Educational Impacts of the Social and Emotional Brain

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KEYWORDS

• Neuroscience • Cognitive • Emotional • Education • Students

KEY POINTS

- The way the brain is "wired" links cognitive and emotional processes so that one cannot function without the other.
- Emotion regulation skills develop as the prefrontal cortex matures, and can be promoted through direct instruction, behavior modeling, and provision of a stable, predictable environment.
- Adolescence is marked by a shift in the brain's emotion/cognition balance; emotion has greater influence during this developmental phase.
- These insights about brain development suggest educational strategies that can promote greater academic achievement.

INTRODUCTION

Recent developments in neuroscience related to social and emotional development have significant implications for educational practice. Social and emotional development are closely linked with cognitive processes, thus significantly influencing overall student development and academic progress. Emotions affect how humans interpret experiences and adapt to changes in internal and external environments. This article asserts that integrating social-emotional learning (SEL) into classrooms is essential for academic achievement because of the way the brain is organized and the process through which brain development occurs. The understanding of these aspects of brain development suggests several strategies for the classroom setting that can influence student achievement (**Table 1**).

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Abbreviations

CBT	Cognitive behavioral therapy
SEL	Social-emotional learning

The importance of SEL is even greater for students affected by psychiatric illness. Up to 20% of students[1] will experience symptoms of anxiety, depression, poor attention, and impulsivity that frequently manifest as difficulties in learning. For students with these symptoms, incorporating SEL may be even more crucial to achieving academic targets. Understanding brain development related to social and emotional aspects of learning can serve as a bridge between the work of educators and that of child and adolescent psychiatrists and other mental health specialists engaged in school-based practice.[2]

OVERVIEW OF SOCIAL-EMOTIONAL LEARNING

SEL describes the features of education that attend to the social and emotional needs of youth that are necessary for supporting academic achievement. Meta-analytic reviews of SEL programming have demonstrated positive gains in academic achievement, improved behavior, and prevention of risk-taking.[3] Contemporary SEL programs promote these gains by mitigating the effects of negative emotion on learning through strengthening students' ability to regulate their responses, and by strengthening positive emotions that motivate students to set and achieve long-term goals. SEL programming accomplishes these goals through 2 related strategies: (1) direct instruction of skills in self-awareness, self-management, social awareness, relationship skills, and responsible decision making, and (2) cultivating a school environment that simultaneously encourages social, emotional, and academic development (http://www.casel.org/social-and-emotional-learning).

EMOTION AND COGNITION ARE ESSENTIALLY LINKED

The brain's wiring ensures that cognitions and emotions influence each other in the apperception of all experiences. Because emotion and cognition are so tightly linked, school classrooms that integrate the social and emotional aspects of learning enhance academic achievement. The appreciation of the tight link between emotion and cognition is relatively new. Until the mid-1990s, the field of neuroscience generally viewed emotion and cognition as distinct neurologic processes. Furthermore, "higher order" rational thought was often held as privileged over emotional processes, with a goal of supplanting emotional reactions with increasingly critical and analytical thinking.[4] What has become clear in the past 2 decades is that emotion and cognition markedly influence one another, and both must be addressed in the learning process.

This link is likely partly because emotions have evolved to help monitor and respond to the environment to promote survival.[5] Emotion serves the important function of coordinating diverse body functions in response to specific contextual demands through directing attention, limiting sensory input, attributing salience to stimuli, and directing the selection of behavioral output.[5] Through these processes, emotion influences what one sees, and as a result, how one behaves.[6,7] The environment holds far more information than humans can process. Therefore, the brain must prioritize sensory input and act on what is most important in the moment. In contexts of high emotional arousal, extraneous stimuli are ignored and attention is focused on information that is critical to survival.[8] When students feel threatened, their focus shifts from academic efforts, such as performing math calculations, toward seeking immediate safety, often through a fight-or-flight response. Social threats may generate similar responses and preoccupy the student's attention. Therefore, efforts to address perceived social-emotional threats could be essential to engaging a student in learning.

HUMANS TEND TO FOCUS MORE ON THE NEGATIVE

Perhaps because of the emotional system's role in maintaining safety, individuals tend to be primed to be alert for potential threats. Beginning in infancy, humans overvalue negative events compared with positive ones,[9] recognize negative events more quickly than positive ones, ascribe more value to negative experiences than positive ones, and remember negative events longer than positive ones.[10] Furthermore, greater emphasis is placed on adversity and loss compared with winning or positive experiences.[11]

This negativity bias is borne out in the anatomy of the amygdala, which is the brain structure most closely associated with responses to threat.[12] In addition, the right hemisphere of the brain more quickly processes and identifies negative experiences.[13] Negative experiences are recognized almost immediately in implicit memory, whereas positive experiences take 5 to 20 seconds to "register."[10] The tendency to focus selectively on the negative can be tempered by learning strategies for managing distress and through challenging negative interpretations of circumstances or events.

EMOTION REGULATION IS A SKILL THAT CAN BE LEARNED

Building emotion regulation skills begins with acquiring an awareness of emotional experience, then establishing a repertoire of responses to experience, and, finally, repetitive practice of these skills in a safe and supportive environment. The ability of adults in the environment to be aware of their own emotional experience and model effective regulation is one key to teaching youth how to regulate their emotions.[14] Children learn from an early age to use social referencing to assess the response of familiar caregivers.[15] Predictable routines and positive reactions from adults also serve as safe signals for children navigating the school environment. Learning to recognize these safe signals and calm emotional reactions can be challenging for youth who experience adversity outside the school environment.

Early experiences significantly influence the ability to regulate emotion, because development of emotion regulation skills begins during infancy.[16] Babies as young as 6 months look away from stimuli that cause distress.[17] By the time they have reached school age, most children have developed the rudimentary skills of identifying emotion in others and regulating their own emotional responses. However, lack of emotional readiness is one of the most consistent concerns reported by kindergarten teachers.[18] For children who have not developed emotion regulation skills, academic success is hard-won. These same children often disrupt learning for their peers because of their low frustration tolerance that often manifests in aggressive outbursts. Recognizing the individual differences in students' ability to regulate emotions and set realistic expectations for performance is key to promoting development in these skills. One avenue for improving emotion regulation skills is through the use of language.

The ability to use language to express a wide range of emotional experiences and to communicate needs and desires markedly increases the student's sense of control over feeling states.[19] Clinicians, teachers, and caregivers often recognize that

Table 1
Implications from recent advances in neuroscience

Neuroscience Finding	Significance	Brain Processes and Structures	Classroom Implications
Emotion and cognition cannot be completely separated	Emotion influences what is seen and the response How one thinks about a situation influences what is felt about it	Prefrontal cortex Limbic system Amygdala Sensory gating	Inclusion of social-emotional development is critical to academic success Cannot exclusively focus on academic achievement without attending to social-emotional experience Explicit positive self-talk (cognitive reframing) can shift emotional valence
Humans tend to overvalue negative emotional content Negative stimuli are perceived more rapidly, more likely to be committed to memory	Negative events may receive greater attention because they are more critical for survival Right hemisphere and amygdala focus on negative while left hemisphere responds more to positives	Amygdala	Although negatives, losses, and fears are selectively emphasized, a brain focusing on this becomes hypervigilant and "seeks trouble," vs learning how to adjust to negatives and feel comfortable
Executive function develops steadily through school-age years	Emotion regulation is a skill that can be learned	Prefrontal cortex	Modeling explicit attention to emotional content and effective regulation

Brain maturation during school-age years occurs through synaptic pruning or refining of connections between neurons Brain reaches 95% of adult size by age 6 y	Unnecessary connections are eliminated through synaptic pruning. Crucial connections are retained and strengthened Experience influences which connections are retained and which pathways become "superhighways" for rapid action	Gray matter: synaptic pruning; cortical thinning White matter: myelination (speeding up connections for greater efficiency) Myelin sheaths insulate the "wiring" between connections, increasing efficiency	Use it or possibly lose it Practice makes permanent Offer wide variety of experiences to stimulate connections
Student brain favors emotional over cognitive pathway	Students filter through emotional centers, whereas adults process similar stimuli through logical brain regions	Amygdala Frontal cortex	Engaging teens' passions may improve academic engagement Adults need reasonable expectations about how teens will engage Adults can "lend" frontal lobe function
Students are more sensitive than adults to social cues	Students take greater risks when they perceive their peers watching Appetitive cues are more distracting to teens Rewards are more enticing	Ventral striatum	Students may require direct instruction to recognize negative consequences of risks and to practice managing desire to impress peers Take advantage of sensitivity to reward: positive feedback for pleasing behaviors Reduce exposure to appetitive distractors (dress code)

frustration and disruptive outbursts sometimes emerge because of learning differences that escalate amid increased academic, social, or emotional demands.

The development of emotion regulation skills depends on the function of the prefrontal cortex (PFC), which shows steady increases in development throughout the school-age years and into early adulthood. In the elementary school years, with increasing PFC maturity, students are able to increase the number of strategies they can use for self-regulation and improve on the ability to flexibly select an optimal strategy.[14] Through the school-age years, children learn to respond to frustration with creative problem solving rather than by giving up.[20] Teachers play an important role in helping children to develop these problem-solving skills through modeling effective emotion regulation and offering multiple opportunities for students to practice emotion regulation skills frequently within daily classroom experiences. Frequent repetition of these skills is vital in development because the brain selectively eliminates neuronal connections that are not used.

TYPICAL DEVELOPMENT PROCEEDS BY PRUNING NEURAL CONNECTIONS

By the time most children enter first grade, the brain has already reached 93% of its adult size.[21] Beginning in late childhood and continuing through adolescence, development proceeds primarily through pruning of the neuronal connections or synapses that have been growing. Synapses that seem unnecessary are eliminated,[22] allowing space to enhance the connections that are deemed to be most critical.[23] The brain continues to develop in this manner into and throughout adulthood, pruning unnecessary branches to place more emphasis on generating more rapid and sophisticated responses to the environment's challenges. During this developmental process, patterns of behavior become codified into habits (ie, automated programs of response that can be generated reflexively in response to environmental cues).

These findings have clear implications for education. First, because underused synaptic connections will be eliminated, students exposed to broad and varied experiences during childhood seem to be better positioned for well-rounded development. Second, the "hard-wiring" of often-practiced cognitive and behavioral patterns suggests that habits learned early on can profoundly influence behavioral outcomes. Early development may represent a critical period for the development of social and emotional skills that are more difficult to master later in life.

EMOTION/COGNITION BALANCE SHIFTS IN ADOLESCENCE

Throughout the elementary school years, the PFC steadily increases in maturity and ability to provide top-down cognitive control of emotional responses. As youth enter adolescence, the development of subcortical emotion centers surges ahead of that of the PFC, shifting the balance of emotional and cognitive control.[24] The increased risk-taking frequently observed in students is likely a result of this imbalance in the development of emotional drive centers and cognitive control centers. Not until early adulthood does the maturity of the PFC catch up, bringing emotion and cognition back into balance.[24]

The cognitive/emotional imbalance during adolescence results in a greater influence of positive and negative emotions on behavior.[25] Teens are more drawn to novelty and thrill-seeking and are also more affected by distress. As parents of teenagers and middle- and high-school teachers have often observed, students tend to be more inclined to make rash decisions with little regard for thinking through consequences.[26] Brain imaging studies show that adolescents filter stimuli, such as facial emotions, through the amygdala, whereas adults process the same stimuli through frontal cortical regions.[27,28] These studies establish a neural basis for the passionate responses observed in adolescent students. The intensity of these responses can get in the way, but finding ways to engage student passion can significantly enhance the learning that occurs.

Peer influence is another important aspect of development that affects school performance in the teenage years. As students struggle with the necessary task of separating from parents/caregivers, peer appraisal becomes more important in their decision-making. Students take greater risks when they believe that their friends/peers are watching.[29] The brain seems to be programmed to reinforce students' tendency to remain attentive to the perceptions of their peers. A recent brain imaging study found that reward regions showed greater sensitization in students when they believed that peers were watching, and brain activation in these regions predicted risk-taking behavior.[30]

PSYCHIATRIC ILLNESS ADDS COMPLEXITY FOR 1 IN 5 STUDENTS

Optimizing education to meet the needs of the typically developing brain can be challenging. For nearly 1 in 5 students, psychopathology imposes additional vulnerabilities.[1] Students who are referred for mental health treatment in schools often face significant deficits in social-emotional domains that require additional support in the classroom (**Table 2**). Psychiatric illness often results in behaviors that impact academic performance not only for students with symptoms but also for classmates. Disruptive behaviors are among the most significant variables affecting classroom performance.[40] Strategies to address these difficulties can improve the learning environment for all students.

One effective clinical approach for treatment of anxiety and depression is cognitive behavioral therapy (CBT). CBT is grounded in the theory that thoughts, feelings, and behaviors influence one another. Treatment addresses problematic automatic thoughts by challenging assumptions and building arguments that promote a more positive self-view. Neuroimaging studies in adults with phobias have shown that CBT can produce changes in neural processes related to emotional responses.[41] Helping youth to understand the connections between their thoughts and their emotions has the potential to significantly shift the trajectory of illness. In addition to clinical efforts, school-wide efforts to address social and emotional development can have a significant impact on students with mental health challenges while promoting healthy development in typically developing youth.[3]

LIMITATIONS

The brain findings reviewed reveal an emerging, but far from complete, scientific understanding of normal brain development. Although these findings seem consonant with tasks of children in different developmental phases and seem to be consistent, they remain early pieces in a more comprehensive understanding of brain development. MRI and other technologies, such as neuropsychological screening and testing, which are likely more readily accessible to all students through advances in computer technology, will allow more thorough and sophisticated elucidation of brain findings regarding cognitive, emotional, and social development. As additional brain findings emerge, their implications for enhancing educational practices will remain a vital consideration.

Table 2
Psychopathology and the brain: school planning to optimize brain development

Psychiatric Disorder	Brain Development Considerations	Implications for School (to Create Compassion/Understanding)	Specific Strategies to Consider in the Classroom
ADHD	Maturation of the frontal cortex is delayed an average of 3 y compared with children without ADHD[31,32] Ability to delay gratification and make decisions may lag behind peers	Lag in ability to control thinking, attention, and planning compared with peers Might look like oppositional behavior when it is actually a deficit more appropriately viewed as a learning disability	Ensure that expectations are clear and reasonable, and skill deficits are being addressed to allow the student's brain to progress/catch up Provide instruction in shorter intervals Increase internalized speech/verbal mediation Assign staff to help with organization/planning and problem solving Change power arguments to reminding student of choices and consequences When behavior is inappropriate, first remind the student of what is expected, then reinforce efforts closer to classroom expectations Allow student to receive instructional content in multiple modalities Use rhyme, rhythm, or music to improve memory of academic content
	Altered reward processing[33]	Higher threshold for feeling rewarded by completion of a task Less likely to respond to delayed gratification	Expect that students with ADHD will be drawn to smaller, more immediate rewards vs larger delayed rewards Provide frequent, intermittent reinforcement of desired behaviors Present students with tasks that are not too frustrating to accomplish Praise effort rather than outcome Help with positive habit formation Use goal-setting and frequent reminders of long-term goals to increase motivation to persist in challenging tasks

Anxiety	Amygdala is activated in anticipation of anxiety-provoking situations much more in anxious than in nonanxious students[34] Perturbed engagement of amygdala and ventrolateral prefrontal cortex is seen in anxious students compared with healthy controls[35]	Anxious students are more likely to become emotionally revved up quicker and with more intensity than their peers Anxious students are less able to access the rational/"thinking" part of their brain during that arousal, making it difficult not only to accurately assess danger but also to engage meaningfully with cognitive tasks (eg, paying attention to teacher) and access skills to calm self down	Consider need for distress tolerance techniques, such as distraction or self-soothing, to help decrease the intensity so that the "thinking" part of the brain can engage Encourage the student to engage in a mindfulness exercise, such as mindful defusion, body scan, or "surf the wave" Help the student practice positive self-talk As much as possible (and when appropriate), do not avoid the triggering event (with the expectation that anxiety will eventually diminish on its own, so the student will have the experience of eventually winning over the anxiety): extinction/habituation training Focus on resilience (increase protective factors and decrease risk factors) and ability to take control back from the anxiety
Depression	Differences in brain volume and physiologic response to reward, inhibitory tasks, and emotional processing have been shown in multiple brain areas including amygdala, hippocampus, basal ganglia, and prefrontal cortex. Students with depression also show differences in activation in brain regions associated with rumination and self-referential thought. Rumination can interfere with performance on a task—especially when cognitive control is required. These abnormalities in brain function typically resolve with successful treatment[36]	The brains of students with depression seem to pass over the potential pleasure of winning a reward to focus on unpleasant emotions caused by the potential for failure. Engaging in tasks is more difficult for students during an episode of depression	Praise effort rather than outcome Encourage student to practice "opposite action to emotion" skills if the impulse is to give up because of sadness and fear of failure Help the student identify the gray areas vs seeing things as black and white (ie, either succeeding or failing) Help the student identify the evidence for and against failure Breakdown the task into smaller, easier-to-accomplish goals Encourage positive self-talk

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Table 2
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Psychiatric Disorder	Brain Development Considerations	Implications for School (to Create Compassion/Understanding)	Specific Strategies to Consider in the Classroom
Bipolar disorder	Overactivation of amygdala with neutral and scary faces[37]	The student might misinterpret another person's facial expression, resulting in increased emotional response This bias impacts behavior and the ability to appreciate the perspectives of others and the ability to establish relationships	If a student seems to become emotional during a conversation, stop and ask the student how the interaction is being interpreted
Substance use	Adolescents have greater risk for developing addiction than adults given similar amounts drug exposure[38] Neural circuits related to impulsivity, novelty seeking, and risk-taking are most influential in whether addiction develops[38] Neuroadaptive changes occur in response to exposure to drugs, and these changes may be permanent[39]	Experimentation with substance use is normative, and therefore identifying problematic consequences is key to engaging students in changing behavior	Programs that advocate a "Just say no" approach are not likely to make a significant impact Delaying onset of first use can significantly decrease risk for addiction Engagement in prosocial/safer risk-taking may be protective

Box 1
Classroom strategies that take advantage of neuroscience findings

1. Tendency to focus on the negative
   a. Practicing alternative self-talk throughout daily events becomes important to better discern which events require changes.
   b. Noticing what persists, viscerally, or haunts a student may reveal needs for additional or alternative self-talk or other accepting (eg, mindfulness) strategies to neutralize or tolerate negative attributions to events.
   c. Examining all of the evidence surrounding a student's conclusions of inadequacy, or negative self-attributions, may enhance the student's ability to integrate negative and positive experiences throughout each school day.
   d. Recognizing the cascade of negativity surrounding one event or a small number of events may alert the student to combating these negative perceptions.
2. Synaptic pruning eliminates connections that seem to be irrelevant to the individual
   a. Exploring students' lives outside of school clarifies what content may be most relevant. This understanding provides teachers with opportunities to encourage students to apply classroom teachings in their own real world. Becoming connected with life outside school can also offer an opportunity to encourage parents to reinforce classroom teachings in real-life circumstances.
   b. Providing predictable and stable experiences, both inside and outside of school, becomes relevant. If a student must use significantly different skills inside and outside of school (eg, gang-related events, domestic abuse/conflict, substance exposures), selection of the most important neuronal structures to retain versus prune may be compromised. Coordination with community outside of the school building has substantial importance for organized versus asynchronous brain development. Providing opportunities (eg, art, music, sports) and encouraging the skills a student needs to engage in these prosocial activities (eg, rehearsing refusal skills, staying engaged with long-term goals) may become priorities in a given school.
   c. Frequent return to previous learnings and connecting to subsequent learnings seems to be helpful in retaining desired neuronal structures and enhancing the student's connections with additional structures, perhaps useful for coordination with other skills. To be clear, preparing a student for functioning in a preferable, but realistic, environment may clarify what curriculum content should be emphasized.
3. Greater emotional than cognitive influence during adolescence
   a. Teacher acceptance of the passion surrounding student positions or perceptions may require teachers to acknowledge the student's intensity and support how important the topic or position is to a student. Caring about any topic is worthwhile and can increase investment in the educational activity. However, sometimes the student's position may be overly emotional and irrational; accordingly, helping students to recognize how their "good intention may go awry" (by alienating more neutral others) may be helpful so that students learn how rationales for positions may be more effective than impassioned pleas.
   b. Very direct, and often repetitive, evaluation of information from more logical schemas may need to be modeled by teachers, because these approaches may not be the natural preference of students. When teachers articulate the logical support for a student's emotionally driven position, the student may be able to integrate emotional amygdala reaction with rational cortical function. Similarly, students may relinquish some of their amygdalar propensities, and include more cortical involvement, if they champion a different, even countervailing opinion than their own perhaps emotionally charged initial reaction.
   c. Paradigms such as examination of a situation, including alternatives and consequences (both for the student and also for others), may shift amygdalar thinking to more rational structures.

4. Influence of peer approval in adolescence through early adulthood
   a. Teachers (and adults working with students) may benefit from recognizing this dynamic tension, which is always present (and making every choice somewhat unpredictable), wherein students balance following the adult-preferred learnings/practices against students' need to establish themselves within their peer group. Therefore, every situation warrants consideration of how the student will "look" to other students, and this can be elicited when problems are presented (eg, "how do you think your peers would perceive you if you chose to do ________?").
   b. Apprising students of this propensity may help them to sometimes recognize decision-making compromised by this circumstance, and potentially rethink choices.
   c. Information that students perceive will help them appear useful/vital to their peers may increase its attractiveness; consideration of the consequences of a decision for the student and the student's peers, and on how the peers will view this student, may help sophisticate the student's thinking.
   d. Consideration of risks and sudden impulses may help students pause during real-life circumstances. Accordingly, "practicing" likely situations students would encounter in real-life environments may help them cultivate a more viable routine when actually confronted with risky situations. This strategy has been used in drug abuse resistance and sexual behavior programs, yet, to the authors' knowledge, never with awareness of the "reward center" activation in the brain. Rather, the effort has been to provide competing responses ("just say no") or ascribe these risk-taking behaviors to "peer pressure," which is now recognized as indirect (peers are not actually pressuring the student) rather than "direct" pressure.

SUMMARY

Emerging brain research illuminates the significant role emotion plays in the developing brain. Social and emotional systems in the brain have evolved to promote survival. These neural systems allow an individual to adapt to the environment through monitoring internal and external signals and organizing advantageous responses. Selective attention to negative emotion, synaptic pruning, shifts in balance of emotional drive and cognitive control in adolescence, and the impact of psychopathology all have a marked influence on student development. Because cognitive processes cannot be fully disentangled from emotional ones, shaping learning environments to minimize negative emotion and enhance the intrinsic rewards of social engagement and mastery of new skills will enhance academic achievement. Child psychiatrists have a unique opportunity to engage with educators in promoting understanding of how these brain processes influence learning and behavior in the classroom across the course of school-age development. Brain findings in childhood psychopathology provide additional clarity about educational programming to address and minimize the impacts of psychiatric illness. Addressing the social and emotional aspects of development can ultimately improve academic achievement for all students (**Box 1**).

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