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In this chapter, the authors present a neuroscientific view of how emotions affect learning new information, and suggest a set of socially embedded educational practices that teachers can use to improve the emotional and cognitive aspects of classroom learning.

CHAPTER 4

Building Smart Students: A Neuroscience Perspective on the Role of Emotion and Skilled Intuition in Learning

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"Neuromyths" Aside: What Do Educators Need to Know about the Emotional Brain?

Recent strides in neuroscience have been increasingly used to inform educational theory and practice. However, while the most successful strides have been made in the areas of academic disciplinary skills such as reading and mathematical processing, a great deal of new evidence from social and affective neuroscience is ripe for application to education (Immordino-Yang & Damasio, 2007; Immordino-Yang & Fischer, in press). In particular, social and affective neuroscience are revealing more clearly than ever before the interdependence between cognition and emotion in the brain, the importance of emotion in guiding successful learning, and the critical

role of teachers in managing the social environment of the classroom so that optimal emotional and cognitive learning can take place (van Geert & Steenbeek, 2008).

The message from social and affective neuroscience is clear: no longer can we think of learning as separate from or disrupted by emotion, and no longer can we focus only at the level of the individual student in analyzing good strategies for classroom instruction. Students and teachers are socially interacting and learning from one another in ways that cannot be done justice by examining only the "cold" cognitive aspects of academic skills. Like other forms of learning and interacting, building academic knowledge involves integrating emotion and cognition in social context. Academic skills are "hot," not "cold"!

In this chapter, we aim to help educators move beyond the oversimplified and oftentimes misleading "neuromyths" that have abounded in education (Goswami, 2004; Goswami, 2006), replacing these with a set of strategies for fostering the sound development of academic emotions (Pekrun, Goetz, Titz, & Perry, 2002) through the use of emotionally relevant and socially contextualized educational practices (Brackett, Rivers, Shiffman, Lerner, & Salovey, 2006). These strategies are not taken directly from the details of neuroscience findings, as drawing such a direct connection would be inappropriate and premature. Instead, we interpret these findings to present a neuroscientific view of the functionality of emotions in learning new information, and build from this discussion a set of socially embedded educational practices that teachers can use to improve the emotional and cognitive aspects of classroom learning.

Before we proceed, we would like to insert a strong cautionary note. While the emerging field of Mind, Brain and Education is making strong strides toward informing educational practice with neuroscientific findings, it is important to maintain a cautious stance (Fischer, et al., 2007). Too often in education, out of the sincere desire to understand and help students, educators have grabbed onto various "brain-based" teaching strategies that are based either in misunderstandings or misapplications of neuroscientific information to education. The teaching and popular press literatures are rife with examples, from the overt labeling of elementary school students as different categories of learners, such as kinesthetic or auditory, to the notion that young babies should listen to Mozart to develop better spatial cognition. At best, these "neuromyths" have wasted monetary or other educational resources; at worst, they may even have been harmful or dangerous to children.

Here, we take a different approach. Rather than presenting details about brain systems and findings that are not directly relevant to the question of how best to educate children, we instead aim to interpret findings from a body of neuroscience research that has made use of a very productive paradigm for studying the emotional and body-related signals underlying learning. This paradigm, known as the Iowa Gambling Task, was designed by Antoine Bechara and others some years ago (Bechara, Damasio, Tranel, & Damasio, 2005), and it has taught neuroscientists a great deal about the formative role of emotions in cognition and learning. In this chapter,

The Iowa Gambling Task has taught neuroscientists a great deal about the formative role of emotions in cognition and learning.

we aim to distill what neuroscientists have learned into a series of neuroscience-based recommendations about emotion and learning in social context that can inform teachers' practice. These recommendations are likely to be reliable and useable because they reflect not one experiment or brain area, but a consensus on the principles of brain functioning that has accumulated from several years of neuroscientific experimentation and debate.

To do this, we first describe the Iowa Gambling Task and the important insights it has revealed into the role of nonconscious emotional "intuition" in successful, efficient learning. We present a typical participant's performance in this paradigm to illustrate the reliable patterns that have been revealed through the many emotion and learning experiments that have made use of this paradigm, and interpret this typical pattern in light of various researchers' findings with normal and brain damaged patients. We then go on to describe how interference with emotional processing during learning, either due to the intrusion of other emotions irrelevant to the task at hand, or in extreme cases to damage of relevant brain regions, can interfere with the building of sound emotional intuitions that guide skilled, rational behavior.

In the second half of the paper, we explicitly address strategies that teachers can use to help students manage and skillfully recruit their emotions in the service of meaningful learning, building from

what the neuroscience experiments have taught us. The overall aim of the first part of the chapter is to describe five contributions from neuroscience research that have taught neuroscientists about the relationship between emotion and cognition in learning and that we feel have important implications for teaching in social settings such as schools. The overall aim of the second half of the chapter is to distill the implications of these contributions into a series of three strategies that could be used to improve teaching and learning in schools. Taken together, we hope this chapter will guide teachers in beginning to incorporate meaningful emotional experiences into their students' learning.

The Brain and Learning: Why Does Emotion Matter?

Neuroscience contribution number one: Emotion guides cognitive learning

Consider the following intriguing scenario from the Iowa Gambling Task (IGT): A participant in a study is seated at a table with a card game before her. Her task is to choose cards from four decks. With each card she draws she has the chance to win some amount of money. Unbeknownst to her, some decks contain cards with larger wins than other decks, but these decks also result in occasional enormous losses that make these decks a bad choice in the long run. How does a typical person learn to play this game, and deduce the "cognitive" rules for calculating and weighing the relative long-term outcomes of the different decks?

In examining our IGT player's performance, we will see that the process of learning how to play this game involves both emotional and cognitive processing, and begins with the development of (generally) nonconscious emotional "intuitions" that eventually become conscious "rules" that she can describe in words or formulas. The development and feeling of these intuitions is critical for successful, usable knowledge to be constructed. As she begins the game, she at first randomly selects cards from one deck or another, noting wins and losses as they come. But soon, before she is even consciously aware that the decks are biased, she begins to show an anticipatory emotional response in the moment before choosing a card from a high risk deck (her palms begin to sweat in microscopic amounts, measured as *galvanic skin response* or GSR). Unconsciously, she is accumulating emotional information about the relative riskiness of some decks. As she proceeds, this emotional information steers her toward the "safe" decks and away from those with high gains but the possibility of large losses. After playing for a while longer she accumulates enough information about the decks that she is able to describe the rule about which decks to play and which to avoid, and we would say that she has "learned."

The Iowa Gambling Task and other experiments have taught neuroscientists about the importance of emotion in the learning process, an importance that probably applies not just here but to math learning, social learning, and to learning in various other arenas in which a person must accumulate information from his or her experiences and use this information to act advantageously in future situations (Bechara & Damasio, 1997). Emotion is guiding the

learning of our participant much like a rudder is guiding a vessel or airplane (Immordino-Yang & Damasio, 2007). Though it and its influence may not be openly visible, it is providing a force that is stabilizing the direction of a learner's decisions and behaviors over time, and helping the learner to recognize and call up relevant knowledge—e.g., knowledge about which deck to pick from or which math formula to apply (See Figure 1).

Neuroscience contribution number two: Emotional contributions to learning can be conscious or nonconscious

In the example of the Iowa Gambling Task, the anticipatory emotional response guiding the participant's choice is not present from the very beginning, but must be slowly learned with experience playing the game. Although she understands that she is engaging in a game of chance with uncertain outcomes, our participant at first has no information—intuitive or factual—that might help her to distinguish between the decks. As she draws, she will at first surely be attracted to the large-gain-large-loss decks as long as she is experiencing the delivery of higher rewards. At this stage, she will already be developing a nonconscious emotional reaction to these decks: one of excitement and attraction.

It is only after her first encounter with an enormous loss that her reaction will change, rapidly shifting from excitement to disappointment. Was this an isolated event? Or should she learn from it and adjust her future choices accordingly? From now on, she will not draw from these decks in the same way as before. She will likely

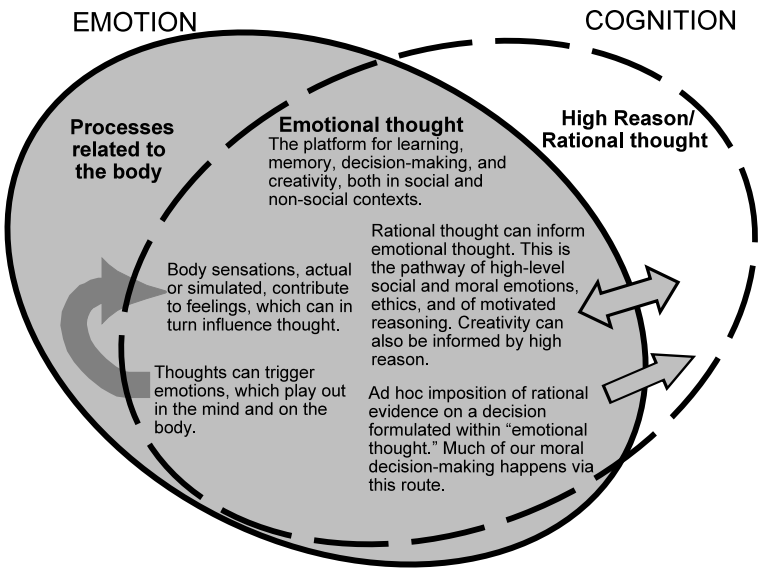

Figure 1 Emotion and cognition come together to produce the thought processes that educators care about, among them ;earning and memory. In the diagram, the solid ellipse represents emotion; the dashed ellipse represents cognition. The extensive overlap between thetwo ellipses represents the domain of "emotional thought." Skilled intuitions are often an important step in the development of emotional thought, and are built through repeated revisiting of real or simulated bodily sensations in the light of the "cognitive" aspects of knowledge.

Source: Immordino-Yang & Damasio, 2007. Reprinted with permission.)

continue to draw from the high risk deck occasionally, feeling tempted by the higher rewards, but she will do so while at the same time fearing to be punished again for her risk taking. As we can see, her emotional rudder is steering her behavior and teaching her about

the decks, making her reluctant to reach for the risky decks, helping her to overcome the temptation of higher rewards, and giving her the energy and impetus to think twice. And as the neuroscience experiments show, all this can be happening underneath the level of her conscious awareness; she may still report that she does not know yet how to play the game, or what to expect from the different decks. Only her nonconscious palm sweating gives away the hidden force of her emotional learning at this early point in the learning process.

Neuroscience contribution number three: Emotional learning shapes future behavior

Having an emotional rudder is helpful when playing the Iowa Gambling Task, but it is just as helpful in many other situations we encounter—both inside schools and out. Consider the third grade student who incorrectly solves a math problem and receives a red X on his paper, or, alternatively, correctly solves the problem and gets a good grade. Consider the community college student whose essay draft misses the mark, or who raises his hand in class and gets an encouraging nod from the instructor.

Just as we saw for the IGT player, the learners' emotional reactions to the outcomes of their behavioral choices become implicitly attached to the cognitive knowledge about the domain—here, either school culture or math or essay writing. These academic activities are no longer neutral to the learner; they become "risky" and uncomfortable, or else exciting and challenging, depending in part on the learner's emotional interpretation of the outcome. In each

of these examples, the learner's emotional reaction to the outcome of his efforts consciously or nonconsciously shapes his future behavior, either inciting him to behave in the same way the next time or to be wary of situations that are similar.

Neuroscience contribution number four: Emotion is most effective at facilitating the development of knowledge when it is relevant to the task at hand

In the context of schools, emotion is often considered ancillary or secondary to learning, rather than an integral part of the knowledge being learned. We expect children, for example, to "get their feelings out of the way" so that they can focus on their studies. In this view, emotions are seen as a disruptive force, antagonistic to good cognition, and in need of regulation and suppression in the interest of mature judgment—be it with respect to social dilemmas such as how to treat your friends, moral dilemmas such as dealing with an instance of cheating (Haidt, 2001), or cognitive dilemmas such as deciding which equation to apply to a problem in math class (Immordino-Yang & Fischer, in press).

Efficient learners build useful and relevant "intuitions" that guide their thinking and decision making.

However, as the IGT task demonstrates, neuroscience is revealing that rather than working to eliminate or "move beyond" emotion, the most efficient and effective learning incorporates emotion into the cognitive knowledge being built. In effect, efficient learners build useful and relevant

"intuitions" that guide their thinking and decision making (Damasio, 1994/2005; Immordino-Yang & Damasio, 2007). These intuitions integrate their emotional reactions with their cognitive processing, and incorporate what has been learned from experience. They are not randomly generated nonconscious whims. Rather, because they are shaped and organized by experience with a task or domain, they are specific and relevant to the particular contexts in which they are learned.

But how can we distinguish between relevant and irrelevant emotions, and how does this distinction play out in academic learning? To understand how the development of the emotional rudder can go wrong, let's return again to the example above. How effectively would the gambler described above learn the game if she were so anxious that she could not "feel" the subtle emotional changes telling her about the valence of the decks? Alternatively, what if she were so excited about an upcoming football game that she could not concentrate on the task at hand? In both cases, she would clearly have an emotional reaction, but with respect to the task it would be a static and invariable one. She would be anxious or excited independent of the particular deck she had drawn from, and independent of the particular outcome obtained. In both of these examples, she would quite possibly not learn to effectively distinguish the different decks based on her emotional intuition because all decks would be experienced with the same type of undifferentiated emotionality. Her learning of the game would fail. Taken together, these examples show that effective learning does not involve removing emotion; rather, it involves skillfully cultivating an

emotion state that is relevant and informative to the task at hand.

Neuroscience contribution number five: Without emotion, learning is impaired

To bring home the importance of emotion in the learning process, consider now an alternate scenario: A different person is gambling in the task, and trying to win the money. However, this person is a neurological patient with damage to an area of the brain that lies just above the eyes (the *ventromedial prefrontal cortex*) and intermediates between the feeling of the body during emotion and the learning of cognitive strategies. How would this person's performance differ? This patient has perfectly intact cognitive abilities; she solves logic problems and does fine on standardized IQ tests. Will she be able to learn how to play the game successfully, though, given that her choice of cognitive strategy can not be subtly informed by her nonconscious emotional reactions to risky decks? Maybe getting emotion out of the way will clear the way for a more direct assessment of the game's rules?

Sadly, this is not the case. The patient would start out just like the typical person, randomly selecting cards from one deck or another. However, instead of developing the anticipatory emotional response that would tell her about the differential riskiness of the decks, her emotional reaction to choosing the cards would not inform her future choices. While normal participants gradually shift to picking from the "safe" decks, the ventromedial prefrontal cortex patient would remain attracted to the large-gain-large-loss decks, picking from them at

least as often as from the "safe" decks. Although she would notice that some decks produce high losses and although she would feel disappointed when these losses occurred, she would not use this information to guide her future game-playing strategy.

Most normal participants are able to identify a conscious rule about which decks to play and which ones to avoid by the time they have picked a total of eighty cards. And even the normal participants who fail to fully and correctly state the rule have developed an advantageous pattern of choosing from the decks by then. But among the group of ventromedial prefrontal cortex patients, things look very different: They continue to choose disadvantageously *even if* they succeed in identifying a conscious rule about which decks to play and which ones to avoid. Put another way, they never successfully learn to play the game. Their conscious knowledge, emotional reactions, and cognitive strategies are not integrated or aligned. The result is that these patients are unable to learn from their experiences, and unable to use what they may consciously appear to "know." (Notably, this deficit extends into the decisions these patients make in their daily lives. They are unable to effectively manage their lives as they did prior to sustaining brain injury, and must be constantly supervised.)

How does this apply to the argument at hand? What this means for the interaction of emotion and cognition is that factual knowledge alone is useless without a guiding emotional intuition. Some ventromedial prefrontal patients know very well which

If students feel no connection to the knowledge they learn in school, the academic content will seem emotionally meaningless to them.

decks are good and which are bad, but this information has no relevance for them when it comes to making decisions. And students in the classroom struggle with very much the same problem: If they feel no connection to the knowledge they learn in school, the academic content will seem emotionally meaningless to them. Even if they manage to regurgitate the factual information it will lay barren and without any influence on their decisions and behavior. Sure, unlike the ventromedial prefrontal patients, they have the capacity to develop emotional reactions to the material they learn. But if the curriculum does not support the development of emotional reactions, if it does not take them seriously when they occur and does not give them any room to influence decisions and behavior in the classroom, then the effective integration of emotion and cognition in learning will be compromised just as it is for the group of patients. For good cognition to manifest itself in the classroom and beyond, emotions need to be a part of the learning experience all along.

Bringing Emotions Back into Classroom Learning: Three Strategies for Teachers

Strategy 1: Foster emotional connection to the material

The first and possibly most important strategy that teachers can use to foster meaningful learning through emotion is to design educational experiences that encourage relevant emotional connection to the material being learned. This fostering of emotional connection can start with the selection of the topic to be explored

itself. Sometimes teachers may have some leeway in deciding which specific topics to present and how to engage the students in these topics. Why not, in a serious and responsible manner, involve students in these selection processes? For example, if the topic to be covered involves learning about ancient Rome, why not allow the students some choice as to whether to write and perform a play about key events, to write research reports about these events, or to design a model senate that mimics that of the early Romans? When the students are involved in designing the lesson, they become clearer on the goal of the lesson, and more emotionally invested in and attached to the learning outcomes. This participatory approach has the power to instill in them a sense of ownership that can go a long way toward making the later learning meaningful and the emotions they experience relevant.

In addition, teachers can make room to relate the material to the life of the students and to students' interests. This relating can take the form of showing how what will be learned can affect their everyday experiences or it can again rely on the students themselves to identify and probe possible connections. As much as possible, students can be encouraged to follow their interests and passions, with the teacher helping them to see the relevance and usefulness of the academic material to these choices. How, for example, did Caesar feel and think about issues like wars that are as relevant today as they were then? When students are encouraged to engage in and identify with the academic material in a meaningful way, the emotional intuitions they develop will be more relevant to the decision-making that faces them in their everyday lives.

Another effective tool from the viewpoint of emotional engagement is teaching students to solve open-ended problems, because these problems allow the students to wrestle with the definition of the task itself, recruiting their intuitive knowledge regarding relevance, familiarity, creativity, and interest in the process (Ablin, 2008). Portfolio, project, and group work, although usually more closely guided, can also turn out to be effective in enabling these emotional aspects of thought. In general, teachers should strive to design activities that create space—space for emotional reactions to appear, along with space to safely make mistakes and learn from them. This likely means breaking away from a highly prescriptive approach that aims to move students along the fastest and most direct way toward mastering specific content, because this fast and direct way will often be emotionally impoverished.

It is in the detours and missteps, as well as in re-finding the path, that rich emotionality is played out, that valuable emotional memories are accumulated, and that a powerful and versatile emotional rudder is developed. In times of standardized testing and curricula packed to the brim it might sound like sacrilege, but from an affective neuroscientific perspective, the direct and seemingly most efficient path turns out to be inefficient, leading too often to heaps of factual knowledge poorly integrated into and therefore ineffective for students' real lives.

Strategy 2: Encourage students to develop smart academic intuitions

Once a topic is chosen, teachers should encourage their students to use their own intuitions when engaging in learning and problem-solving activities in the classroom. From a neuroscientific perspective, intuition can be understood as the incorporation of the nonconscious emotional signal into the knowledge being acquired. Thinking back to the Iowa Gambling Task, normal participants playing the game begin to show signals of emotional unease before choosing from risky decks; only eventually does this emotional reaction become incorporated into the participants' conscious understanding of the rules for playing the game. That is, even before the participant can consciously describe the rules, she has nonconscious "intuitions" about how things will turn out when she chooses from one or the other card decks. As we have seen, the development of these experience-based intuitions increasingly guides her decision-making, and eventually organizes the formation of conscious, cognitive rules for the game—in educational language, she has "learned"!

Just as the Iowa Gambling Task participant needs a collection of both positive and negative experiences to help her learn the relevance of the different decks and the implications for the choices she should make, students must be offered adequate chances for the development and feeling of experience-based intuitions about how and when to use the academic material. "Is the use of this mathematical procedure warranted in this instance?," "Am I getting closer to the correct solution?" Students' private (or collective) reflections on questions such as these are critical to the development of useful, generalizable, memorable knowledge. And, at their base, answering these questions

requires integrating emotional with cognitive knowledge to produce skilled intuitions—the kind of intuitions that will transfer to other academic and real-life situations.

Although it is understandable that teachers feel pressured to help their students learn a lot of information as quickly as possible, and although it is true that, at least initially, students may be slower to build the full representation of the material, in the long run neuroscience suggests that it may be more effective for teachers to judiciously build into their curricula opportunities for the development of skilled intuition. As we have seen, although students may be slower to build the full representation of the material, without the development of sound intuitions undergirding their representations, it is likely that the students will not remember the material in the long-term, and that even if they remember it in an abstract sense, they will have difficulty applying it to novel situations.

Neuroscience suggests that it may be more effective for teachers to judiciously build into their curricula opportunities for the development of skilled intuition.

Strategy 3: Teachers should actively manage the social and emotional climate of the classroom

In addition to the importance of the students' learning activities, the development of students' intuitions also depends on the social aspects of the classroom climate. While allowing for the development of skilled intuition is important, simply having the space to make

mistakes will not be enough, because students will only allow themselves to experience these failures if they can do so in an atmosphere of trust and respect. It is here that the classroom climate and the social relationships between the teacher and students have crucial contributions to make.

Faced with the challenge of bringing positive emotions back into the classroom, teachers may feel tempted to take the easy route and stir up students' emotions in artificial and non-task-related ways, such as by telling jokes, showing cartoons, doling out prizes, or turning a blind eye to students acting out. And indeed, a carefully timed dose of humor or incentive can certainly help students to invest in the classroom culture as an enjoyable place to belong. Such activities can also go a long way in helping students to feel safe in expressing and learning from their mistakes, and in building social cohesion among the students and between the students and the teacher-necessary ingredients of engaged learning.

At the same time, the task-irrelevant emotions that activities such as contests and jokes are designed to generate may actually interfere with students' ability to feel the subtle emotional signals that steer the development and application of new conceptual knowledge. As we saw in the Iowa Gambling Task, overanxious, overexcited, or distracted participants may have trouble learning the game. For emotion to be useful, it has to be an integral part of knowing when and how to use the skill being developed. Especially in young learners or in students whose engagement or connection to academic learning is tenuous, the emotional signals that undergird skilled intuition could easily be drowned out.

And so, effective teachers are faced with a balancing act. On the one hand, task-irrelevant emotions oftentimes serve an important initial role in establishing a safe and enjoyable social climate in the classroom. On the other hand, too much task-irrelevant emotion can undermine the development of students' ability to feel appropriately emotional about their academic learning. For teachers to effectively manage the social-emotional climate of their classroom, they must strike a balance between these two kinds of emotion by actively managing the emotions of their students, helping the learners to attend to, trust, and thrive on the subtle emotional signals they are slowly building as they accumulate meaningful academic experiences. As learners become more emotionally skilled, task-irrelevant emotional activities can fade, leaving actively engaging emotional learning experiences in their place.

As learners become more emotionally skilled, task-irrelevant emotional activities can fade, leaving actively engaging emotional learning experiences in their place.

Conclusion: A Neuroscientific Perspective on Emotions, Intuitions and Learning

A rich body of recent neuroscience has demonstrated the interrelatedness of emotions and cognition, and the importance of emotion in rational thought (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001; Haidt, 2001; Immordino-Yang, 2008). Yet, much of contemporary educational practice considers emotion as ancillary or

even as interfering with learning. In this chapter, we discussed the critical role of emotion in learning, and showed that students' accumulation of subtle emotional signals guides their meaningful learning, helping them to build a set of academic "intuitions" about how, when and why to use their new knowledge.

Rather than trying to remove emotions from the learning context, teachers can use this neuroscientific perspective to actively orchestrate an emotional climate in the classroom that is conducive to feeling these subtle emotional signals. As students learn to notice and refine these signals, their learning will become more relevant and meaningful, and ultimately more generalizable and useful in their everyday lives.

References

Ablin, J. L. (2008). Learning as problem design versus problem solving: Making the connection between cognitive neuroscience research and educational practice. *Mind, Brain, and Education, 2*(2), 52-54.

Bechara, A., & Damasio, H. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*(5304), 1293-1295.

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (2005). The Iowa Gambling Task and the somatic marker hypothesis: Some questions and answers. *Trends in Cognitive Sciences, 9*(4), 159-162.

Brackett, M. A., Rivers, S. E., Shiffman, S., Lerner, N., & Salovey,

P. (2006). Relating emotional abilities to social functioning: A comparison of self-report and performance measures of emotional intelligence. *Journal of Personality and Social Psychology, 91*(4), 780-795.

Damasio, A. R. (1994/2005). *Descartes' error: Emotion, reason and the human brain.* London: Penguin Books.

Fischer, K. W., Daniel, D. B., Immordino-Yang, M. H., Stern, E., Battro, A., & Koizumi, H. (2007). Why Mind, Brain, and Education? Why now? *Mind, Brain and Education, 1*(1), 1-2.

Goswami, U. (2004). Neuroscience and education. *British Journal of Educational Psychology, 74,* 1-14.

Goswami, U. (2006). Neuroscience and education: From research to practice? *Nature Reviews Neuroscience, 7*(5), 406-411.

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science, 293*(5537), 2105-2108.

Haidt, J. (2001). The emotional dog and its rational tail: A social intuitionist approach to moral judgment. *Psychological Review, 108*(4), 814-834.

Immordino-Yang, M. H. (2008). The smoke around mirror neurons: Goals as sociocultural and emotional organizers of perception and action in learning. *Mind, Brain, and Education, 2*(2), 67-73.

Immordino-Yang, M. H., & Damasio, A. R. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. *Mind, Brain and Education, 1*(1), 3-10.

Immordino-Yang, M. H., & Fischer, K. W. (in press). Neuroscience

bases of learning. In V. G. Aukrust (Ed.), *International Encyclopedia of Education, 3rd Edition, Section on Learning and Cognition.* Oxford, England: Elsevier.

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist, 37*(2), 91-105.

van Geert, P., & Steenbeek, H. (2008). Brains and the dynamics of "wants" and "cans" in learning. *Mind, Brain, and Education, 2*(2), 62-66.