Mary Helen Immordino-Yang

Mary Helen Immordino-Yang, EdD, is a cognitive neuroscientist and educational psychologist who studies the brain bases of emotion, social interaction, and culture and their implications for development and schools. A former junior high school science teacher, she earned her doctorate at the Harvard University Graduate School of Education. She is the associate North American editor for the journal *Mind, Brain and Education* and the inaugural recipient of the International Mind, Brain and Education Society's Award for Transforming Education through Neuroscience. She is currently Assistant Professor of Education at the Rossier School of Education and Assistant Professor of Psychology at the Brain and Creativity Institute, University of Southern California.

Matthias Faeth

Matthias Faeth is a doctoral student at the Harvard Graduate School of Education. His interest is the interaction of emotions and learning from an educational, psychological, and neuroscientific perspective. He is currently living in Montreal where he is also pursuing his research at the Centre de Recherché en Neuropsychologie et Cognition (CERNEC) at the Université de Montréal.

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

The Role of Emotion and Skilled Intuition in Learning

Mary Helen Immordino-Yang and Matthias Faeth

Advances in neuroscience have been increasingly used to inform educational theory and practice. However, while the most successful strides forward 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 prime 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 of 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 solely at the level of the individual student in analyzing effective strategies for classroom instruction. Students and teachers socially interact and learn 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!

Beyond Neuromyths

In this chapter, we aim to help educators move beyond the oversimplified and often misleading "neuromyths" that abound in education (Goswami, 2004; Goswami, 2006) by replacing them with a set of strategies for fostering the sound development of academic emotions (Pekrun, Goetz, Titz, & Perry, 2002). These strategies are guided by 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. We then 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 education literature and popular media are rife with examples, from the categorizing of elementary school students as specific kinds of learners (such as kinesthetic or auditory) to the notion that young babies should listen to Mozart to develop better spatial cognition than they might otherwise develop. At best, these neuromyths have wasted educational resources; at worst, they may even have been harmful or dangerous to children.

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, 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 usable because they reflect not one experiment or brain area, but rather a consensus on the principles of brain functioning that has accumulated over several years of neuroscientific experimentation and debate.

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

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 we 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 from the intrusion of other emotions irrelevant to the task at hand or, in extreme cases, because of damage to relevant brain regions—can interfere with the building of sound emotional intuitions that guide skilled, rational behavior.

In the second half of the chapter, 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 neuroscience experiments have taught us.

Thus 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 can 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?

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 rules for calculating and weighing the relative long-term outcomes of the different decks?

1. Emotion Guides Cognitive Learning

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. It begins with the development of (generally) nonconscious emotional intuitions that eventually become conscious rules, which she can describe in words or formulas. The development and feeling of these intuitions is critical to construct successful, usable knowledge. 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 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). Nonconsciously, 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 awhile 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."

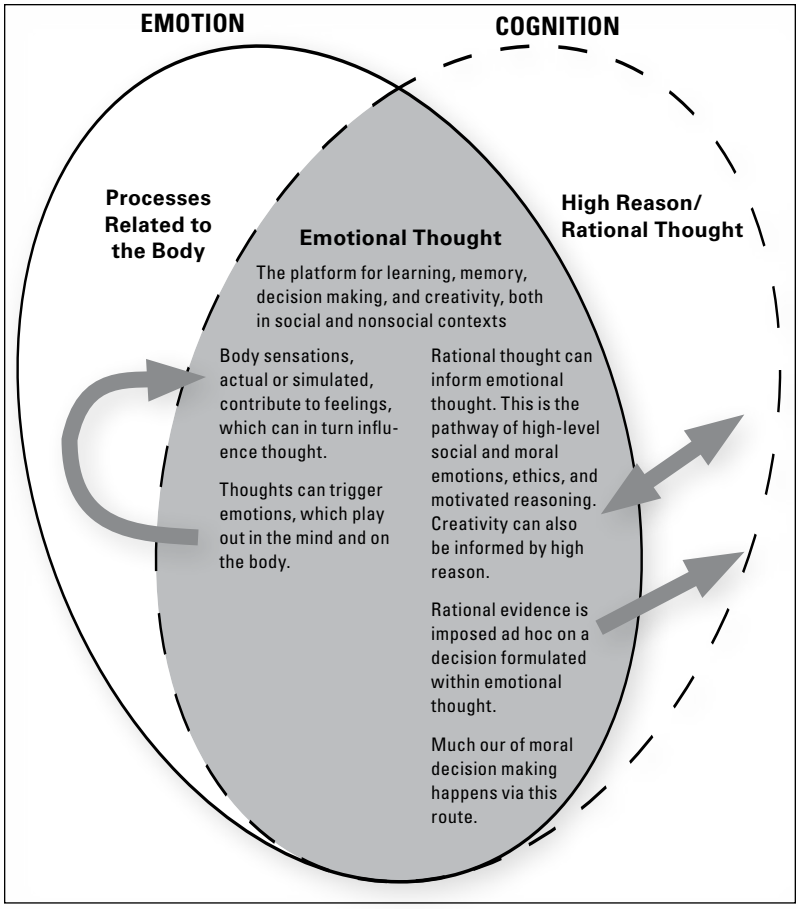
The Iowa Gambling Task and other experiments have taught neuroscientists about the importance of emotion in the learning process, an importance that probably applies not only here, but also

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 that information to act advantageously in future situations (Bechara & Damasio, 1997). Emotion guides the learning of our participant much like a rudder guides a ship (Immordino-Yang & Damasio, 2007). Though it and its influence may not be visible, it provides a force that stabilizes the direction of a learner's decisions and behaviors over time. It helps the learner recognize and call up relevant knowledge—for example, knowledge about which deck to pick from or which math formula to apply (see fig. 4.1). In the diagram, the solid ellipse represents emotion; the dashed ellipse represents cognition. The extensive overlap between the two 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.

2. 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. It must be slowly learned from 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 the loss an isolated event? Or should she learn from it and adjust her future choices accordingly? From then on, she will not draw from the decks in the same way as before. She will likely 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



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

Figure 4.1: How emotion and cognition come together to produce the thought processes that educators care about, among them learning and memory.

punished again for taking the risk. 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 of this can be happening underneath her level of 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 sweating palms

give away the hidden force of her unconscious emotional learning at this early point in the learning process.

3. 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—both in school and elsewhere. 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 observed in the IGT player, learners' emotional reactions to the outcomes of their behavioral choices become implicitly attached to the cognitive knowledge about the domain—in the previous examples, 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.

4. 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

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

equation to apply to a problem in math class (Immordino-Yang & Fischer, in press).

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. Intuitions 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 affect academic learning? To understand how the development of the emotional rudder can go wrong, let's return to the previous example. How effectively would the gambler 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, say, 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, her reaction would be static. She would be anxious or excited independent of which deck she drew from and independent of the 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 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 emotional state that is relevant and informative to the task at hand.

5. Without Emotion, Learning Is Impaired

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 mediates between the feeling of the body during emotion and the learning of cognitive strategies. How would this person's performance differ from the person in the previous example? 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 cannot be subtly informed by her nonconscious emotional reactions to risky decks? Maybe getting emotion out of the way will allow 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 player, 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 feel disappointed when these losses occurred, she would not use this information to guide her future playing strategy.

Most normal participants are able to identify a conscious rule about which decks to play and which to avoid by the time they have picked a total of eighty cards. Even the normal participants who fail to state the rule fully and correctly 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 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 decisions these patients make in their daily lives. They are unable to

manage their lives as effectively as they did prior to sustaining the brain injury and must be constantly supervised.)

For the interaction of emotion and cognition, all of this means that factual knowledge alone is useless without a guiding emotional intuition. Some ventromedial prefrontal patients know very well which decks are good or bad, but this information has no relevance for them when it comes to making decisions. Students in the classroom struggle with much the same problem. If they feel no connection to the knowledge they learn in school, then the academic content will seem emotionally meaningless to them. Even if they manage to regurgitate factual information, it will not influence 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 accommodate the reactions when they occur and allow them to influence decisions and behavior in the classroom—then the effective integration of emotion and cognition in learning will be compromised. For effective cognition to manifest itself in the classroom and beyond, emotions need to be a part of the learning experience all along.

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

Bringing Emotions Back Into Classroom Learning: Three Strategies for Teachers

In this section, we provide three guiding strategies to help teachers accommodate and support the development of emotional learning.

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. Such fostering of emotional connection can start with the selection of the topic to be explored. Sometimes teachers have some leeway in deciding which topics to present and how to engage their students in them. Why not, in a serious and responsible manner, involve students in the selection process? For

example, if the topic is learning about ancient Rome, why not allow students a choice among writing and performing a play about key events, writing a research report, or designing a model senate that mimics that of the early Romans? When students are involved in designing the lesson, they better understand the goal of the lesson and become more emotionally invested in and attached to the learning outcomes. This participatory approach has the power to instill in students a sense of ownership that can go a long way toward making later learning meaningful and the emotions they experience relevant.

In addition, teachers can relate material to the lives and interests of their students. Relating can mean showing how new learning can affect students' everyday experiences, or it can mean students themselves identifying and probing connections. As much as possible, teachers should encourage students to follow their interests and passions and help them to see the relevance and usefulness of the academic material to these choices. How, for example, did Caesar feel and think about war? That question, applied to students or today's national leaders, is as relevant now as it would have been in Caesar's time. When students are encouraged to engage and identify with academic material in a meaningful way, the emotional intuitions they develop also will be relevant to decisions they face in their everyday lives.

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

It is in the detours and missteps as well as in rediscovering the path that students experience rich emotionality, accumulate valuable emotional memories, and develop a powerful, versatile emotional

rudder. In a time of heavily used standardized testing and curricula packed to the brim, this idea might sound unorthodox. But from an affective neuroscientific perspective, the direct and seemingly most efficient path turns out to be inefficient, leading too often to abundant factual knowledge that is poorly integrated (and therefore ineffective) in students' real lives.

Encourage Students to Develop Smart Academic Intuitions

Once a topic is chosen, teachers should encourage 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 signals into knowledge acquisition. Recall the Iowa Gambling Task, in which typical participants playing the game began to show signs of emotional unease before choosing from risky decks. Eventually this emotional reaction was incorporated into the participants' conscious understanding of the rules of play. That is, even before a 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. The development of these experience-based intuitions increasingly guides the participant's decisions and eventually facilitates the formation of conscious, cognitive rules for the game—in educational language, she has "learned"!

Just as the Iowa Gambling Task participant needs both positive and negative experiences to learn the relevance of the different decks and the implications for various choices, so too must students have opportunities to develop intuitions about how and when to use academic material. They will learn to ask relevant questions, such as "Is the use of this mathematical procedure warranted in this instance?" and "Am I getting closer to the correct solution?" Students' private (or collective) reflections on such questions are critical to the development of useful, generalizable, memorable knowledge. And, at their base, answering these questions requires integrating emotional and cognitive knowledge to produce skilled intuitions—the kind that will transfer to other academic and real-life situations.

Neuroscience suggests that learning may be more effective if teachers judiciously build into their curricula opportunities for students to develop skilled intuition.

It is understandable that teachers feel pressured to help their students learn a large amount of information as quickly as possible, and at least initially students may be slow to attain mastery. However, neuroscience suggests that in the long run, learning may be more effective if teachers judiciously build into their curricula opportunities for students to develop skilled intuition. Without the development of sound intuitions, students likely will not remember the material over the long term. And even if they do remember it in an abstract sense, they will have difficulty applying it to novel situations.

Actively Manage the Social and Emotional Climate of the Classroom

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 providing students with space to make mistakes will not be enough. Students will allow themselves to experience failure only if they can do so within an atmosphere of trust and respect. Thus classroom climate and 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 when students act out. Indeed, a carefully timed dose of humor or an incentive certainly can help students invest in the classroom culture as an enjoyable place to belong. Such activities also can go a long way in helping students feel safe expressing themselves, learning from their mistakes, and building social cohesion—all necessary ingredients of engaged learning.

At the same time, emotions that are irrelevant to tasks at hand 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 students whose engagement or connection to

academic learning is tenuous, the emotional signals that undergird skilled intuition could easily be drowned out.

Effective teachers are faced with a balancing act. On the one hand, task-irrelevant emotions can serve an important initial role in establishing a safe and enjoyable social climate in the classroom. On the other hand, too much irrelevant emotion can undermine the development of students' ability to feel appropriately emotional about their academic learning. For teachers to manage the social-emotional climate of their classroom effectively, they must strike a balance between these two kinds of emotion by actively managing the emotions of their students, helping learners to attend to, trust, and thrive on the subtle emotional signals they build 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.

A Neuroscientific Perspective on Emotions, Intuitions, and Learning

A rich body of recent neuroscience research 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. As we have shown in this chapter, the role of emotion in learning is critical. Students' accumulation of subtle emotional signals guides 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 orchestrate an emotional climate in the classroom that is conducive to students feeling these subtle emotional signals. As students learn to notice and refine these signals, learning will become more relevant and meaningful to them and ultimately more generalizable and useful in their everyday lives.

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