THE BRAIN BASIS FOR INTEGRATED SOCIAL, EMOTIONAL, AND ACADEMIC DEVELOPMENT

HOW EMOTIONS AND SOCIAL RELATIONSHIPS DRIVE LEARNING

MARY HELEN IMMORDINO-YANG, LINDA DARLING-HAMMOND, CHRISTINA KRONE

PART 2

THE MAJOR NETWORKS OF THE BRAIN PROVIDE A VIEW INTO THE ESSENTIAL DIMENSIONS OF COGNITIVE, EMOTIONAL, AND SOCIAL PROCESSING AND THEIR DEVELOPMENTAL INTERDEPENDENCE.

Though work on the brain from two to three decades ago sought to identify specific brain regions’ unique contributions to mental processing, many scientists have shifted to a focus on the networks of connectivity between regions that facilitate different activity modes important for thinking and learning. The basic organization of these networks appears to be present at birth and to develop across the first decades of life, but it is the way the brain is used, including how a person thinks, feels, and relates to others, that strengthens and tunes these dynamic networks over time. The growth and balance of these networks depends in part upon a person’s environment, opportunities, and relationships, which together influence the “cross talk” of neurons within the same network and the delicate balance of activity among the networks.

There are three major brain networks that together support a broad range of mental capacities. Through their co-regulation and coordination, each of these networks contributes to social, emotional, and cognitive functioning, allowing a person to operate well in the world and to take advantage of learning opportunities. Extensive research in adults connects the functioning of these networks to intelligence, memory, mental flexibility and creativity, mental health, capacities for emotion regulation and attention, and other essential abilities. In children, adolescents, and across adulthood, the functioning of these networks correlates with the quality of one’s environment, resources, and relationships and improves with targeted intervention. To varying degrees, these networks appear to be malleable across the lifespan.
The Stages of Brain Development and Associated Learning Opportunities

Views of the brain across childhood and adolescence illustrate how different regions develop with varying intensity at different stages. While the sequence of spurts in brain development is relatively universal, there is individual variability in how and when brain regions develop that reflects interactions between individuals’ propensities and their social, emotional, cultural, cognitive, and physical contexts.

Considering neural developmental sequences together with individuals’ propensities and contexts can therefore provide insight into the developmentally appropriate activities that young people may engage in, learn from, and enjoy at different stages.

For more on developmentally appropriate learning activities for each stage, see pages 11, 14–16.

NOTE: These brain images illustrate one aspect of how different systems in the brain are developing and maturing from ages 5 through 20 and beyond. As the brain regions change from red to green to blue, the outer cortical layers of the brain are thinning, which in this age range can reflect more consolidated and efficient processing. Think of these images as providing a sense of the relative sequence of maturation of different systems.
THE EXECUTIVE CONTROL NETWORK:

The Executive Control Network facilitates attention, allowing people to hold information in mind, shift strategies or approaches as necessary, and focus on the completion of goal-directed tasks.\textsuperscript{142,147,148} The Executive Control Network is important for ignoring extraneous information and distractions, as well as for regulating emotions, maintaining goals and focus, and controlling impulses.

THE DEFAULT MODE NETWORK:

The Default Mode Network is heavily recruited during all sorts of tasks that involve internally directed, interpretive, and reflective thought, for example when remembering past experiences, imagining hypothetical or future scenarios, or deliberating on inferred, abstract, or morally relevant information.\textsuperscript{149–153} or daydreaming.\textsuperscript{154} The Default Mode Network is important for conceptual understanding, reading comprehension, creativity, nonlinear and "out-of-the-box" thinking,\textsuperscript{151,155,156} feelings of inspiration, social emotions like admiration and compassion,\textsuperscript{157} identity development,\textsuperscript{158,159} and for "looking in," or thinking about things that aren't in the physical "here and now."\textsuperscript{151,160}

THE SALIENCE NETWORK:

The Salience Network weighs emotional relevance and perceived importance and urgency of information to facilitate switching between mindsets supported by the inwardly focused, meaning-oriented Default Mode Network and those supported by the outwardly focused, task-oriented Executive Control Network.\textsuperscript{141,148,161–163} This switching of mental modes reflects subjective, affective evaluation by the Salience Network of external signals from the environment and internal bodily signals, such as from hunger and anxiety.

EDUCATIONAL IMPLICATIONS

Optimal learning environments attend in age-appropriate ways to developing each of the broad capacities supported by the brain's major networks: this includes sustained, flexible attention and productivity on tasks (roughly speaking, the domain of the Executive Control Network); reflection, memory, and meaning-making (roughly speaking, the domain of the Default Mode Network); and emotional relevance (roughly speaking, the domain of the Salience Network).

Optimal educational activities foster engagement and learning by leveraging opportunities to strengthen, balance, and mutually reinforce these capacities in culturally relevant, meaningful, and productive tasks.\textsuperscript{128} Productive tasks foster motivation and accomplishment by coupling interest and relevance with accessibility—representing the right level of difficulty, in the "zone of proximal development,"\textsuperscript{217} just beyond a learner's current competence—and supports to enable progress. To be willing and able to tackle challenging tasks, students must also learn to perceive themselves as capable of succeeding, which illustrates the connection between cognitive and emotional capacities.\textsuperscript{89} Learning environments that are structured to be consistent with how the brain develops generally include these features:

They place the learner's emotional and social experience at the forefront. Productive learning environments attend to learners' subjective perceptions and help students build scholarly and social identities that incorporate their new skills.
and knowledge. They help people to feel safe and purposeful, and to believe that their work is important, relevant, and valuable.

Creating an emotionally safe environment requires schools and classrooms where strong, affirming relationships are built among adults and children. Teachers create classroom communities grounded in respect, in which all students are affirmed for their value, with shared norms and responsibilities for all members. School structures support personalization, often with teaching teams that share students, advisory systems in which a small group of students are supported by a single advisor over multiple years, and looping, in which students stay with the same teacher for more than one year. Teachers actively help students develop positive academic identities by communicating their interest and belief in the competence of students who may otherwise be threatened by stereotyping and stigma, and by supporting their learning with appropriate scaffolding. Students engage in tasks as scientists, mathematicians, writers, social scientists, and artists, taking on these scholarly roles and identities while learning disciplinary concepts, skills, and modes of inquiry.

They support age-appropriate exploration and discovery. Productive learning environments support age-appropriate exploration and discovery, followed by reflection and discussion for deeper understanding. They support learners in monitoring their own learning, so they can flexibly move between these modes of engagement—knowing when and how to dig in, stop and think, gather more information, or seek help—as they pursue meaningful learning goals.

Environments that support the physiological preconditions for brain development enable learning. For individuals to take full advantage of learning opportunities, certain physiological preconditions must be met.

Among these are:

**SLEEP/REST:**

Both physical and mental health, and the ability to think well, depend on getting an adequate amount of quality sleep. Sleep is fundamental for neural plasticity and the consolidation of memories, as well as for removing toxic proteins that build up in the brain over waking hours. When people are sleep deprived, their brain networks are not as coherently organized or regulated. Over time, chronic sleep deprivation leads to impairments in mood, emotion regulation, memory, cognition, creative thinking, and situational awareness. Individuals vary in the amount of sleep they need, but sufficient sleep is required for optimal learning.

**NUTRITION AND LOW EXPOSURE TO TOXINS:**

Adequate nutrition and absence of toxins are necessary for healthy brain development, especially in children. Deficiencies in nutrients, such as iron, and diets rich in refined sugars and high in saturated fats, have been found to compromise brain development, and can lead to impairments in learning, memory, and cognition. Exposure to environmental toxins as a result of poor water, sanitation, and hygiene conditions, air pollution, and even low levels of lead, have negative impacts on brain development that can be permanent. Exposure to drugs and alcohol, especially among adolescents, has negative impacts on brain development.

**PHYSICAL ACTIVITY, EXERCISE,**
GREEN SPACE:  
Physical activity impacts the physiological regulation underlying social and emotional well-being, cognition, and memory.\textsuperscript{187,188} The efficiency and organization of neural networks is supported by fitness.\textsuperscript{189,190} Academic achievement and behavior in children as well as physical and psychosocial well-being and cognition across all ages have been found to improve in the short term and the long term as a result of physical exercise.\textsuperscript{191–195} Though brain development and learning occur with a sedentary lifestyle, abundant research suggests that physical activity is highly beneficial, and that its beneficial effects are strengthened with the availability of green (natural) space.\textsuperscript{196,197}

EMOTIONAL WELL-BEING, SOCIAL RELATIONSHIPS, AND SAFETY/ BELONGING:  
In part via the release of hormones that signal the brain and trigger epigenetic effects, emotional well-being promotes health, brain development, and optimal learning, while chronic and excessive stress and loneliness are toxic to brain development.\textsuperscript{78,198–200} Stress from threats to emotional safety and feelings of belonging, such as stereotype threat, influences a person’s underlying physiology and neural functioning, robbing a person of working memory resources.\textsuperscript{201} Such identity-related stress impacts cognitive performance in the short term,\textsuperscript{202} and in the longer term has been linked to premature aging of the brain and body.\textsuperscript{203,204}  
The negative effects of stress can be buffered through supportive parenting, relationships, community, and school programs.\textsuperscript{203,205,206} Exposure to green spaces has also been found to reduce biomarkers of stress and to increase health and well-being.\textsuperscript{207–209} Individuals who have experienced trauma, or toxic stress from abuse or neglect, often require extensive supports and targeted interventions strategically integrated throughout their schooling experience.  

CULTURAL WELL-BEING:  
An extension of emotional well-being, cultural well-being pertains to the broader roles, group affiliations, and identities that situate a person within a group and provide a sense of shared history, values, lifestyle, and purpose.\textsuperscript{210} However, when individuals from privileged groups stereotype, marginalize, or oppress members of stigmatized groups, this imposes a lifelong burden on those socially identified with the marginalized group. This impacts cognition as well as physiology.\textsuperscript{202,211} The experience of discrimination—which can pose physical harm, unfair treatment, economic deprivation, stereotype threat, and lack of access to housing, green space, quality food, health care, and other basic needs—is a major source of stress undermining cognition and well-being, with implications for health, brain development, and learning.

Furthermore, if one’s cultural beliefs and values feel at odds with those of the dominant cultural group, the conflict can cause misalignment between a person’s goals and ways of being and the expectations of the setting.\textsuperscript{212} This perceived invalidation or subordination undermines emotional and social well-being and belonging. Interventions and supports in the home, school, or community that specifically target cultural well-being improve educational, socioeconomic, and health outcomes.\textsuperscript{213–216}
The orange in these images depicts regions in the brain that were activated when individuals experienced strong emotions as they watched stories meant to inspire admiration and compassion.

Among the regions of the brain showing heightened neural activity are:

1) the **brain stem**, which is involved in regulating breathing, heart rate, and other basic survival processes and is essential for consciousness;

2) the **right and left insulae**, which sense the viscera and can be thought of as feeling emotion-related “gut” responses and integrating these feelings with cognitive processes; and

3) **regions of the Default Mode Network** that are involved in processing psychological self, building coherent narratives, calling up personal memories, and thinking about beliefs and moral values (Immordino-Yang, Christodoulou & Singh, 2012).

Coordinated activity across the insulae, which anchor the Salience Network, and the Default Mode regions (see page 11 for more information), is thought to support reflective, emotionally relevant meaning-making.
To support exploration and discovery that adds up to learning important concepts and skills, teachers construct small and large tasks in which students are asked, often in small groups, to explore essential questions using scholarly tools and processes—to figure out how something works, why a phenomenon is as it appears, how to find a solution to a problem, or what will happen if something is done in a particular way—and are provided with access to materials, equipment, and manipulatives to pursue the answers.

Teachers skillfully integrate this inquiry with direct instruction and with opportunities for students to share their thinking and problem-solving strategies, so that students can put general principles and conceptual maps of the domain together with experiential information and specific disciplinary skills. Students have opportunities to teach each other, and through learning how to reflect on, evaluate, and revise their work, they increasingly take control of their own learning process.89219

They support flexible and efficient thinking. Productive learning environments attend to the trade-off between plasticity and efficiency in brain development,220,221 strategically offering activities that encourage flexible thinking along with those that encourage mastery of necessary building-block skills and knowledge.

In the United States there has been a tug-of-war between teaching students to pursue conceptual understanding so that they comprehend ideas deeply, and ensuring that they memorize math facts, phonetic sounds, historical facts, or other pieces of information so that they can efficiently retrieve them. Often these debates are grounded in the common misconception that "basic" skills have to precede complex thinking and reasoning, which is not consistent with current models of brain network development.

Optimal learning environments attend in age-appropriate ways to developing each of the broad capacities supported by the brain’s major networks: this includes sustained, flexible attention and productivity on tasks (roughly speaking, the domain of the Executive Control Network); reflection, memory, and meaning-making (roughly speaking, the domain of the Default Mode Network); and emotional relevance (roughly speaking, the domain of the Salience Network).

True, it is important to enable students to learn symbol systems that help organize the brain for academic skills. For example, the basic academic skills of phonological decoding and mathematical calculating specialize specific brain circuits through practice over time.222,223 However, it is also true that the very processes of reasoning, conversing, exploring, and conjecturing strengthen the coherence and balance of brain networks, fostering greater intelligence to apply to all kinds of learning tasks. Making sense of reading, for example, requires sense-making abilities and wide-ranging knowledge of the world that supports understanding of the text, as well as decoding skills and attention.224 The most effective educational strategies typically allow students to develop conceptual understanding of domains as they engage in hands-on learning and higher-order thinking to build a foundation for situating the more specific, basic skills they will eventually make automatic—moving flexibly between exploration, reflection, and practice.89

In addition to basic skills and complex mental processes, various specific features of
environments can enhance cognitive processing and flexibility, and beneficial character traits such as open-mindedness. For example, multilingual environments can offer cognitive, social, and emotional benefits, as can playing a musical instrument, engaging in the visual and performing arts, and being physically active in ways that require coordination, social communication, and strategy. These activities can enhance the development of the brain, perceptions of patterns, and reasoning ability in mathematics, visual/spatial fields, and verbal expression.

They help students acquire habits of mind and character. Productive learning environments help students acquire habits of mind that facilitate acquisition of age-appropriate knowledge and skills, reasoning, and ethical reflectiveness. These habits of mind become tools for navigating the world as a learner, bringing curiosity, interest, persistence, and a deep thirst for understanding.

To develop habits of mind such as curiosity, awareness of one's own understanding, and persistence—as well as empathy and ethical reasoning—teachers engage students in extended tasks that incorporate students' interests and choices, and require planning and follow through. These tasks also provide students with opportunities to exhibit and explain their thinking, gain feedback from one another, and revise their work. These processes contribute to deeper learning and help students develop perseverance, resilience, and a growth mindset.

Stronger achievement occurs when these tasks are undertaken in a cooperative classroom with a mastery focus where students are recognized for accomplishing their individual and collective learning goals, rather than in a competitive setting that focuses on where students rank or on what grades they have achieved. An emphasis on cooperation can support more ethical and empathetic behavior, as does an emphasis on pursuing work connected to pertinent issues and problems in the world beyond their classroom.

CONCLUSION

The science on how the brain develops helps explain why young people's social, emotional, and academic development are intertwined. In addition to basic physiological needs like nutrition and sleep, brain development requires social relationships, emotional experiences, and cognitive resources, which ready the brain to take advantage of learning opportunities. To provide purposeful learning opportunities for young people—and strategic opportunities for brain development—requires educators to attend to the development of the whole child in context and to the need for aligned partnerships throughout the community that can support children's and their families' health and well-being. Educating the whole child, and engaging families and communities in this process, is not just a luxury for those with the opportunity and the means, or a remediation strategy for the underprivileged or underperforming. It is a necessity for all children. Genuinely pursuing an integrated, whole-child approach to education will require substantial innovation in policies and practices, but children's brain development, and the learning that depends on it, are at stake.

All of the citations for this report are available online at http://as.pn/braindevtfootnotes.
ABOUT THE AUTHORS

Mary Helen Immordino-Yang is a member of the Council of Distinguished Scientists of the National Commission on Social, Emotional, and Academic Development and a professor of education, psychology and neuroscience at the University of Southern California. She is the author of Emotions, Learning, and the Brain: Exploring the Educational Implications of Affective Neuroscience (W.W. Norton, 2015).


Christina Krone is a doctoral student in urban education policy at the University of Southern California

GRAPHIC CREDITS


THE NATIONAL COMMISSION ON SOCIAL, EMOTIONAL, AND ACADEMIC DEVELOPMENT

The Aspen Institute National Commission on Social, Emotional, and Academic Development is engaging and energizing communities to re-envision what constitutes success in our schools. Scientific evidence demonstrates that social, emotional, and academic development are interconnected in the learning process. The Commission is drawing from research and promising practices to explore how to make all these dimensions of learning part of the fabric of every school. Building upon existing work in schools, communities, and states across the country, the Commission is working to identify specific action steps in research, practice, and policy that will help shape and sustain a new era of education that reflects what we know about how learning happens.

The Commission’s members are leaders from education, research, policy, business, and the military, and the full Commission team includes a Council of Distinguished Scientists, a Council of Distinguished Educators, a Youth Commission, a Parent Advisory Panel, Partners Collaborative, and a Funders Collaborative.

CONTACT US

Learn more about the Commission, see our full list of Commission members, sign up for our newsletter, follow us on Twitter at @AspenSEAD, and email us with questions at aspensead@aspeninstitute.org.