Teachers' Awareness of the Learner-Teacher Interaction:
Preliminary Communication of a Study Investigating the Teaching Brain

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Abstract

A new phase of research on teaching is underway that seeks to understand the teaching brain. In this vein, the present study investigated the cognitive processes employed by master teachers. Using an interview protocol influenced by microgenetic techniques, 23 master teachers used the Self-in-Relation-to-Teaching (SiR2T) tool to answer "What are you focusing your mind on throughout the process of teaching?" A number of emergent themes were identified in participants' responses and one, Awareness of Interaction, is discussed here. This theme refers to teachers' recognition of the learner-teacher (L-T) relationship as a separate entity or system. Within interaction, at least three types of awarenesses emerged in teachers' responses: 1) connection, 2) collaboration, and 3) mutual effects. Further, some teachers described a sense of synergy with their students due to this L-T interaction. The results suggest that a teacher's awareness of interaction plays an important role in the teaching brain, and support the implications of the proposed teaching brain framework (Rodriguez, 2013a).

Background

Despite decades of educational research, our understanding of teaching continues to evolve. As expressed by Clark (1995), educational research on teaching has migrated through three phases: the Process-Product approach, The Teacher Thinking approach, and the Teacher Knowledge approach. The Process-Product approach defines teaching by its observed behaviors (e.g., organization, classroom control, lecture, demonstration, feedback, etc.) and their association with observed measures of student achievement. The Teacher Thinking approach provides a different perspective of teaching, one focused on the internal mental processes of the teacher such as their planning, decision-making, reflection, and attitudes. The Teacher Knowledge approach frames teaching around seven key knowledge domains including content, general pedagogy, curriculum, content specific pedagogy, learners and their characteristics, educational contexts, and educational purposes.   Each of these teaching educational research frameworks provides important and complementary knowledge about how we understand teaching. Today a new phase of research on teaching is underway that seeks to leverage this knowledge base and apply new ideas about the dynamic nature of the brain and new neurobehavioral imaging technologies to further develop our understanding of teaching.

Research on the learning brain has demonstrated that human learning is dynamic, variable and context dependent (Blakemore & Frith, 2005). This research promotes an understanding of learning that accounts for observable behaviors and internal mental processes. It embraces the variation observed in learners and seeks to connect behaviors with cognitive development as well as observable brain processes (RW.ERROR - Unable to find reference:444). Just as dynamic systems-thinking has reimagined learning development, we are now just beginning to apply these theories, tools, and models to teaching. How can we extend our prior understanding of teaching with these lessons from research on the development of learning? Can we, again, approach the question of what is teaching and find new answers?

Using these new ideas from the development of learning, we can reexamine the question of what is teaching. If we presume that like learning, teaching is a dynamic mental process, then we should begin by examining the cognitive processes of teaching before searching for neurological correlates of observable teaching behaviors. However, research on teaching is challenging as the act of teaching is dependent on an interaction which must involve both a teacher and a learner. In order to simplify some of the complexity involved in the learner-teacher interaction, there has been an abundance of research on learning which is used as a proxy assessment for teaching and teachers. Even the Teacher Thinking approach of research on teachers' cognitive processes has been confounded by teachers' inablity to separate their success in teaching from their students' academic success (Dellinger, Bobbett, Olivier, & Ellett, 2008). While it may be true that one success depends on the other, it is still necessary to independently measure and understand a teacher's mind and brain throughout their process of teaching if we are to better understand the variable of the teacher during the learner-teacher interaction (Rodriguez, 2012).

This study contributes to this new phase of research on teaching by attempting to identify the cognitive processes and "patterns of mind" engaged by master teachers during their teaching

experience and to describe how these processes interact with the student during the phenomenon of teaching. Specifically, it aims to identify key cognitive processes of the teaching mind-brain and contextualize them within the dynamic interaction of teaching.

Study Design

This paper reports a preliminary analysis of qualitative interview data. An in-depth qualitative interview design was utilized to support teachers in describing their cognitive processes while teaching, from instructional planning through implementation and reflection. Participants were asked to respond to an interview question in both a free-response and scaffolded interview format. Our design was influenced by a microgenetic interview method because this approach is often utilized for an in-depth analysis of participant responses and behaviors within a specified period of time (Siegler & Crowley, 1991). This type of microgenetic, intensive observation allows for an understanding of developmental processes as they are occurring (Granott & Parziale, 2002; Kuhn, 1995). Our interview protocol was designed to closely record participant responses and observe the participant following the use of a developmental tool (SiR2T, see below for a description). This tool was embedded within the interview task.

Self-descriptions are often difficult to measure and assess reliably because one's understanding of self is embedded within personal context and relationships (Putnam & Borko, 2000). Therefore we adapted a microgenetic interview method, Self-In-Relationships (SiR), which helps to highlight the self by relating it to one's context and relationships (Kennedy, 1994).   This adapted interview, Self-in-Relation-to-Teaching (SiR2T), provided participating teachers with a question to answer in both a low and high support environment to describe their cognitive processes of teaching. Typically in a microgenetic study participants repeat the same problem-solving task within one session in order to assess intra-individual variability (Siegler & Crowley, 1991). The variability is derived from the strategy modification employed by the participant as they move forward with completing the task. However, it has also been shown that a modification in the interview protocol itself can elicit significantly more complex responses from participants (Bochner, 1994; Cousins, 1989).   Considering that the present study aimed to discover teachers' cognitive processes throughout their teaching, we adapted the interview context to encourage a shift in teachers' task performance. First, participants responded to the interview question in an open-ended condition. Then, participants were asked to revisit the question within a supportive condition using the SiR2T tool. The task remained constant but participants were given a high-support tool to utilize in crafting their responses. The intent with this study design was to encourage developmental change in participants. We expected that in a high-support condition they would be able to answer the interview question with a significantly more complex response (Fischer, 1980). This would then enable us to observe peak performance of their cognitive skill of teaching.

Sample and setting: A convenience sample of master[1] teachers were recruited from HGSE partner schools and organizations. Because there is no gold standard definition for master teacher, the

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[1] The definition of master teacher varies from state to state (Grantmakers for Education, 2012; McClean, 2009; Ohio Department of Education, 2007). However in general a master teacher has vast experience teaching and has been recognized for their distinguished ability to master their content, deliver instruction and assess for student understanding and learning. They have proven their ability to create effective learning environments which promote success for all students. Master teachers have also committed to their continued professional growth, leadership and collaboration within education at large.

study relied on the expertise of referring administrators and educators to identify participants. Inclusion criteria included active teaching status, at least five years of experience, and an administrator's letter of support. Recommended teachers were contacted via email. Those teachers who expressed interest were included in the study.

The sample consisted of 23 participants from New York and Massachusetts. This included five lower elementary teachers (PreK-2 with one parent/child teacher), three upper elementary teachers (grades 3-5), four middle school teachers (grades 6-8), six high school teachers (grades 9-12) and four graduate-level professors. Nine teachers were in public school settings (4 suburban and 5 urban, 2 of these schools were charter schools). Ten teachers were at private school sites all in suburban locations. School philosophies ranged from non-traditional progressive schools (including Waldorf) to no-excuse charter school sites. Graduate professor sites ranged from Ivy League institutions to community college. Classes taught by participants ranged from K-12 core subject areas to visual/liberal arts, vocational and technology curricula.

Materials and Methods

Research findings on teaching have not produced a developmental skill theory of the teaching mind-brain (for the remainder of this paper, we use the word brain to refer to the joint entity of the mind-brain). We believed that by organizing cognitive processes of the teacher's brain (as shared by the teacher) during their process of teaching we would be able to design a new model to explore the teaching brain in future studies. After a review of model building approaches we elected to adapt the Self-in-Relationships (SiR) interview to solicit and organize feedback from teachers about the underlying constructs of their teaching. The SiR has been used in prior studies to elicit deep reflection in participants, unpacking self-reported perceptions of internal concepts (not unlike the cognitive processes in the teaching brain) (Cheng, 1999; Kennedy, 1994). Furthermore, it also provides a microgenetic structure and task to help organize the rich data collected from the interviews.

The SiR method was originally used to explore adolescents' perspectives of themselves in realtion to others (Cheng, 1999; Fischer, 2008). The approach is a complex, microgentic interview and asessement that involves multiple steps – each of which has been tailored to the study aims. For example, in the low support setting the SiR interview asks an open-ended interview question to yield the functional performance of the participant. This is followed by a high support setting where participants are asked a series of probing questions about self-conception. This is done by asking participants to use words to describe themselves in relation to others and to identify patterns that exist across relationships which help to identify their "real" self (Kennedy, 1994). In order to assess the development of participants data was measured utilizing the skill scale from Dynamic Skills theory because it suggests that in high support situations individuals are more likely to reach and describe abstract understandings of systems (Fischer, 1980) . Skill theory is often used to understand the cognitive development of individuals (Fischer & Bidell, 2006).

Self-in-Relation-to-Teaching (SiR2T)

While there is no skill theory specific to teaching, the first author has hypothesized that the cognitive processses involved in teaching could be comparable to learning in that they are both dynamic and context dependent (Rodriguez, 2012). Teacher's self-descriptions are often confounded with student performance and therefore difficult to tease out (Shulman, 1987). Therefore, both low and high support situations were included in the modfied SiR interview protocol (termed SiR2T, i.e., SiR adapted to teaching) to more effectively uncover teacher thinking. Additionally, by providing a low and high support setting, teachers are more likely to reach and describe their understanding of the abstract systems involved in their teaching process.

In the low support situation, teachers participated in an open-ended writing exercise in response to the question *"What are you focusing your mind on throughout the process of teaching"*. The question inquired about the teacher's process specifically so that teachers would not merely discuss when they were "in front" of the classroom teaching. Significant research on teacher thinking has demonstrated that planning and reflection is an important aspect of teacher cognition (Leinhardt & Greeno, 1986; Peterson & Clark, 1978). During the low support condition teachers simply responded to the question in free form via email. The intent of this portion of the interview was to record teacher's first reactions to the concept of their cognitive processes without directing teacher's towards specific topics to address. By design, this low support situation would yield functional performance and serve as a priming exercise for participants as they considered the full spectrum of their teaching process (from planning through reflection).   By priming them to consider this full spectrum we believe that teachers were more situated within their context and, therefore, more likely to provide robust descriptions of their self-understanding (O'Connor, 2008; Urzúa & Vásquez, 2008).

The high support portion of the interview was comprised of the SiR2T self-diagram task and clarifying questions which consisted of an initial speculative set of teaching brain characteristics drawn from cognitive science literature (Aoki, Funane, & Koizumi, 2010; Battro, Fischer, & Léna, 2008; Battro, 2010; Passingham, 2008), developmental and cognitive psychology (Fischer, Rose, & Rose, 2007; Premack & Premack, 1996; Strauss, 2005), biology (Caro & Hauser, 1992; Thornton & Raihani, 2008), and teacher education literature (Clark & Peterson, 1986; Wilson, Shulman, & Richert, 1984). The hypothetical teaching brain characteristics were broken down into categories of self, personal context, skills, and external influences.

Interview Protocol

At the time of the scheduled interview, participants received Part I (low support) of the interview. Responses were given in free-form (1-2 paragraphs) and emailed back to the interviewer. Upon receipt of Part I, another email was sent to the participant titled "Part II interview" which included the SiR2T tool with instructions. Participants were told to have the SiR2T tool in front of them throughout the interview. Following delivery of the email, a phone/video call was initiated by the interviewer to conduct the Part II interview which was the high support setting. Each interview was tape recorded for record keeping and transcription.

The SiR2T interview tool consists of three concentric circles on one sheet of paper. The circles are labeled as most important, less important and least important moving from the center circle to the outer. Below the circles are four boxes of the proposed teaching characteristics. Each category (Self, Personal Context, Skills, and External Influences) contained four to five potential characteristics within it (for example humor, confidence, and empathy were listed under "Self"). Teachers were told that the words were specific to them not to their students or others. Answering the same exact question (i.e., "*What are you focusing your mind on throughout the process of teaching")* participants were asked to place the words within the three concentric circles. As they described where to place each word the interviewer acted as their scribe and filled in the document for them. Participants moved throughout the words at will without following specific criteria but were asked to eventually use all of the words. Throughout the process participants were encouraged to expand or explain their choices. The interviewer asked questions to clarify responses when necessary. Participants were then prompted to review characteristics they had grouped together and discuss whether they felt some characteristics connected to each other. Participants were then asked to compare their initial low support response with their high support response to note anything that they wanted to add or address.

Data Analysis

A two-part qualitative coding method was used. We coded interview data using grounded theory to create a range of themes for what teachers were focusing their minds on throughout their process of teaching. Emic coding was utilized for the first phase, followed by etic coding. Emic coding allows researchers to discover patterns of thinking that are not predetermined, yet are significant to our understanding of the phenomenon in question (Charmaz, 2009; Thornberg & Charmaz, 2012). Because there is little extant research on the teaching brain, it was important to capture unexpected descriptions of teacher's cognitive processes. In turn, once unexpected patterns were identified, etic coding allowed us to see if these patterns or categories existed across the data.

Emic and Etic coding: Two coders simultaneously listened to each audio recorded interview following along with personal copies of written transcripts and noting patterns of responses that would be interesting to explore. Both researchers independently detected statements and actions requiring codes for all 23 interviews. The independent nature of this process served to maintain reliability and avoid confirmation bias. For the first third of interviews, coders proposed themes and categories which arose from each transcript. To determine the most prominent patterns from the data, emergent themes and categories were discussed and consolidated until agreement was reached for a single list. This list was compiled to build a coding manual with decision rules to guide the etic analysis of the next two-thirds of transcripts.   This top-down coding process included applying the predetermined categories from the first third of the transcripts as well as discovering new emergent patterns and clarifying existing categories.

New insights gained from the coding discussions were continually incorporated into the codebook. Themes that were unique to only individual teachers were separated out. The primary coder then drafted a detailed memo that included an overview of the teacher, descriptions of the different themes pertinent to the individual teacher, and supporting direct quotations as examples for each

theme. Memo writing is typical to qualitative data analyses such as grounded theory (Groenewald, 2008; Maxwell, 2005). Direct quotations were labeled with relevant category descriptions within each theme. If they existed, counterexamples for the different themes were identified and included in the memo, once again, to avoid confirmation bias. The second coder reviewed the memo draft and made edits which confirmed, denied or challenged the primary coder's account of the coding discussion. This process continued for each teacher until final agreement was reached on the memo. Upon completion of all transcript coding and final memos, analysis across all memo documents was completed to discover patterns/themes within and between participants.

Due to space limitations for this article we would like to highlight one emergent theme specifically: awareness of interaction. When this theme originally emerged we identified it as instances where a teacher described their interaction with a student as having mutual effects. This code was utilized when the teacher's response was such that it showed a connection and relationship, as well as a discussion of how the teacher was affecting the students and how the students were affecting the teacher. We believed this indicated a type of feedback loop because the student was giving the teacher some type of feedback and due to that information the teacher shifted, which then changed the learning experience for the student (and so on). This type of description showed the teacher's awareness that both the student and teacher impact one another. The following were categories that existed within this theme:

- Mutual effects/impact
- Connection/relationship
- Feedback loops
- Reaction based on feedback
- Dialogue
- Reciprocity

Results

This study sought to identify underlying cognitive processes of the teaching brain as expressed by practicing master teachers. Emic and etic analyses revealed an interesting awareness of interaction exhibited by teachers. Though the original code for awareness of interaction was one which focused primarily on the mutual effects involved in an interaction, emergent patterns suggested that, overall, interaction refers to teachers' recognition of the learner-teacher relationship as a separate entity or system, an awareness discussed in an earlier publication (Rodriguez, 2013b). This supports the hypothesis proposed in the teaching brain framework (Rodriguez, 2013a) indicating that teaching is not merely recognizing the student and the teacher as independent complex systems interacting. Rather that the learner teacher (L-T) interaction creates a separate yet dependent system.

Within the umbrella of interaction (or L-T system), there appeared to be at least three types or awarenesses of interaction that emerged from teacher interviews: 1) relationship/connection, 2) working together/collaboration, and 3) mutual effects/feedback loops. Beyond these awarenesses,

some teachers were also able to recognize and express a sense of synergy in their teaching due to this L-T interaction.

1) Connection:

This awareness refers to instances when teachers describe the tight *relationship* or *deep connections* they have with students beyond the necessary interchanges involved in academic content. It appears that at its most basic level, an awareness of interaction entailed teachers' realization that they form relational bonds with their students that are essential to the learning and teaching that take place in their classrooms. In describing whether there is a distinction between her *real* versus *teacher self* one teacher, Meredith, an elementary school teacher, stated that, "It's back to that connection piece... I want children to know that when they walk in the door, I'm really authentically happy to see them. And it matters that they came to school, and it matters that we're gonna spend this together. That, umm, they know that when I speak to them, I'm gonna do it respectfully, and that I have the same expectation of them for each other and for me, umm, and that's not just about, I guess, because it's not just that I'm setting rules for how people interact with each other. It's about knowing each other, and why is that important." For Meredith it is important that both she and the students have a relationship where they understand each other authentically in order to connect on a personal level. This personal connection is at the center of her identity as a teacher and foundational to the processes she sets up in her classroom and the decisions she makes in her teaching.

Another teacher shared a time when her personal connection with students allowed both her and a student to share feelings which were critical to their mutual success. While Andrea, a pre-K teacher, was detailing the demands of being in a classroom, she shared that a few years ago she had to take time off and travel back home when her father passed away. In describing the return to her classroom after being away, Andrea discussed the deep emotions involved in her relationship with students and illustrated how these are integral to the ways in which they interact. Andrea shared "When I came back and told the kids that I was like really sad and I said, 'I might cry and I want you to know that that's okay if you see me crying.'" Andrea continued to say that, "basically [students] then took on this empathetic role to take care of me. Not in that sense of that it was, like I was putting that responsibility on them but it was like, 'Alright, okay. So Andrea's feeling a little sad, so what are we all going to do? How are we going to step up our game?'" To stress this deep relationship Andrea shared that, "then one, one little girl just said to me, 'You know', and it wasn't like... Like egocentric or anything, she was just like, 'You've been gone a lot. Don't do that anymore.'" Andrea replied, "Okay. Alright. So I'm not gonna go." She understood that the young child, "was putting a notch, I think, think for me the value of being a really like close community is that she even felt that she could say that to me." Andrea's example highlights a teacher's ability to both express her feelings and recognize a student's feelings due to the tight relationship that they share. Her example demonstrates the awareness of relationship or connection that allows teachers to be authentic human beings while also empowering their students to express the feelings that affect their learning. As described by another elementary teacher, Laura, "when a teacher really knows a kid and can connect for that kid, then, you know, that's... That's gonna be the surest path to academic success." Teachers who identified the relationship/connection aspect of interaction seemed to refer to it as necessary for their success and their students' success.

2) Collaboration:

This awareness refers to instances when teachers describe that the teaching endeavor entails shared knowledge, work, and responsibility on the part of both the teacher and the learner. Teachers who

described the L-T interaction in these terms described working with the student to achieve a common goal, whether it be learning, understanding one another, or completing a task. This type of collaboration was described as making decisions together as part of the *bargain* of teaching and learning. Johan, a graduate professor, shared that, "If [students] didn't need help learning, they wouldn't need a teacher, right? If you already knew how to do something or if you could just teach yourself how to do it, then you probably would just do that. You wouldn't be sort of asking... You wouldn't be setting yourself up in this environment where you have a person who's trying to sort of help you figure it out. So, I think part of it, making a connection to me, in that sense, that's just part of what I think of as the bargain of being teachers and students. The bargain is, I have the knowledge of something and you would like to learn about that or somebody else feels that you should learn about this, and so let's try to work together to help you learn about it." In his description of the "bargain of being teachers and students," Johan gives students an active role in the interaction. He describes students as actively deciding whether or not to participate in their learning, and thus, choosing whether or not they will collaborate with the teacher in this process. Johan does not appear to see teaching as a unidirectional power dynamic that flows from teacher to student; instead, he sees it as necessarily having two active agents—the teacher *and* the student—that together share the responsibility for the outcomes of their interaction.

Very similarly Sidney, a high school teacher, shared that "when I learned to own who I was, which I did within the first year of teaching and just say like, this is not... It's not like I'm a superwoman or a bad woman. I'm just a white woman from [New England] and this is what I know and what I'm bringing to the table, and I'm honoring what you know and what you bring to the table. And so, let me teach you, um, what I know that will help you gain access to power and to, you know, freedom, in a way because education is freedom. And you teach me what you know and how... And the ways in which you know it, so that I can be a more inclusive person in our classroom." Again, Sidney illustrates a view of her teaching that is equal parts teacher contribution and student contribution. It is through sharing their individual sources of knowledge that Sidney sees herself and her students achieving the ultimate benefits (e.g., power and freedom) of education. Clear within both Johan's and Sidney's examples are the thinking that the collaboration between teacher and student incorporates the learner and teacher as independent systems with individual contexts. These two systems form a unit, a bargain, and collaborate to create a L-T system with a shared purpose of developing new knowledge. This was expressed clearly by Marian, a teacher of a combined parent-toddler class who greets her students each year by saying, "Here we all are. We have different parenting styles. We have different ways, and yet we're all gonna work together, support each other and work as a... We're all on the same team here. We're here for the growing and the learning and the loving of all these children that are in the class together and of each other."

3) Mutual effects:

The awareness of mutual effects refers to instances when teachers describe the reciprocal effects experienced throughout the teaching and learning process. This category is characterized by examples when a teacher describes that they changed an approach, *responded* to, or were affected by the behaviors or *feedback* of a student; and that in turn, their response caused the student to change or *shift* their behavior or approach to learning. Delia's teaching process highlights this awareness. As she describes it she is, "always out there looking for new strategies, techniques, or ideas to implement within the classroom to better [her] teaching, as well as to enhance the students' learning experience." During her teaching process she is, "constantly looking to see how the students are engaging with the material and looking to decide whether or not [she] need[s] to shift the strategy that [she is] using or

present in a different way, based on how they're reacting or interacting with the material, and maybe [she] need[s] to micro-unit it more or add a visual for different of learners." Delia, a middle school teacher, explains that her teaching decisions are dependent on the student's intentional and unintentional feedback (Rodriguez, 2013a) and their continued learning is based on her responses to this feedback.

The reciprocal effect is described by Susan as a "dance." Implied in this metaphor is Susan's understanding that her pedagogical moves are dependent on her student's moves and that, likewise, her student's steps are dependent on her steps. She admits that as a graduate professor she is always learning because, "Never ever ever ever, do you, as a teacher, wanna stop learning. It influences the newness of your approach, which influences the receptivity of your students and makes them as excited as you are." In understanding the mutual effects of the L-T interaction, teachers seem to be aware that the teacher and learner in the system are experiencing changes in their understanding, knowledge, and identity as a result of their coming together; as a result of the new system they have formed together.

4) Synergy:

In an interesting and unexpected emergent pattern that arose from the data, we identified the category of synergy in teachers' responses. In these instances teachers often described the *vibe* or *energy* created during a deep human interaction of teaching and learning. It was as though some teachers saw the various forms of interaction as leading to an experience of flow between students and teachers. After sharing that she found teaching rewarding, Liz, a middle school teacher, provided a series of examples to illustrate why she found teaching so rewarding, such as collaborating with teachers, solving puzzles with kids and even developing curriculum. However, she then settled on sharing that it is "just that feeling, you know, you know as a teacher that, that feeling of things clicking, things just are clicking, things are clicking, you don't want to stop. You don't want it, and the kids are like, I don't wanna go to a gym you know, I don't wanna go home and you're feeling the same thing. And a lot of that is really about human connection. Are we connecting? Are they... Are we just jibing, you know. And it's the same with teachers. Am I sharp? Are we? And so, you know what, so much of it is when you get in the zone, the problem there, there's no here, no be, time kind of stands still, you know, when it's that zone of sort of creative, um, work that you're doing." This description of joined flow was not unique to Liz, and as can be gleaned from her excerpt, such descriptions were peppered with references to the different awarenesses of interaction.

Peggy, a pre-K teacher, shared that it is important to find synergy with her students so she can make decisions together with them. In her own words: "I feel like that's a huge responsibility that these kids bring who they are, so it's my job to find that synergy, and that means I have to spend a lot of time getting to know each one, one-on-one, and then when I put them in a group, when I put them in a pod of four, that they're actually actively listening to each other. It is so powerful when they take on the role of peer-teaching with each other, or they learn how to actively listen to each other, and the synergy that I'm thinking about is in those, those group meetings, where you're talking about balance and they just start clicking off, I set up a little provocation or I say some provoking things, and they just start to click." In this example, Peggy not only illustrates the synergy between teacher and student but how this synergy can then influence the synergy among students. In this description she goes even further to

explain when this synergy goes outside of the (L-T) teaching brain framework utilized in this study to show interaction between students. She describes that, "First, [students] wanna sort of please me and they wanna be part of this thing with this teacher, right? And then all of sudden, they start connecting with each other. So, that's when I feel the synergy, when the hands start to go up and then they start to... bring them back to each other, keep bringing them back to each other, for the concept." This insight offers exciting information for further development of the teaching brain system to identify the multiple interactions involved in teaching.

Discussion

Results from our data suggest that a teacher's awareness of interaction plays an important role within the teaching brain and, thus, the developing teaching brain framework (Rodriguez, 2013a). Master teachers describe how this awareness is critical to their teaching ability and the success of their students. The emergent categories of connection, collaboration, mutual effects, and synergy serve as important potential constructs for further exploration. Moreover, our observations of the awareness of interaction support the importance of the recently hypothesized independent L-T system and the potential role of synergy in teaching (Rodriguez, 2013b). According to this framework, the L-T system is in constant, dynamic interaction with the teacher- and learner-centric systems or "brains". Master teachers seem to be aware of this system that connects themselves and the learner. This awareness likely represents one of many important constructs in the teaching brain framework.

The centrality of interaction in teaching has recently been identified in several neurobehavioral studies. Yano (2013) described a series of experiments in which he used sensitive monitoring techniques to map human interactions and in the process discovered how human interactions are a key to creating flow and enhancing productivity. Watanabe's (2013) experiments identified how bonding through coordinated interpersonal interactions occupies a substantial portion of teaching; offering empirical evidence in support of teaching as a dynamic phenomenon where interpersonal interactions occur explicitly and implicitly at multiple levels. Most recently, Holper et al., (2013) simultaneously measured brain activity (using functional near-infrared spectroscopy - fNIRS) of teacher-student dyads during a structured teaching exercise. They observed that successful teacher-student interactions were characterized by correlations in brain activity, while unsuccessful interactions were anti-correlated. They also observed changes in the teacher's brain activity based on student activity suggesting mutuality and a potential neurological correlate of synchrony in teaching. Our data fit well within this exciting new literature and suggest that teachers are aware of the phenomena being observed in these cognitive psychology and neurological experiments.

Our findings support prior speculations in the teaching brain framework of a distinct learner-teacher interactive system (Rodriguez, 2013a; Rodriguez, 2013b) and how awareness (a type of meta-cognition) of this interaction serves an important role in teaching. These findings suggest the need for further investigation of how this awareness affects teaching and learning. More studies are needed to empirically test the role of interaction awareness and other purported teaching brain components and pathways. While this qualitative approach influenced by microgenetic techniques elicited important observations, we need to develop experimental teaching "tasks" that can simulate teaching interactions

and apply modern technologies that can measure subjects simultaneously (Hari, Himberg, Nummenmaa, Hämäläinen, & Parkkonen, 2013; Konvalinka & Roepstorff, 2012). These experimental approaches will continue to shape the teaching brain framework, contributing to our understanding of teaching as a developmental skill in all humans (Strauss & Ziv, 2012).   The ultimate goal is to create a developmental scale of the skill of teaching from birth through adulthood.

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