Project Description

A large body of literature describes the rift between neuroscience and education, two theoretically related fields that have struggled to establish common ground. Researchers have pointed to a disconnect between the promise of cognitive neuroscience data and actual application to the classroom. Several problems have been posed, including an inability among teachers to acquire and recognize relevant data, a lack of knowledge and skills to interpret neuroscience data effectively, and an inadequate capacity and expertise among educators to respond effectively to neuroscience data and actually put it to use in the classroom. The present proposal considers the ways that neuroscience and education can forge common ground to ameliorate these problems. Drawing on the shared use of descriptive models by researchers in cognitive neuroscience (brain-imaging) and education (teachers' mental models of cognitive processes), the aim of the project is to collect teachers' experience-based intuitive mental models of learning processes in their students' brains. Building on the claim that a connection between data and the classroom will necessitate bi-directional and collaborative communication between scientists and educators, a clinical interview method has been chosen as the tool for uncovering these espoused mental models. Interviews will be carefully recorded and analyzed in an interpretive fashion to identify common elements of models within and across subgroups of teachers. Hypotheses will be formed regarding different classroom approaches and the models of learning in the brain associated with teachers' experiences within these approaches.

Relevant Literature

Over the last ten years, a discourse has been reverberating among researchers in education, psychology and neuroscience regarding the promise of new data on the brain for advancing the science of education and learning. Since the 90's, the so-called "Decade of the Brain," much of the initial zeal for direct application of neuroscience data has faded. There is sober consensus in the current literature that describing *how* data on structural and functional changes in the brain can actually be used to inform educational policy and practice is a difficult task (Ansari and Coch, 2006; Goswami, 2006, Bruer, 2006).

For one, researchers identify a lack of ability on the part of teachers to acquire and recognize relevant data, leading to acceptance of "neuro-myths" and "Brain-Based" learning packages that are not supported by science. Ansari and Coch (2006) refer to questionable media reports and oversimplified claims about left/right brain, critical periods and "brain-buttons" that inundated schools over the last decade.

Another problem is teachers' lack of knowledge and skills necessary to interpret neuroscience data. Goswami (2006) notes that the progress in neuroscience labs is largely theoretical, and without a firm understanding of *hypothesis*, *theory* and *established model*, teachers are not able to establish how data fits into the "big picture."

Furthermore, Goswami states that teachers often view scientific research as too concerned with establishing rigor in precise experimental manipulations and complain that science researchers simply provide too much data.

These inherent difficulties have invited skepticism from the some in the research community: even if teachers can be "fed" neuroscience data and taught to digest it, do they have adequate capacity and motivation to actually to put it to use in the classroom? Bruer has been at the forefront of this attack since his 1997 paper "A Bridge Too Far." He describes in a recent publication that the core concepts used by neuroscientists are different from those used by psychologists and classroom teachers. He goes further to describe how a superficial fascination with synapses and brain images causes teachers to overlook a substantial body of largely untapped cognitive psychology research (Bruer, 2006).

In 1999 NRC declared "Neuroscience has advanced to the point where it is time to think critically about the form in which research information is made available to educators so that is it interpreted appropriately for practice." This has led many of these researchers to pose solutions for "building bridges" that can span the chasm between neuroscience and education. Ansari and Coch (2006) describe a need for "practical mechanisms" to support and foster meaningful integration between the brain-lab and the classroom so that teachers will be more informed consumers. This must be accomplished through awareness and understanding of similarities and differences between research in neuroscience and education and by establishing points of contact between scientists and educators including bidirectional dialogue and collaborative experiment design. Goswami (2006) urges that a new generation of multi-disciplinary researchers must dedicate their combined expertise in both neuroscience and education to presenting high quality knowledge on the brain in digestible form and interpreting neuroscience *from the perspective of* and *in the language of* educators.

Taken together these goals stack up to a long and difficult project, and the task before the neuroeducation researcher is to identify a place to begin. For the present proposal this place is the teacher's own experience-based intuitive models of how learning happens in the brain.

Strauss (1993) claims that without determining the nature of teachers' mental models about children's minds and learning, new information will not be able to engage or change these models. Using a semi-structured *clinical interview technique* he collected and analyzed teachers' answers to questions about what they would do in specific teaching situations, uncovering common models that he could then connect to information processing models presented by cognitive psychology (i.e. working memory, elaborative processing).

Since it was developed by Piaget (1975), the clinical interview method has branched into a variety of techniques for research in developmental psychology and education (Ginsburg, 1997; Clement, 2000). The strength of the clinical interview method, as opposed to non-clinical data gathering techniques, is that it can be used to collect and analyze data on mental processes at the level of a subject's authentic ideas and meanings, and to expose hidden structures and processes in the subject's thinking that could not be detected by less open-ended techniques (Clement, 2000).

Cognitive models can be seen as a locus of similarity between research in neuroscience and education. After all, cognitive neuroscience is built on models of brain processes provided by cognitive psychology, and these models are as fundamental to cognitive neuroscience as they are to the applied science of learning (Bruer, 2009). Even so, there is a lack of research leading to insightful explanatory models of students' learning processes. Part of the reason for this is that these models do not result from the carefully controlled experiments favored by cognitive psychology and neuroscience. Higher-level cognitive processes are by nature non-linear, full of feedback loops and processes that compete and coordinate. Models of these processes that can be understood and used by teachers must be true explanatory models that are iconic and analog in nature being built up from "more primitive and familiar notions (Clement, 2000). "

In his own research constructing models of problem solving in algebra students, Clement urges the need to begin with generative, interview-based case studies. These are analyzed and theoretical hypotheses take the form of models that are grounded in naturalistic observation of behaviors. As data is collected and analyzed, these initial models are revised in a bi-directional research technique incorporating both bottom up

(inductive) and top-down (deductive) methods. Through this process, investigators become sensitized regarding what to look for, and observation categories can be developed for future data, providing the foundation for the design of convergent studies.

Clement (2000) suggests that a good technique is to *draw* what happened in the mind of a subject. As mental processes can involve many interconnections and relationships over time, creative representations in the form of diagrams can be very helpful devices for keeping track of such complexity, drawing inferences, seeing new connections and criticizing and improving models.

The present proposal sees a promising role for explanatory models of students' learning processes, actively constructed (sketched), as they are imagined to occur in real time in the brain, by teachers during reflection on various unique experiences in the classroom. These models will be gathered through bi-directional dialogue between individual teachers and a researcher with combined expertise in both neuroscience and education and extensive training in the clinical interview technique.

It is the aim of this research to utilize these models as "practical mechanisms" to support and foster meaningful integration between the brain-lab and the classroom. It is hoped that the present study will build solid ground for future research that can begin to tackle the job of presenting high quality knowledge on the brain in digestible form and interpreting neuroscience *from the perspective of* and *in the language of* educators, eventually leading to collaborative experiment design that can go back to the brain lab.

Project Design

A generative clinical interview method with embedded brain-sketch tasks will be employed to uncover teachers' experience-derived intuitive models of learning processes related to knowledge acquisition, and subsequent learning or understanding. Each semi-structured clinical interview will conducted by the Principal Investigator with a total of forty teachers. Teachers will have been teaching between three and ten years, and will teach children from Pre-K through middle school. Twenty teachers will be currently teaching in a public school environment where they follow NYC standards, benchmarks and standardized testing schedules. The other twenty teachers will be teaching in private

schools that are considered fairly "progressive" in terms of: (1) having no top-down packaged curricula, granting teachers a significant degree of freedom in curriculum design and implementation, and (2) employing certain approaches in the classroom (i.e. "child-centered" learning, Reggio-Emilia/Project Approach, Montessori, dynamic/portfolio-based assessments).

Open-ended questions will be used to collect information on each teacher's background, their unique path to teaching and their current teaching philosophy. Follow-up questions will encourage teachers to describe any experiences that arise during these questions.

Next, subjects will be asked to speak to several terms that were chosen for their general relevance to the cognitive process of learning: *knowledge, procedural knowledge, declarative knowledge, understanding.* While teachers might vary in their ability to define these terms literally, each represents a concept with which teachers are *experientially* familiar. Taken together the terms represent interactive yet functionally different processes in the brain.

Finally, the interviewer will focus closely on specific examples provided by the interviewee as they explain or make sense of these terms. These examples will be the basis for the brain sketch exercises. Subjects will be asked to first reflect on and carefully describe the experience as it took place their own classroom over the past few years, for instance, a time when they made a concept easier for a student, or an instance when they wanted to know that a student understood a certain concept after a unit. Then, the subject will be encouraged to think about what was happening in the student's brain at that moment, and use colored markers and sketch pad to depict, in any way they choose, what they imagine this process to look like - as if they could open their student's head and peek inside. The interviewer will deflect any questions about how or what the subject is supposed to draw, encouraging him or her to "put themselves" in the experience with the student and be as simple or creative as they wish in their depiction. These models will be used as a concrete basis for further discussion. (See Appendix A for a transcript of the protocol).

Audio and video of each interview will be recorded, including clear still footage of the brain-sketches. Using the Columbia University VITAL (Video Interactions for Teaching And Learning) system, the Principal Investigator will clip (edit small pieces of video out of larger interview), label and organize videoed responses to teacher background and philosophy questions, as well as responses to terms. Brain sketches will be similarly clipped and organized and then analyzed in an interpretive fashion. Models will be organized based their explanatory nature regarding the depictive way teachers chose to represent underlying cognitive processes and the language used to explain their choices. Depictive elements and explanations will be carefully combed to identify the pictorial representation of specific cognitive mechanisms and the language used to explain it: Do teachers use simple descriptions of mind-behavior relationships based on their own experience of thought (psychology), an information processing model (cognitive psychology) or an understanding of neural circuitry, synapses and neuronal reorganization (neuroscience)?

The Principal Investigator will look within and across groups for common elements in models. A common element will be one that appears in the models of more than 50% of teachers. Teachers' backgrounds, teaching philosophies and term definitions will be analyzed to establish theoretical hypotheses regarding connections between a teacher's body of experiences and how they influence and shape their models of how learning happens in the brain. These hypotheses can be used to create observation categories for subsequent investigation into how intuitive experience-based models affect the way teachers from specific education backgrounds may acquire, interpret and use neuroscience data in the classroom.

Project Significance

The present proposal approaches the rift between neuroscience and education from a truly neuroeducational perspective. According to Kurt Fischer, head of the Mind Brain and Education initiative at Harvard, what education needs is not a "quick fix" from

neuroscience, but rather the creation of a new field that integrates neuroscience and other cognitive sciences with education. (Fischer and Immordino-Yang, 2008). In terms of its research goals, mechanisms and methodology, the proposed project can be seen as a true collaboration between developmental and cognitive psychology, education and neuroscience.

In a recent statement by the DANA foundation, Hardiman and Denckla (2009) wrote that the link between the brain-lab and the classroom must be two-way, that the experiences of educators can suggest questions about learning that neuroscientists can explore. Goswami (2008a) admits that "neuroscience does not, as yet, study teaching." and that this is ironic as "successful teaching is the natural counterpart of successful learning." By choosing the teacher's intuitions as the locus for investigation, this project represents an important bi-directional relationship that holds new promise for successful interaction.

Within his general skepticism of a happy marriage between neuroscience and education, Bruer (2006) holds out tentative hope for the rare imaging study that goes beyond simply establishing localization claims and instead exemplifies both a sufficient appreciation for the complexity and subtlety of competing cognitive models and an ability on the part of researchers to interpret imaging data in light of all the relevant behavioral and neuropsychological data available. The overarching goal of the proposed research is to begin building a foundation for collaborative experiment design between educators and neuroscientists in order to answer "big picture" questions that matter to teachers. Some specific questions are:

> *What matches will be revealed between teachers' intuitions about students' brains and neuroscience findings once the barrier of different language is removed? What holes in teachers' knowledge about the brain will be revealed (independent from missing neuroscience vocabulary or terminology)?*
>
> *In what way does a teaching approach supported by current neuroscience recommendations such as those provided by Mind Brain and Education Science*

(i.e. active construction of knowledge, situated learning experiences, a key role of motor and sensory experiences in learning) (Tokuhama-Espinosa, 2010) correlate with intuitive models of learning that align with neuroscience?

How do teacher's choices to redesign or reject prior strategies based on "what works" in their classroom reflect an intuitive understanding of these neuroscience-based recommendations?

This ethic of care and respect for teachers' intuitions is in its own right a significant aspect of the proposed project. According to Tokuhama-Espinosa (2010) "Great teachers have always sensed what methods worked; thanks to brain-imaging technology and better research techniques, it is now possible to substantiate many of these beliefs with empirical scientific research." Ultimately, the work of the educational psychology researcher and the teacher, the cognitive neuroscientist and the neuroeducator all merge within the child's brain. If neuroscience hopes to find its way into the classroom, it needs to consider that teachers have, in essence, been peering into children's brains long before the first brain imaging techniques emerged.

Specific Relevance to Initiative on Data Use and Educational Improvement

The goal of the present proposal is to demonstrate a practical mechanism for approaching the following questions:

How can neuroscience data be presented so that it can be adequately acquired and recognized as relevant by teachers?

By meeting within the shared framework of the cognitive model, this project aims to build support for such models as valuable tools for presenting findings from the brain lab in a way that: (1) complements and builds appropriately on models provided by cognitive psychology (2) is consistent with the current presentation of cognitive neuroscience data (brain-scans or brain pictures with active areas lit up) (3) and can be understood at face value by the educator.

How can neuroscience data be matched to the level of interpretation and skills of teachers?

It is important to consider that the levels of interpretation and skills for handling data may differ widely across various teachers' backgrounds, philosophies and approaches. The current proposal seeks to describe ways in which an individual's unique knowledge and experiences contribute to their espoused mental models of learning in the brain. Research has shown that these models are the framework for incorporating new knowledge, and that new information is not potent unless it can be successfully integrated at the level of a specific individual's model. Through a richer understanding of these models and the levels of interpretation and skills they represent, the present project will lead to better methods for successfully matching neuroscience data to different teaching approaches.

What common language can be achieved for discussing neuroscience data on students' learning?

Before researchers can hope to achieve a common language for discussing neuroscience data on students' learning, evidence must be gathered on the language teachers use to discuss this learning and how it happens in the brain. One problem is that many teachers are not called upon to talk about learning in the brain, and therefore may not be challenged to translate ideas into language, and to develop a common language for discussing these ideas with other teachers or with members of related fields. By employing a clinical interview technique, the present proposal intentionally places value on building a common language through dynamic social collaboration. Rather than removing language from its natural context, the two-way conversation, in favor of more controlled data-gathering techniques, using the clinical interview will allow information to be collected at the level of a subject's authentic ideas and meanings

How can neuroscience data be put into recommendations that resonate with teachers and that ultimately will be used?

Recommendations from neuroscience will not resonate with teachers unless they match teacher's experience-based intuitions about what works in their own classrooms. Unfortunately, neuroscientists have not spent adequate time studying education and learning within the reality of the classroom environment to have a strong sense about what works or does not work with students. The proposed project represents a shift toward a bi-directional research approach via dynamic collaboration between a neuroeducational researcher (who is also a teacher) and other teachers. A deep knowledge of the experience-based intuitions of teachers regarding learning in the brain is seen as vital for transposing neuroscience data into recommendations that will resonate and for understanding the concrete details of how these recommendations can actually be put to use in the classroom.

Principle Investigator

Julia Niego

Julia Niego received a BA in Behavioral Neuroscience from Colgate University, where she designed and implemented ERP studies examining changes in brain activity associated with an anti-stereotype training task, and co-authored an article for *Developmental Neuropsychology* (Kelly et al, 2002*)* hypothesizing a role for gesture in co-defining speech during development. Over the past four years she has collaboratively developed and taught a progressive Montessori-based program at a private preschool in Brooklyn, NY. She is currently a MS student in Neuroscience and Education at Teacher's College, Columbia University, and plans to obtain an advanced multi-disciplinary degree in neuroeducation.

Project Advisors:

Herbert Ginsburg, PhD. Developmental Psychology, University of North Carolina

Herbert Ginsburg has made significant contributions to an understanding of mental processes involved in the development of children's mathematical thinking using the clinical interview method. He currently teaches the clinical interview method as a research tool at the graduate level at Teacher's College, Columbia University and advises doctoral research in the Cognitive Sciences.

Peter Gordon, PhD. Psychology, Massachusetts Institute of Technology

Peter Gordon is the Program Coordinator for the Neuroscience and Education Program at Teacher's College, Columbia University. His research focuses on the developmental neuroscience of language and cognition. He currently teaches Speech and Language Pathology and Neuroscience and Education at the graduate level at Teacher's College Columbia University and advises multi-disciplinary doctoral research.

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Appendix A

Interview Protocol

Intro:

Name?

What/where do you teach? What ages?

How long have you been teaching here? Where did you teach before that?

How did you come to teaching?

Teaching Philosophy

Can you sum up/describe what you've learned from your past experiences in the classroom? What describes your developing philosophy as a teacher?

Describe a detailed experience (based on above answer)

Explaination of purpose of interview

I am studying relationship between neuroscience and education.

Obstacle to neuroscience "coming in" to classroom:

Teachers learn through their experiences; recommendations from science don't necessarily resonate with teacher's intuitions

Set-up of tasks

The experiences described are all things that "live in the brain"; You've been working with brains in a sense for the last ___ years;

"Throw away" what you've learned from books, classes, media, etc in order to uncover your intuitions in yourself on what you think/imagine is going on in the brains of your students.

Terms

Can you speak to the following terms and how they relate to your teaching:

Knowledge

Procedural vs declarative knowledge

Understanding (vs knowledge)

Experience brain-sketch exercises

Can you think of an experience where you wanted to know what a student knew about x

Tease apart different knowledge/understanding being assessed and sketch a model of what you imagine is going on if you could "peek" inside their brain (based on specific experiences related by teachers)

Follow-up

Does anything strike you about these sketches and how they relate to teaching/planning in your classroom?

Conclusion: Can you relate this to your teaching philosophy?