administrators, at K–12 schools as well as at universities and colleges, how

fruitful, beneficial, and valuable the kinds of interactions are that we have described here on a small scale; we hope that this article might serve as a catalyst to begin or continue discussions among researchers, practitioners, administrators, and policy makers.

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