A Call for a Multidisciplinary Approach to the Scientific Study of Teaching:

Inspirations from Howard Gardner

Written in honor of Howard Gardner’s 70th birthday.

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I would like to thank Howard Gardner for his friendship and the extremely interesting conversations we have had over approximately four decades and to Juko Ando, Antonio Battro, David Berliner, Susan Carey, Yadin Dudai, David Henry Feldman, Paul Harris, Jill Collier Indyk, David Klahr, Uri Leron, Jin Li, Ulf Liszkowski, Elena Pasquinelli, David Perkins, Miriam Reiner and Margalit Ziv, my wonderful colleague of over 10 years with whom I have worked most closely on the topic of teaching and who will surely disagree with some of what is written on these pages.

December 2012

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Howard and I go back a long way. So long, in fact, that I don’t remember when we first met. The bad news is that my memory may be failing. The good news is that it feels like I have known him all my life, a feeling that gives me great pleasure. A characteristic of our memories is that we have snippets of recollections of our past. I will share one with you with regard to Howard.

He asked me to comment on his book *Frames of Mind: The Theory of Multiple Intelligences* when it was in manuscript form and before he submitted it to a publisher. While reading it I recognized it as a tour de force and, personally, I felt like I was returning home. Intellectually, I had been brought up in a European tradition. Jean Piaget and Heinz Werner, who were daily staples for me, suggested that developmental psychology should not be restricted to the ontogenetic development of human children, but should also embrace a diverse range of topics, such as comparative psychology, neurology, embryology, anthropology, phylogeny, culture, history, the arts, you name it. When I read Howard’s manuscript, I knew that I was in the presence of such a view.

Howard’s work has almost always had an interstitial attitude. That clashes with the academy, which is arranged in ways that encourage specialization. Articles in journals are in domain-specific areas. Grants are given to those who think within the confines of a discipline and often a sub-discipline. Prizes are often awarded to those who contribute to a discipline. There are exceptions, of course, but the rule of thumb is specialization.

Howard would have none of that. His work defies the specialization commonplace. Rare is the person who has such wide-ranging thinking, exceptionally broad knowledge from a bewildering range of disciplines and an ability to master and harness them to illustrate his ideas.

Much of what appears on these pages draws inspiration from Howard. In fact, he might even say that what I describe here (teaching) is another intelligence to be added to those he presented in the past, e.g., linguistic, mathematical, musical, bodily-kinesthetic, interpersonal, etc. intelligences. And he may be right. But I believe that unlike those he portrayed for us, teaching allows us to pass on knowledge, skills attitudes, understandings and more to our offspring. It enables humans to have a cumulative culture and, as a consequence, a history.

I am taking a fresh look at the ancient field of teaching, a look that brings many domains into discussion. From ancient times, we have recordings from approximately 4000 years ago, of Sumerian students’ feelings about the canings they received when their learning was not up to the standards of their teacher (Cohen, 2007). And around 2400 years ago, Plato described what may have been the first recorded complete lesson when a teacher, none other than Socrates, taught Meno’s slave boy how to double the area of a square. In modern times, the lesson has been termed Socratic teaching. It would probably raise cries of protest from Socrates were he here now because he thought, then, that he did not teach the slave, but merely engendered in the slave what the slave already knew.

From its inception, understanding the nature of teaching and its flip side, learning, has had a venerated history. In the 2400 years that have ensued since Socrates helped the slave boy learn how to solve a problem in mathematics, many leading figures have weighed in about education in general and teaching, more specifically. A short list of those who helped propel our thinking about teaching are St. Thomas Aquinas, Rene Descartes, Immmanuel Kant, Henri Rousseau, and moderns such as William James, John Dewey, Lev Symenovich Vygotsky, Jean Piaget, Israel Scheffler, George Steiner and Ted Sizer. And, of course, there were and are scholars and practitioners who attempt to improve teachers’ teaching in education courses for teachers who are already teaching and for those who are preparing to teach.

Although there are exceptions, most of these philosophers and psychologists profoundly enlightened us about the nature of human beings, the goals of education and the nature of teaching done by professionals within the confines of schools. But human teaching can be understood as more than a profession. It is also a noble calling. It is for those whose hearts have succumbed to the enchantress’ song, the one that lures us to those moments of cooperation when inspired teaching and learning join each other. Anyone who has taught knows that a near-miracle repeats itself each and every time excellent teaching and learning conspire to advance our pupils, no matter what their age.

These magical moments are impelled by teachers’ altruism, the gift of giving precious knowledge to others so that they can better understand themselves and their world. This happens when a sense of trust is forged between the teacher and her students, one that binds them in the belief that although there is an unequal relation between them, the teacher will behave ethically and will not abuse the power her role bestows upon her. These parts of teaching’s mission are deeply embedded in its essence. And when the parts come together that essence feels as if lit by a divine spark.

Cooperation, altruism, and trust. These are fundamental ingredients that underlie teaching. Each sets the stage for teaching. But none of them alone or in concert is teaching.

These magical moments appear countless times every nanosecond around the globe. Most take it as a given. It was right under our noses all the time and was understood that that’s what we do. I don’t take it as a given. And most don’t ask themselves questions about its origins. I do and have gone back to basics.

In addition to professional teaching being a calling, it also occurs outside of schools. I believe it is a remarkably profound essence of human nature. Along with my colleague Margalit Ziv, I have been claiming that teaching is a natural cognitive ability on the part of humans (Strauss, 2005; Strauss & Ziv, 2012; Strauss, Ziv & Stein, 2002).

One aspect of this claim is that very young children teach without ever having been taught how to teach. I appeal to the reader’s sense of wonder in the following ideas. Consider this. It appears that despite research on the development of teaching being conducted in different countries, in different laboratories and with different tasks, there are converging developmental findings indicating a similar developmental trajectory for the ways children teach over time. Teaching may just be developmentally reliable.

Here’s another idea to take into consideration. A youngster is taught how to play a game she had never seen or played prior to having been taught it. In order to play the game with a friend, who doesn’t know how to play it, she has to teach him. One might think that, when teaching, she could imitate the experimenter’s teaching strategies she had just experienced when she was in the role of learner. But this is unlikely because in her role as a teacher, the learner she is teaching would almost surely not respond to her instruction in a way identical to the way she, the teacher, did when she was in the role of the learner. This suggests that she’ll have to teach under conditions that she hadn’t encountered, i.e., she is teaching a game she just now learned to another child who is responding to her teaching in unfamiliar ways. In order to pull that off, this means that she needs to have a representation of how one teaches to cause learning in others' minds, with all its complexity. I am in awe at this profound ability that we find even in children age 3.

The present short piece I am writing in honor of my good friend Howard has several parts. First, I call for a wide-ranging multidisciplinary, scientific approach to teaching. From there I present an educational implication that unfolds from that call. That is followed by a presentation of a problem that imbues modern understandings of teaching, but I chicken out because I don’t try to solve it. And last, I wrap up what I have been attempting to say.

**A Call for a Multidisciplinary Scientific Approach to Teaching**

Teaching as an area of scholarship and research has been the focus of many disciplines, but that might escape even the most discerning eye because researchers often work in domain-isolation. A glance at bibliographical references makes the point. Journal articles in a field, say cultural evolution, often don’t include references to articles in other fields, say the philosophy of education, and vice versa.

Despite this situation, I believe we could have, for the first time, a contemporary scientific study of our ancient domain where researchers from a number of fields could attempt in concert to address issues related to teaching. This has the potential to inform a new understanding of teaching and could also have educational implications.

I suggested with my colleague Margalit Ziv (Strauss & Ziv, 2012) that teaching theory and research can benefit from an integrated multidisciplinary effort. Domains that have potential to add to our basic knowledge about teaching include the ontogenetic development of human teaching (Davis-Unger & Carlson, 2008 a, b; Strauss et al., 2002), anthropology (Greenfield, 2004), cultural evolution (Mesoudi, Whiten & Laland, 2006), cognitive evolution (Arbilly, Motro, Feldman, & Lotem, 2011; Shultz, Nelson & Dunbar, 2012), nonhuman animal teaching (comparative psychology) (Thornton & Raihani, 2008, 2010), brain sciences (Battro, 2007, 2010; Rodriguez, 2012), artificial intelligence (Dessus, Mandin, & Zampa, 2008), cognitive archeology from prehistoric periods (Chazan, 2012), psycholinguistics (Bartsch, Wright, & Estes, 2010), philosophy (Scheffler, 1965), intelligent tutoring systems (Kopp, Britt, Millis, & Graesser, 2012), computer-human interface systems, silicon-biology interfaces, and more. Scientists from these fields, were they to work in cooperation, could help yield a mother lode for the domain of teaching.

Here is a partial list of what we might be looking for were we to attempt to create a scientific understanding of teaching.

* Describing the range and amount of teaching in various cultures. Although teaching is almost surely universal, it is not uniform. The kinds of teaching found in various societies can help us determine its range. Research can be conducted on teaching in societies in which there are no schools, e.g., some horticultural societies (Greenfield, 2004; Maynard, 2002, 2004) and hunter and gatherer societies (Hewlett, Fouts, Boyette & Hewlett, 2011). In addition, the amount of teaching that people engage in differs profoundly both across and within various societies (Premack & Premack, 1996). Explanations for variations in the range of kinds and amount of teaching have the potential to help us better understand it.
* Describing teaching’s components by examining it in its extremes. A while ago, I suggested we could learn about teaching by gaining a better understanding of uncommon teachers (Strauss, 2005). Some teachers are extraordinary gifted. Were we to learn what they know, what they know how to do and what they actually do in their astonishing teaching, we might have an avenue into understanding it. At the other end of the astonishing scale are those who have what I coined “teaching disabilities.” Some things don’t seem to work for them. It would be helpful to understand what seems to be diminished or missing among those teachers. In both extreme cases, we will probably see a magnification of the roles of empathic, interpersonal and emotional aspects of teaching come into play in tandem with cognition and that could expand our understanding of teaching.
* Ontogenetic development in children. As mentioned, my claim has been that teaching is a natural cognitive ability on the part of humans. Although that doesn’t mean that we should necessarily see very early signs of teaching’s incipient cognitive components, it would lovely were that to be the case. And it is. Liszkowski and his colleagues (Liszkowski, Carpenter, Striano & Tomasello, 2006; Liszkowski, Carpenter & Tomasello, 2008) and Akagi (2012) showed that preverbal children at one year of age act to close a knowledge gap between themselves and an experimenter. Recognizing that there is a knowledge gap and acting to close it are defining marks of teaching. Other cognitive aspects of teaching can be examined from the point of their inception along their developmental trajectories as they reach maturity.

These three domains are among the many I listed above. I elaborated on them slightly so as to convey a sense of where we can go looking in order to create a contemporary scientific view of teaching. Securing this view will not happen tomorrow nor will we see it the day after. But it is a goal we should keep in mind.

***Educational Implications of the Scientific Study of Teaching***

There are a number of areas where education can gain from the creation of a multidisciplinary scientific vision of teaching. One I discuss here is fitting teaching to individual learners.

I ask the reader to think for a moment about the extraordinary headway being made in basic science research and multidisciplinary theory-building and product development in biotechnology, genetics, biochemistry, drug development, etc. One exciting pragmatic possibility of scientific advances in these fields is the vision of creating medication that will be tailored for groups of individuals. At present, this vision holds that groups of individuals who have similar genetic patterns respond better to a certain medication protocol than to other protocols. And groups that have the “same” disease but whose genetic patterns are different won’t respond to that protocol and will be in need of a different one.

The first part of the equation is diagnosing the differences between groups of people. Research in basic science has been propelling that forward at a rapid clip. The second part, finding differential drug treatments that work for each group, has been moving at a fast pace but it lags behind the diagnostic part.

I believe we can hold a similar vision for teaching. Basic research in a number of fields has the potential to yield the kinds of knowledge we may need so that we can make teaching individualized for types of learners.

Uh oh. I think I hear some nay-sayers. Some are whispering, “Been there; done that. We’ve been through this already, and nothing came out of it.” To be sure, there have been many discussions in educational circles about not having a scientific data base from which to make educational decisions about teaching.

So why is my call different? In the past, the long list of fields I mentioned as potential contributors to a scientific view of teaching were not considered. Perhaps this is a side-effect of domain-isolation. Educators may not have been aware of those fields. Also, it might have been the case that the whole gamut of fields I mentioned were known to the education community, but weren’t thought to be relevant to teaching. It could also be the case that these fields were recognized as being of importance for teaching but, at the time, those fields were not sufficiently advanced to be seen as partners in a search for a scientific understanding of teaching. So as to be clear, I believe all those fields, even though they are in different stages of their own development, can contribute to gaining a scientific view of teaching. As a rejoinder to some nay-sayers, I say: “Haven’t been there; haven’t done that”.

Others might object that we have neither the models nor the sophistication of all the sciences that work in concert for achieving individualized medicine. What is there in teaching that comes close to chemistry, biochemistry, genetics, bioengineering and more, they ask. And they are right, of course.

But the fact that we don’t have that sophistication doesn’t mean we shouldn’t try to achieve it. Rather than despairing at what we don’t have, we could view this situation as a challenge to develop that knowledge. That is what stands at the forefront of my call for a multidisciplinary scientific understanding of teaching.

But, you know what? Maybe we actually do have a good starting point for gaining this new understanding of teaching: the cognitive sciences. That domain, writ large, addresses models of the mind and how learning occurs there. Great headway has been made in that domain.

And what about teaching, those acts that are intended to cause learning in others? That domain lags far behind where the cognitive sciences are with respect to the learning sciences. That should not deter us, though, in conceptualizing our ancient/new domain with an eye towards how the cognitive sciences can inform teaching.

***Houston, We Have A Problem***

So far I have been attempting to provide a map of where we could go so as to create a multidisciplinary scientific vision of our ancient field. Not that you didn’t think about it, but there are a whole host of problems that will almost certainly crop up as we move towards that goal. Some are conceptual. Clearly, practitioners of different fields bring different conceptual systems about teaching to the table. Another problem is related to conceptual issues. Proponents of different fields bring different methodologies and tools to bear on understanding their field. And there are also potential interpersonal problems. How can you arrange matters so that people will be open enough to learn about what others think even though that thinking may be jarringly different from their own?

As an example of what considerations could arise when a multidisciplinary approach to teaching is adopted, I now present one problem for your consideration without trying to solve it: what are the relations between theory of mind (ToM) and teaching?

***Theory of Mind and Actual Teaching: A Problem***

Many, including me, have suggested that there is an intimate connection between theory of mind (ToM) and actual teaching. ToM gets at what children make of others’ mental states and allows people to share dispositions and anticipate each other's behaviors. Premack and Premack (1996) noted that teaching is underpinned by ToM in the following way: “To teach effectively, one individual must understand what another *sees*, *knows*, *wants*, and *is trying* to achieve” (italics in original, p. 308). I’m not going to question this received wisdom. It is reasonable as far as it goes. But I believe it doesn’t go far enough. Two important pieces are missing that, were they added, we’d have a more complete understanding of how ToM and teaching are related.

To make my point, I briefly present: (1) our current knowledge about children’s developing understanding of ToM concerning teaching, (2) what we know about children’s developing teaching strategies, (3) empirical relations between 1 and 2, and (4) the problematic nature of claims made about relations between how we understand others’ minds and how we teach to cause learning in those same minds.

***Children’s Developing Understanding of ToM about Teaching***

Three aspects of ToM, as they relate to teaching, are: a knowledge gap, intentionality and false beliefs. With regard to understanding the role of a knowledge gap between people in teaching situations, Olson and Bruner (1996) wrote: “no attribution of ignorance, no effort to teach” (p. 12). We teach someone who doesn’t know something, not someone who knows it. Strauss et al. (2002) tested this understanding and its development by presenting children stories of the following kind: “Uri is a teacher. He knows how to write. Jonathan knows how to write. Omri doesn’t know how to write. Who will Uri teach: Jonathan, Omri or both”? Strauss et al. (2002) found that by age 3.5 children already know that the teacher should teach the child who doesn’t have the knowledge or skill in question.

Intentionality is also an important aspect of teaching. The intention to cause learning in another’s mind separates teaching from other activities. How is it tapped? A child is presented two stories where someone either intends or doesn’t intend to teach someone. In both stories, the child being tested is told that the outcome of the intended or unintended teaching is learning or its lack. The child being tested is asked if there was teaching in the first and second stories. Here, the stories tap if the child understands the roles of intentionality and learning outcomes in someone else’s teaching.

Frye & Ziv (2005) and Ziv, Solomon & Frye (2008) found a developmental course for understanding intentionality about teaching. Similar to the development of understanding intentionality without reference to teaching, they found that children age 3.5 judged whether teaching occurred based on the learning outcomes (if there was learning, teaching occurred even if that teaching wasn’t intentional), whereas children age 5.5 thought that if there was an intention to teach then teaching occurred, even if learning did not ensue.

False beliefs about teaching deal with whether or not a teacher would teach based on her belief about the knowledge state of a learner or what that knowledge state actually is. To tap the development of this understanding, Strauss et al. (2002) and Davis-Unger & Carlson (2008 a, b) presented false belief tasks about teaching. Children were told about a situation in which a teacher believes that a child knows how to read but in fact the child doesn’t, or believes that a child doesn’t know how to read, but the child actually does. The child being tested is asked if the teacher will teach in those two situations. These tasks tap children’s understandings about whether or not teaching will take place based on their false belief or on the reality of what the learner does or doesn’t know. Findings suggest that by and large, like with classic false belief tasks, children below the age of 5 solve these false belief teaching tasks incorrectly and above age 5 they solve them correctly.

These three examples show how ToM is tapped in research on children’s understanding of teaching. And it has been shown that their understanding develops at ages that are similar to those revealed when intentionality and false belief are examined without reference to teaching. Other aspects of ToM that have a bearing on actual teaching include the notions that: a person (the teacher) can be a source of knowledge for another person (the learner), learning can occur in others’ minds, there is psychological causality in teaching and learning, this psychological causality is of an action-at-a-distance kind and more (Strauss, 2005).

***Children’s Developing Teaching Strategies***

In a fairly comprehensive review of children’s teaching strategies and their development, Strauss & Ziv (2012) reported that children display an amazing array of strategies from an early age and that it follows a developmental course.

There is proto-teaching among 1-year-olds where they point out the location of an object that an experimenter was looking for. Here, there is a knowledge gap where the infant knows where the object is and the experimenter doesn’t, and the infant points to the object’s location and, as a result, closes the knowledge gap.

By age 3, children’s main teaching strategy is demonstration accompanied by explanations. Children age 5 usually provide verbal explanations for the task at hand, and those explanations are accompanied by demonstrations. Many children around age 7 are capable of teaching contingently. In other words, many have a representation of the learner’s knowledge state and as that knowledge state changes due to the teacher’s teaching, the teachers adjusts her teaching based on her representation of the learner’s new knowledge state.

***Empirical Correlations between Children’s Developing Understanding of Teaching and Their Actual Teaching***

As mentioned, some researchers stated that there should be a relationship between children’s developing understanding of aspects of ToM and their actual teaching (Olson & Bruner, 1996; Wood, Wood, Ainsworth and O’Malley, 1995). However, few actually tested those relations. The first to do that were Strauss et al. (2002) and then Davis-Unger & Carlson (2008 a, b). And, indeed, correlations were found between children’s developing understanding of ToM and their actual teaching. With increasing age, more children solved ToM tasks and their teaching also moved from demonstrations to explanations.

***Problematic Claims about ToM and Actual Teaching***

Despite these correlations, there are two problems. The first gets at inferences from data. The fact that there are correlations between the development of ToM and actual teaching doesn’t mean that they are related conceptually. For example, we might be in the presence of two systems that develop independently. The onus of proof is to show why they should be interdependent developing systems. Data about correlations don’t get that job done.

That leads me to the second problem, which is considerably deeper than the first. There is a large problem about how we go from beliefs about something to actually doing it. Teaching is a case in point about this conundrum.

Gergely & Jacob (2012) wrote compellingly about this, and I lean on their analysis. They make a distinction found in the philosophical literature between two kinds of cognitive systems. The first is termed theoretical rationality. This kind of rationality is a property of a person’s belief system. An example is a teacher’s belief that pupils have information processing constraints on their learning. A belief is thought to be rational if it is consistent with other beliefs held by that person.

The second cognitive system is practical rationality. It is a property of a person’s decision system. For instance, a teacher gives a demonstration of how to reassemble a disassembled carburetor and upon seeing that a pupil didn’t learn how to reassemble it, the teacher teaches again, this time breaking down the assembling into small incremental steps, checking that the pupil learned each step before proceeding to the next one. A decision system is thought to be rational if it selects an action that is likely to maximize the person’s desire or preference. In our case, the desired goal is to cause learning in the pupil’s mind.

How can these two kinds of rationality be connected? The main idea here is that the decision made by the decision system (practical rationality) draws on the belief system (theoretical rationality). In the case I presented above, the belief system holds that pupils have information processing constraints. The teaching decision to break the assembling of the carburetor into small parts is based on that belief.

The picture drawn by Gergely and Jacobs (2012) is much more complex than I am making it here, but I believe that the distilled version I just presented honors one of their main ideas. So far so good. Now let’s look at what this means for the nature of the relationships between ToM and teaching.

For me, it is unclear why ToM, as currently conceptualized, is related to how children (and adults for that matter) actually teach. Here’s the rub: the fact that a child knows that a more knowledgeable person teaches a less knowledgeable one, that the intention to teach is a defining characteristic of teaching and that teaching is based on what the teacher believes the learner’s knowledge state is do not suggest *how* she could actually teach. When teaching, none of these and many other aspects of ToM lead to our explaining and demonstrating nor do they enable a teacher to contingently adapt the many forms of teaching to their representation of the learner’s changing knowledge state.

To find ways to describe a cognitive system of how people teach, we are going to need more than these kinds of ToM knowledge. Something big is missing here. In fact, three parts are missing, and they all revolve around learning, which is the goal of teaching.

The first missing part is a ToM about learning. What do children understand about the nature of the mind, what learning is and how learning occurs in the mind? A developmental question is: how do those understandings change over time? For some reason, we don’t have a literature about this for children.

To be sure, there has been considerable work on children’s learning of school subject matter (such as science, math, history) concepts. Closer to the point I am making is work on how children understand the mind and representations (false beliefs, deception, desires). Even closer to what I am proposing is work on how people understand that motivation aids learning (Dweck, 1986, 2002; Elliot & Dweck, 1988 ) as well as what intelligence is (Stipek & Gralinski, 1996).

But as important and interesting as these areas are, and they are, as far as I know, there is no research on children’s ToM understanding of the *workings of the mind that leads to learning*, i.e., their understanding of *how* people learn. I believe that were we to get a handle on this area, we would have important knowledge about an aspect of children’s belief systems that is central to teaching and that is because learning is what teaching aims to cause.

Researchers have conducted a number of interesting studies that tested various aspects of children’s developing understanding of knowledge acquisition. Some of them are their understanding of: knowledge states of ignorance and knowledge, when they learned, and how they learned. I will reinterpret the aspect of how they think they learn, resulting in what I am looking for, as described above.

By and large, research findings are that children age 3 have difficulties in what I will describe and by age 5 or 6, these difficulties have more or less disappeared. Let’s see what has been tested to date.

Knowledge states were tested by looking at children’s understandings of the absence (ignorance) and presence (knowing) of knowledge (Pratt & Bryant, 1990). Young children recognize that someone can be ignorant or have knowledge. Teaching aims to lead a pupil from a state of ignorance (or partial knowledge or false beliefs) to a state of knowledge.

Other studies were conducted to test what children know about when they learned (Esbensen, Taylor, & Stoess, 1997; Tang & Bartsch, 2012). For example, a child was taught something she didn’t know and afterwards was asked when she learned that new knowledge. Children age 3 thought they always knew what they had learned several minutes before.

And finally, I got to the point I want to make. I suggested that it is very important to tap children’s understanding of *how* they learn in order to determine the nature of the intertwined theoretical and decision systems.

But I have issues with what has been tested under that rubric. When testing children’s understanding of *how* they learn, researchers present tasks such as the following: Children are asked if they can know the contents of a drawer when they see the contents, are told about them or infer them from clues they were given. Tasks of this sort have been thought to test children’s developing understanding of *how* they learn (Gopnik & Graf, 1988; Sobel, Li & Corriveau, 2007).

I reinterpret this and believe that these kinds of tasks get at children’s understanding of the *conditions under which learning occurs*. I believe tasks of this type tap what children think the sensory modalities are that, when exposed to the environment, allow learning to occur. For example, under the condition that a child sees the drawer’s contents, she will know what is in the drawer.

I reiterate: I don’t believe these kinds of tasks tap what children think about *how* they learn. So what is it I am looking for regarding how children understanding that?

For the moment, I ask you to suspend criticism about the above and allow me to take you to adult teachers’ understanding of how learning occurs in children’s minds. Work I have done on mental models (Mevorach & Strauss, 2012; Strauss, 1993, 2001, 2012) looked at adult teachers’ models of the mind and how learning occurs there. Mental models were inferred from the ways they spoke about how they teach and the ways they actually teach.

Adult teachers refer to conditions that are both external to and within the mind that allow learning to occur. A partial list of external conditions includes the physical environment (noise, temperature) and teaching (the pace at which one teaches, how the subject matter is organized in teaching). Internal conditions that set the stage for learning, but are not learning, are those that are within the mind. They include children’s knowledge (their prior knowledge about the subject matter being taught) and their emotional/ motivational state (if they have math or history phobia, an abiding interest in what is being taught, a sense of efficacy about their learning, etc.).

Note that as important as these (and the other categories that remain unmentioned) are for learning, they refer to the conditions under which learning occurs. They set the stage for learning, but they are not about *how* learning occurs. When adults speak about *how* learning occurs, they speak about it metaphorically. For instance, they say that new *material* gets *connected* to already-learned knowledge that exists in children’s minds prior to their being exposed to what is being taught. One way this connection is made is through analogy. Another way that learning happens is when the learner doesn’t have prior knowledge about what is being taught. Because there is no way that the new knowledge can get connected to already-learned knowledge, new knowledge gets *driven into* memory through repetition.

As mentioned, their views are metaphorical. They do not speak about the biochemistry of short-term and long-term memory in neurons nor do they mention neural networks. But they do have folk psychology views about *how* learning takes place in children’s minds. And that is closely connected to their actual teaching.

If this is acceptable, then a task we could set for ourselves is to trace the developmental trajectory of understandings about *how* learning occurs from some starting point in childhood through adulthood. Were we to describe that, we would be closer to understanding the nature of the relations between theoretical and decision systems about learning and teaching, and that would bring us closer to having a scientific cognitive understanding of teaching.

You, the reader, might be thinking that what I am writing about is a bit picayune and is merely adding an area to ToM that has been neglected to date. Although it would be nice to know something about it, it’s nothing to write home about. I introduce the second missing part of ToM about teaching and then show why the first missing part could be of interest to all of us working in the area of teaching.

The second missing part is a ToM theoretical system about how teaching causes learning in others’ minds. This gets at how children understand this causal, action-at-a-distance relationship. It would be of interest to know how children understand why someone’s teaching was successful or unsuccessful in bringing about learning in others, what they would recommend to do if their teaching wasn’t successful, and more. As far as I know, no research has been done in this area.

The main reason I believe it is of interest to find out how children understand teaching (and what that understanding’s developmental trajectory is) is that this kind of belief system (theoretical rationality) of how teaching causes learning is likely to be closely linked to the decision system (practical rationality) of actual teaching. As mentioned above, the decision system rests on the belief system and is considered rational when it works to increase the likelihood of attaining its goal. The goal of teaching is to cause learning in others. Hence the importance of filling in the missing part about children’s developing conception of *how* learning occurs, which is the first missing part, and filling in the second missing part about children’s developing conceptions of teaching.

A third missing part is related to the first two. We would want to know how children’s developing understanding of learning and how teaching causes learning in others, are connected to the ways that these children actually teach.

So here’s the claim: theoretical belief systems about learning and how learning is brought about by teaching are missing in the research and theory-building literature. As a result, we don’t know how these two are related to how children actually teach. Were we able to describe these three missing parts, we would then be in a better position to determine the nature of the connections between the development of those aspects of ToM (theoretical rationality about understandings of learning and teaching) and the development of children’s actual teaching (decision system). That ought to take us a step closer to having a more complete cognitive map of and a scientific read on teaching.

***An Anecdote and Wrapping it Up***

In teacher education, through no fault of our own, we sometimes give the following unintended message to our future teachers: “You are embarking on a noble road. You will be passing on and helping your pupils construct our precious cultural heritage that has developed over the centuries. Through your teaching, you will help children learn about themselves and our world. A large part of your mission is to bring about such learning. Unfortunately, we don’t know much about what learning is and how teaching brings it about. But we do salute you and wish you the very best in your important role as a teacher”.

I attempted to make a case for the need to have a contemporary, scientific and multidisciplinary understanding of our ancient field of teaching. We are living in exciting times. Fields that impinge on a cognitive understanding of teaching are developing rapidly and ripe fruit is out there ready to be picked. The time for beginning the harvest is upon us. Were we to heed this call, we have the potential to create a paradigm shift in an ancient field. And the new understanding we could eventually create could serve our children and the teachers who teach them.

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