Building Executive Function

The Missing Link to Student Achievement

NANCY SULLA

An **Eye On Education** Book

ROUTLEDGE

Building Executive Function

Educators clamor to provide top-notch lessons and resources for students, but if students lack executive function, even the best materials won't produce the desired results. If students haven't developed the brain-based skills to focus, catch and correct errors, identify cause-and-effect relationships, and more, they can't make sense of lessons. Executive function is the missing link to student achievement. But how can you develop this in the classroom?

In this new book, bestselling author Nancy Sulla has the answers. She explains how building executive function requires a combination of activities, structures, and teacher facilitation strategies aimed at six increasingly complex life skills that should be the goal of any school: conscious control, engagement, collaboration, empowerment, efficacy, and leadership. She also offers a variety of examples, activities, and structures fit for every grade level and subject area. With the book's practical strategies and tools, you will be inspired, armed, and ready to establish a clear framework for building executive function in all your students.

Nancy Sulla is the founder and President of IDE Corp. (Innovative Designs for Education), a consulting company specializing in instructional and organizational design.

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The Missing Link to Student Achievement

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To my sister Marge, gone too soon, who worked as a school psychologist with disadvantaged children in Appalachia, building executive function skills before we knew it was fashionable.
We're still at it, Marge!

Meet the Author

Nancy Sulla is the creator of the *Learner-Active, Technology-Infused Classroom*—a student-driven classroom framework that puts students in charge of their own learning. She is the founder and President of IDE Corp. (Innovative Designs for Education), an educational consulting company specializing in transformational professional development. She holds a B.A. in Education from Fairleigh Dickinson University, an M.A. in Computer Science from Montclair University, and an Ed.D. in Educational Administration from Fordham University. Her diverse background includes teaching at the elementary, middle school, high school, and college levels; working as a computer programmer and systems analyst; and leading teachers as a district administrator prior to launching IDE Corp.

Nancy's passion for changing the world through redesigning the culture and pedagogy of school fuels her writing and consulting. She focuses on helping schools design problem-based, student-driven, *Learner-Active, Technology-Infused Classrooms*; designing experiential schools that address the interests and needs of all students; and taking a systems approach to educational leadership.

Contents

eResources

The tools in the Appendix of this book will also be available as free eResources 

, so you can easily download and print them for classroom use.

You can access them by visiting the book product page: www.routledge.com/9781138632035. Click on the tab that says "eResources" and select the files. They will begin downloading to your computer.

Acknowledgments

I am most grateful to the many educators who are changing the world through their amazing *Learner-Active, Technology-Infused Classrooms*. I wish I could name you all! I have such respect for you for stepping outside your comfort zones to challenge your belief systems and shift paradigms: to go from being ferries to bridge builders. I am humbled in your presence. I must give a shout out to Chester W. Taylor Elementary School principal Julie Marks and the first group of kindergarten and fourth-grade teachers to launch their *Learner-Active, Technology-Infused Classrooms* there. You were the inspiration for this book, as you will read in the introduction.

As always, my collaboration with my talented, dedicated, and gritty colleagues at IDE Corp. fuels my daily work. You guys rock! Thanks for the feedback, stories, midnight email responses, and support while I wrote this book. Lauren Davis, my publisher, you continue to come to my rescue when my mind is blocked and inspire me with your unwavering belief in my work.

I am drawn to the spirit of the woman who was the first to map the prefrontal cortex in the seventies and open the door to further study of executive function, Patricia Goldman-Rakic. While she is no longer walking this Earth, her words and work mesmerize me.

With the advent of Twitter, I am further supported by a wonderful PLN of educators with whom I've had the pleasure of countless hours of sharing and inspiration, including, most notably, #leadupchat, #satchatwc, #engagechat, #dtk12chat, and our own group, #LATICchat.

Introduction

When my sister and I were young and would misbehave, rarely of course, my father would sit us down to discuss our actions and the consequences of those actions. I remember we used to say, "Just punish us!" We loathed the lengthy discussions of our wrong-doings. Our friends were either punished or grounded, but not us; we were engaged in discussion. I look back and think of how my father was a natural at teaching us *cause-and-effect*, *seeing multiple sides to a situation*, *considering future consequences in light of current action*, and more of what I now know to be the skills of executive function.

I designed my student-driven *Learner-Active, Technology-Infused Classroom* (#LATIC) model in the seventies when I was teaching. It later became the cornerstone of my consulting career and my company, IDE Corp. My intent was to combat student boredom with school and put students in charge of their own learning, building student responsibility, engagement, and academic rigor. Over the years, I realized that something else was happening in those classrooms that propelled student learning. It wasn't that I was teaching teachers how to present a better lesson; it had to be something related to students taking charge of their own learning. It was when we expanded our work to Florida, in working with principal Julie Marks and the kindergarten and fourth- grade teachers at Chester W. Taylor Elementary School, that the pieces started to fall into place. These teachers were involved in the first-year rollout of designing a *Learner-Active, Technology-Infused School*. The teachers so enthusiastically worked as two well-oiled teams in designing their classrooms; they were "all in" as grade levels. The principal set her expectations for implementing my model and supported the teachers throughout, spending considerable time in classrooms, inspiring and assisting teachers in implementing the *Learner-Active, Technology-Infused Classroom* with fidelity. The students the school serves come from economically disadvantaged homes and struggle academically, so the gains were clearly visible. In thinking through the success stories over the decades of my work, I suddenly realized that the "missing link" that was being addressed by the model was executive function. The structures of the *Learner-Active*, *Technology-Infused Classroom* seemed to organically support the growth of executive function. Needless to say, I had to research the topic further, and then came this book! All the teachers in the school, grade level and special area, now

run *Learner-Active, Technology-Infused Classrooms*, making them the first fully #LATIC school in Florida.

You don't need to be running a *Learner-Active*, *Technology-Infused Classroom* to use the strategies in this book to build executive function. If you are, however, I've noted all the #LATIC structures referenced by capitalizing them. The executive function skills in the book are italicized. And you'll see, too, a set of Twitter hashtags for the various aspects of executive function. This book will come alive if all who are reading it start tweeting out their stories, pics, structures, and thoughts about executive function; so, tweet away!

I hope the book will help you to think more deliberately about all the structures, activities, and facilitation strategies you can use to develop executive function in your students. The more you think through the deliberate activation of executive function, the more it will just become a part of the way you think about teaching and learning.

I do have my policy hopes with this book as well. While the overemphasis on ELA and math instruction to address state tests appears, on the surface, to make sense, the reality is that students engage considerably in the types of activities and thinking that build executive function while engaging in the arts, physical education, social studies, and science. That means that studying the arts could improve a student's math score! As a fourth-grade teacher, I inspired all my students to sign up for chorus and instrumental music lessons. As a middle school math teacher, I took my class outside regularly to study math by playing kickball. The marginalizing of some of these content areas and reduction in time spent engaged in them is, I believe, doing a disservice to our students and hindering their overall achievement. We need to look at learning as an interrelated system of studies, with all content areas supporting one another: the connecting thread being executive function.

Throughout the book you will see specific Twitter hashtags related to building executive function: #EF_ConsciousControl; #EF_Engagement; #EF_Collaboration; #EF_Empowerment; #EF_Efficacy; and #EF_Leadership. I hope you'll use these to post your successes, resources you develop, classroom pictures, and questions to broaden the educational conversation on the importance of executive function for all.

1

The Power, Promise, and Pitfalls of Executive Function

See if you can envision this. You have a 2″ nail hammered partway into a piece of wood; your goal is to drive the nail all the way in. Have you got the picture? You start applying pressure with the palm of your hand; but no matter how hard or long you push, the nail does not move. You then step back from the situation and get a hammer. With a few quick strokes of the hammer, the nail moves through the wood to its destination.

You have students who attend class and have some background content but need to master a lot more to achieve at the desired level. You start teaching lessons and purchasing materials that break down the content into seemingly reasonable steps for one to learn. But your students aren't achieving at the desired level. You then take a step back and shift your focus to building executive function, and students begin achieving at higher levels of content mastery.

Do you see the metaphor here? Do you understand it? If so, you've just demonstrated your strength in executive function. Were you able to *create a mental image* of the nail-into-board scenario? Were you able to *hold on to information while considering other information* when you read the second paragraph after reading the first? Were you able to consider the *cause-and-effect relationships* of hitting the nail with the palm of a hand versus hitting it with the hammer? Were you able to *shift focus from one event to another* when you ended the hammer-and-nail paragraph and read the executive function and achievement paragraph? Were you able to *think about multiple concepts*

simultaneously after reading both and engaging in a comparison? Were you able to *focus* and *concentrate* while reading those two paragraphs? Having those italicized skills made the text accessible to you. If you did not have those skills, you could have read those paragraphs over and over again, to no avail. Trying harder wouldn't have gotten you further down the road of understanding. These are just some of the skills of executive function: a set of skills that help direct the management of information and behavior.

Now consider a possible home scenario. You open a door, pushing it a little too hard; it slams into the wall behind it, punching a hole in the drywall. You think, "I bet I can learn how to fix this and save the expense of hiring someone." Where will you find out how to accomplish this task? With a quick Web search, you find a how-to sheet of directions with text and pictures; you also find a video of someone demonstrating and explaining the process. Easy! Well, not so fast. Review the list of executive function skills in Table 1.1 and check off the ones you will need in order to process this information you found, that is, to successfully follow the video or direction sheet and patch the hole.

I checked off about two dozen skills without which the hole will not be patched. You can have a direction sheet on how to spackle a wall, but if you can't *shift focus from one event* (reading the directions) *to another* (spackling the wall), those directions will be useless. If you can't *persist in a task*, you'll soon find a jar of spackle and a spackling knife sitting on the floor while you're off engaging in some other activity, and the hole in the wall remains.

Table 1.1

❑ Attending to a person or activity	❑ Thinking about multiple concepts simultaneously
❑ Focusing	❑ Setting goals
❑ Concentrating	❑ Managing time
❑ Thinking before acting	❑ Working towards a goal
❑ Initiating a task	❑ Organizing actions and thoughts
❑ Persisting in a task	❑ Considering future consequences in light of current action
❑ Maintaining social appropriateness	❑ Making hypotheses, deductions, and inferences
❑ Storing and manipulating visual and verbal information	❑ Applying former approaches to new situations
❑ Identifying same and different	❑ Defining a problem
❑ Remembering details	❑ Analyzing
❑ Following multiple steps	❑ Creating mental images
❑ Holding on to information while considering other information	❑ Generating possible solutions
❑ Identifying cause-and-effect relationships	❑ Anticipating
❑ Categorizing information	❑ Predicting outcomes
❑ Shifting focus from one event to another	❑ Evaluating
❑ Changing perspective	❑ Self-assessing
❑ Seeing multiple sides of a situation	❑ Overcoming temptation
❑ Being open to others' points of view	❑ Monitoring performance
❑ Being creative	❑ Reflecting on goals
❑ Catching and correcting errors	❑ Managing conflicting thoughts

Consider that today, with increased access to the Internet and more people uploading professional and amateur "how to" videos and direction sheets, you can locate information on nearly any topic you wish to pursue. If you search for "subtraction with regrouping," you'll find a wealth of resources. If you search for "light and shade in oil painting," "basketball jump shot," "how to use a gluestick," or "balancing chemical equations," you'll likewise have no lack of resources. Many of the skills and concepts students need to learn are readily available through a variety of sources on the Internet. This is far different from the accessibility to content that was available just a decade ago. What *is* important, however, is that you can identify a *reliable* source, and that requires executive function. Likewise, being able to take in the content information and translate that into learning requires executive function. So, with all the "physical access" students may have to the Internet in school and at home, only the possession of strong executive function skills will provide them with the "cognitive access" to the content that will lead to learning. Physical access to content through lessons does not equal the cognitive access that leads to learning. Without the skills of executive function, you cannot access the information needed to transform thinking and produce powerful learning. Executive function is, therefore, the coveted missing link to student achievement.

Schools seeking to improve student achievement tend to invest in textbooks, computer programs, curricular programs, and related professional development on teaching lesson-level content. While an effective lesson and great materials may be necessary to learning, they are not sufficient to ensure learning. They will be to little or no avail with a student who lacks executive function. The key to unlocking content and ensuring a pathway to long-term memory is through executive function.

What is Executive Function?

"The executive functions are a set of processes that all have to do with managing oneself and one's resources in order to achieve a goal. [Executive function] is an umbrella term for the neurologically based skills involving mental control and self-regulation" (Cooper-Kahn, Dietzel, 2008, p. 10). While there is no one universally accepted definition of the term *executive function*, this one reflects most other definitions.

What is intriguing is the connection between the definition of executive function and the prefrontal cortex: the part of the brain most involved in the development of these skills. Early definitions of executive function from the 1970s refer to those skills that are handled by the prefrontal cortex, while the prefrontal cortex has been defined as the part of the brain that handles execu-

Table 1.2 Executive Function Skills

Organization
Working Memory
Cognitive Flexibility
Planning
Reasoning
Problem-Solving
Self-Regulation
Inhibitory Control
Self-Awareness

tive function. The prefrontal cortex develops skills of executive function, while developing those skills further develops the prefrontal cortex. That is because the prefrontal cortex continues significant development after birth into adolescence and is not fully matured until the mid-twenties. Thus, the "I use; I grow" relationship is characteristic of executive function and the prefrontal cortex.

Russell Barkley (2012) explores the various definitions of executive function and provides his own synthesis: "The use of self-directed actions so as to choose goals and to select, enact, and sustain actions across time toward those goals usually in the context of others often relying on social and cultural means for the maximization of one's long-term welfare as the person defines that to be" (p. 171). The prominent concept in the various definitions is that we choose to use executive function skills to advance our goals. If I want a treat, I may have to *overcome temptation* to misbehave; if I want to solve the puzzle, I may have to *create mental images*, *anticipate*, and *evaluate* my actions; if I want to finish my chores so I can go and play, I may have to *set goals*, *manage time*, and *persist in a task*; and so forth. The skills, as I present them here, fall into two overarching categories: organization and self-regulation (see Table 1.2). Each of these subcategories contains a set of more specific executive function skills (see Appendix A).

While you may find varied lists of skills compiled by others, they all tend to focus on these overarching categories and skills. And the list of skills outlined in Appendix A can serve as a great resource for you as you rethink classroom instruction and the teaching – learning relationship.

Redefining "The Basics" of Curricular Content

Have you ever attempted to teach a student new content and presented what you felt was a very good lesson, demonstration, or explanation, only to find yourself frustrated that the student wasn't able to follow along and understand the content? Teachers learn to begin lessons by activating prior

knowledge. A lesson on adjectives, for example, typically begins with a recall of nouns and their purpose and then moves to brainstorming words that describe nouns. Schools tend to define "the basics" of a subject area in terms of skills and concepts within that subject area, but it may be that the path to achievement runs deeper than that. Perhaps the basics of understanding adjectives, for example, aren't simply understanding nouns and the concept of description. *Thinking about multiple concepts simultaneously*, *categorizing information*, *identifying same and different*, *storing and manipulating visual and verbal information*, *persisting in a task*, and other skills should be considered the true foundations for understanding adjectives. Without those skills, no matter what a teacher presents, students will fall short of achieving an understanding of adjectives. I'm not suggesting that teachers eliminate content instruction; I'm suggesting teachers create a foundation of executive function such that students can cognitively access that content (see Table 1.3).

The foundational skills for learning to recite the alphabet include *attending to a task*, *focusing*, *storing verbal information*, and *persisting in a task*. The foundational skills for understanding the causes and outcomes of World War II include *identifying cause-and-effect relationships*, *seeing multiple sides of a situation*, *considering future consequences in light of current action*, and *analyzing*, to name a few. The foundational skills for performing a piece of music include *concentrating*, *working towards a goal*, *monitoring performance*, *evaluating*, *catching and correcting errors*, and *persisting in a task*. The foundational skills for writing a fictional story include *creating mental images*; *being creative*; *organizing thoughts*; *making hypotheses, deductions, and inferences;* and *remembering details.* Discussing an experiment includes the foundational skills of *attending to a person or activity*, *concentration*, *shifting focus from one event to another*, *maintaining social appropriateness*, *seeing multiple sides to a situation*, *managing conflicting thoughts*, and *overcoming temptation*. The foundational skills of sketching a still life of apples might be *shifting focus from one event to another*, *analyzing*, *changing perspective*, *organizing actions and thoughts*, *monitoring performance*, and *applying former approaches to new situations*.

Table 1.3 To Master the Concept of the Adjective

You Need To	*Which Means You Can*	*Which Means You Can*
• Think about multiple concepts simultaneously • Categorize information • Identify same and different • Store and manipulate verbal and visual information • Persist in a task	• Understand and use words • Understand and use nouns • Understand the concept of description • Describe people, places, and things	• Understand and use adjectives

Cognitive Access

Given that more traditional "lessons" that were once the monopoly of teachers are now readily available through other venues, such as the Internet, the role of the teacher and the focus of school instruction must shift. Students who possess strong executive function skills can cognitively access a lesson and learn from it; those who do not possess strong executive function cannot.

The same is true for a classroom teacher's lesson. Those students who possess strong executive function can pay attention, follow along, and construct meaning from the information. Those who do not possess strong executive function will learn little, regardless of how accomplished and talented the teacher is. The achievement gaps that exist in schools today, therefore, may be more a matter of the brain's (cognitive) accessibility to content—that is, through executive function skills—than access to instruction.

While the spotlight on executive function first appeared in the world of special education, the reality is that growth in executive function skills is needed by all students. Many students in regular education classrooms who are not identified for services related to special education struggle with academic achievement. The part of the brain that controls executive function does not fully develop naturally until the age of 25; thus, anyone under that age who is challenged in the area of achievement may benefit from a focus on executive function. If you've ever heard anyone, including yourself, address a teenager or young adult with the question, "What were you thinking?" you can be sure that executive function was at the core of that frustration.

The value of teachers, therefore, goes far beyond presenting content presentation. If schools can help enhance and advance brain development related to executive function, they can provide their students with much greater cognitive accessibility to learning and higher-order reasoning and protect them from the many unhealthy decisions that they might otherwise make. With executive function as the missing link to student achievement, schools cannot afford to let it be a topic of conversation only in special education circles; executive function must dominate the conversation of educational pedagogy.

Preparing Students for Their Future

As of the writing of this book, the world had just entered what is known as the Fourth Industrial Revolution (World Economic Forum, 2016). The First Industrial Revolution was ushered in by the invention of the steam engine; the Second was characterized by the use of electricity for mass production and the rise of the factory; and the Third had as its hallmark computer technology and

automation. Computers can automate many jobs for greater speed, accuracy, and efficiency. This caused a shift in the workforce towards humans moving off the production line and, instead, handling jobs that require design, personalization, and service. With the Fourth Industrial Revolution and the rise of artificial intelligence, the computer no longer has to depend on its programmer to offer it new capabilities. Systems of computers interacting with one another, the environment, and humans are poised to design their own future systems, making them less dependent upon programmers. They have the ability to be adaptive, robust, predictive, and anticipatory.

"The Future of Jobs" report (World Economic Forum, 2016) offers some insight into the near future. An estimated 65% of students entering kindergarten today will graduate and work in jobs that don't exist today. In-demand skills are shifting from the technical to the social: "persuasion, emotional intelligence and teaching others" (WEF, 2016, p. 3). While technical skills will continue to be important, they must be coupled with strong social skills and the ability to collaborate. Data-analysis and presentation skills will be in demand across job sectors. Such higher-order skills are the realm of the prefrontal cortex and executive function. These insights point to the need to help students maximize their executive function abilities to learn at levels beyond simple content acquisition. Let's begin with the origin of executive function: the prefrontal cortex of the brain.

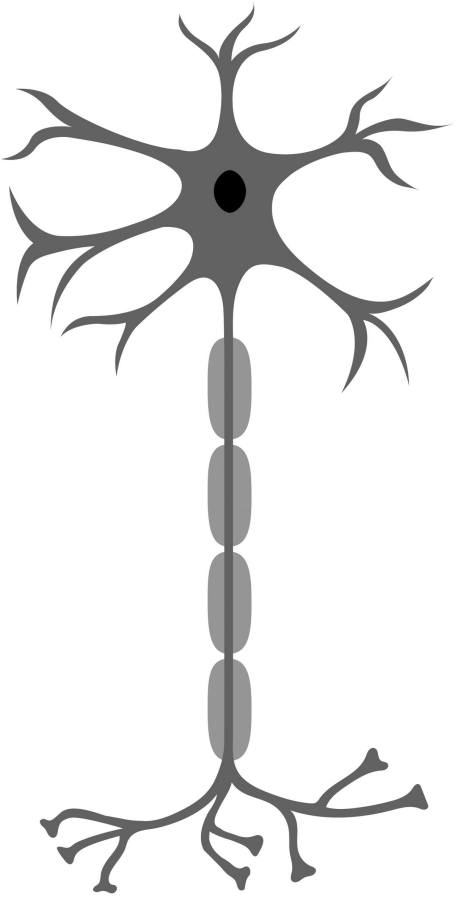
What's in a Brain?

To understand executive function, it is helpful to become familiar with the physiology and development of the human brain. The brain is composed of specialized cells called neurons, referred to informally as "gray matter" (Figure 1.1).

Neurons have all these little projections off them called *dendrites*. The dendrites are the message receivers. Neurons also each have one long axon, which projects out from the neuron and ends with another cluster of axon terminals. That long axon is referred to as "white matter": more on that a little later.

The neuron sends out signals in the form of chemicals that travel down the axon to the axon terminals, which are positioned close to the dendrites of another neuron. The tiny space between the axon terminal of one neuron and the dendrite of another is known as a synapse. The chemical is fired from the axon of one neuron, across the synapse, to the dendrite of another neuron. The more signals that are fired between two neurons, the stronger the connection, thus building brainpower, if you will. To put these neurons

Figure 1.1



in perspective, the average human adult brain has approximately 100 billion neurons, each of which is connected to up to 10,000 other neurons. That's one quadrillion connections being managed by the brain!

As educators, we often refer to a student's prior knowledge, or *schema*. This means that an existing, strong neural network is holding information for the student to retrieve and use. As young children enter school, their brains, and particularly the prefrontal cortex, are undergoing what is known as a synaptic proliferation: Many new synapses are becoming strengthened, representing learning. The more experiences, the more practice, the more engagement with content, the more synapses will become strengthened and, therefore, the more gray matter is being created. This is why it is so important that our younger learners' days are filled with varied experiences and hands-on exploration.

As the brain matures, the axons become covered with a myelin sheath to protect them, a process known as myelination. This increases the speed of

the signals flowing down the axon, thus improving the brain's memory and processing speed. The axon and its myelin sheath represent the white matter in the brain.

Typical Brain Development for Executive Function

The brain is typically described as being made up of various regions, each of which handles different functions, from breathing and movement to emotions and complex thought. At the front of the brain, just behind the forehead, is the prefrontal cortex, which handles most executive function skills. From birth, the prefrontal cortex continues to develop steadily, with inhibitory control and working memory being the first executive functions to solidify. The dendrites and connections in the prefrontal cortex grow by use. The more students hear language, the greater their ability; the more they see objects and hear objects' names, the more able they are to learn names of objects. Thus, the more executive function skills students encounter, the more the prefrontal cortex grows. The more you ask a young child to identify same and different, follow multiple steps, categorize, and be creative, the more the prefrontal cortex that handles these executive function skills grows.

The brain then undergoes significant growth between the ages of four and five, which you'll note if you work with or have been around four and five-year-olds. For four-year-olds, the reality that they can't do or have what they want feels like the end of the world. Then, within a year, five-year-olds with typical brain development seem to have a much more reasonable view of reality. They can delay gratification, understand simple cause-and-effect relationships, *consider future consequences in light of current action*, and so forth.

Stanford's Marshmallow Test

You may have heard of Stanford University's "Marshmallow Test," which is described in more detail in Walter Mischel's book *The Marshmallow Test: Mastering Self-Control* (2014). Mischel, a researcher at Stanford, conducted an experiment in the 1960s and 1970s with over 600 children between the ages of four and six to study the ability of a child to delay gratification. The child was placed in a room, seated at a table. The test administrator placed one large marshmallow in front of the child and said that the child could eat the marshmallow now or wait for the test administrator's return with a second marshmallow, at which time the child could eat both. The test administrator then waited approximately 15 minutes before returning with the second marshmallow. A minority of the children ate the first marshmal-

low immediately. Most attempted to wait, using self-talk and distracting themselves from the marshmallow. Approximately a third actually waited the full time and received the reward. Age was a major determinant in the child's ability to delay gratification, further supporting the belief that executive function skills increase with the growth of the prefrontal cortex between the ages of four and six. Experience in the skills listed in Appendix A will be key to prefrontal cortex growth in primary and elementary students.

Adolescence

During adolescence, the prefrontal cortex undergoes a second substantial growth phase, known as *synaptic proliferation*, and a pruning phase. Those synapses that are not regularly used are pruned and are no longer available for use by the neuron. This relates to the "use it or lose it" phrase: If a youngster is learning piano and practicing regularly, most likely the brain's neurons will be firing and solidifying the connections and, thus, the capability. If a youngster has a few piano lessons and then stops playing, those unused synapses will eventually atrophy and the learning will most likely be lost.

The pruning process combined with myelination actually make the brain more effective and the prefrontal cortex stronger. However, during the pruning process, which typically occurs at puberty, the brain loses gray matter. Additionally, the brain matures from back to front, meaning that the prefrontal cortex is the last to mature, around the age of 25. Meanwhile, the part of the brain that reacts to pleasure and rewards is located at the back of the brain and therefore matures during adolescence, while the prefrontal cortex, which handles reasoning and judgment, is still developing. Adolescents are particularly prone to whatever stimulates the pleasure sensors of the brain, yet they have little ability to effectively evaluate those and make healthy judgments. Add hormones to that mix and you have the typical teenager! Teenagers need cues and protocols for surviving those teenage years. Once the growth spurt of pruning and myelination processes starts slowing down, a teenager has one powerful brain!

The Effect of Stress on the Prefrontal Cortex

Stress is not good for anyone's overall health, but it is particularly harmful for the developing prefrontal cortex. Children who live under chronic stress, which could include poverty, domestic violence, emotionally or physically abusive parents, protracted divorce, and so on, tend to demonstrate lower

levels of executive function. It is important to understand the impact of stress on the body.

Built into the human body, from the beginning of our days on Earth, is a "flight or fight" response to danger. If you are being attacked by a wild animal, for example, you have two choices: attempt to fight it, or run as fast as you can. Deep inside the brain is an almond-shaped area known as the hypothalamus; it exists in all vertebrate animals. Its job is to make a connection between your central nervous system (brain, spinal cord) and the endocrine system, whose job it is to send hormones to targeted organs based on the body's need. At the first sign of a stressful situation, your hypothalamus sends a signal to the pituitary gland (a pea-sized gland just below the hypothalamus), which sends a signal to the adrenal glands that sit atop the kidneys. One of the functions of the adrenal glands is to secrete adrenaline and cortisol in the face of stress. Adrenaline immediately focuses your attention on the problem and provides you with that rush of energy. You've most likely experienced it when you were in a near accident: having an animal run out in front of you while driving and having to steer clear of an accident, jumping out of the way of a falling object, and so on. You feel that rush, your heart starts pounding faster, you seem to visualize in slow motion so you can focus, and you may sweat. That's adrenaline, the first responder to stress, which is putting your body in motion. It dissipates as quickly as it is created, so your body does not build up adrenaline during stress.

Immediately following adrenaline is cortisol, which pumps glucose into the large muscles that are in your legs and arms, thus enabling you to fight or flee. The body draws energy away from the less important functions when you're fighting or fleeing in a stressful situation. Those include digestion and the development of the prefrontal cortex. Consider that when you're dealing with an animal attack, you really don't need to digest that meal, nor do you need to focus on higher-order reasoning. The body cannot distinguish between the stress of a charging animal and seeing your mom break down because she can't pay the bills, or being told you have to pack your things and leave your home, or being the victim or viewer of abuse. In these situations, you don't need to fight or flee, so all that glucose entering your system goes unused, building up in the body.

Young children who live in significantly stressful situations experience chronically high levels of cortisol in their systems. Chronic levels of cortisol lead to dendritic atrophy—big words that mean that those dendrites that are firing chemicals across synapses to build brain capacity are shriveling up. The brains of "stressed-out" children are literally less physiologically capable of learning than they would be without stress.

Hope for Advancing the Growth of the Prefrontal Cortex

Phineas Gage was a railroad construction foreman in 1848. In blasting through rock, the workers would pack dynamite into blasting holes, using a long tamping iron, and then ignite it. Somehow, Gage was distracted in the process and the dynamite ignited while the tamping iron was still in the hole. It shot out of the hole, thrust upward through the explosion, pierced Gage's jaw, destroyed a molar, took out his eye, and exited at the middle front of his skull, just below his hairline. After the accident, Gage was conscious and sat upright while transported by horse and carriage back to his house. He spoke with Dr. John Harlowe throughout the immediate treatment. The rod had sliced through Gage's prefrontal cortex, but it did not seemingly affect any life-supporting areas of the brain. Gage was 25 years old at the time. Three key events paved the way for what we know today about executive function and the prefrontal cortex.

First, Gage's doctor and friends found that, after the accident, his personality had changed considerably, to the point where his friends referred to him as "no longer Gage." His doctor's notes indicated that Gage had outbursts of profanities, could not stick to plans, cared little for others, and was impulsive. Gage had survived the accident with no damage to his motor skills or basic brain functions; the rod had only destroyed a section of his prefrontal cortex, an area not closely related to human survival. However, his doctor was intrigued by the effects of the destruction of that part of the brain. His executive function skills, as we define them today (see Appendix A), were greatly impaired.

The second event came years later, when Dr. Harlowe tracked down the family after Gage's death only to find that he had resumed a fairly normal life, even holding a job as a stagecoach driver in Chile before returning to San Francisco where he died of a seizure, believed to be related to the accident, at age 37. At the doctor's request, Gage's body was exhumed and the skull and tamping iron were given to the doctor. They reside today at a museum at Harvard Medical School.

Thirdly, in the 1970s, a psychologist and historian by the name of Malcolm Macmillan took an interest in the story of Phineas Gage. For more than 40 years, he has studied the accounts of the accident. One day, Macmillan was watching Queen Elizabeth's husband, Prince Philip, racing horse coaches, and he realized that they were similar to those that Gage would have ridden in Chile. As he watched the intricate movements that Prince Philip made to the reins, he realized that Gage could not possibly have performed those functions without executive function, and thus, an intact prefrontal cortex. Macmillan concluded that Gage's prefrontal cortex must have, in fact,

regenerated. This led to the possibility of what we now know is the plasticity and ability of the prefrontal cortex to recover and grow. Gage's life is one of the topics well known to neurology students. The recovery of his prefrontal cortex should be considered by teachers to represent hope for students who lack or are delayed in developing executive function skills.

Making a Difference in the Classroom

The term *executive function* emerged in the 1980s, relatively recently in education history. Executive function encompasses a collection of skills related to working memory, inhibitory control, planning, organization, and higher-order reasoning. While once the focus of research into mental illness, it has come to also be associated with autism, attention deficit disorder (ADD), and attention deficit hyperactivity disorder (ADHD). Now, it is becoming more obvious that the skills that comprise executive function are the keys to academic achievement for all.

While scientific knowledge of the workings of the prefrontal cortex are relatively new, we now know that executive function skills are necessary for making sense of classroom instruction and that, through targeted experiences, teachers can contribute to the growth of the prefrontal cortex and executive function skills. Therefore, teachers can have a positive impact on student achievement by incorporating deliberate activities, structures, and facilitation strategies into the learning environment. For younger students, building foundational executive function skills will better position them to learn academic content. For older students who seem to have a strong foundation, continuing to focus on building executive function skills may save them from making some very detrimental decisions in their lives.

If a principal escorted a new student with a broken arm into class, the teacher would make adjustments to accommodate the learner, given the physiological deficit. No teacher would say, "try harder," instructing a student to reach an object with a broken arm. Likewise, the term "try harder" should not be applied to students with an underdeveloped prefrontal cortex. Telling a child who has memory problems to "try harder" is ineffective and harmful to a student's sense of self. Addressing deficits through deliberate activities and structures will yield far greater results in a relatively short period of time.

Where to Start

Rather than focusing on executive function skills as another content area to be mastered for its own sake, approach executive function skills from the

perspective of their importance in building important life skills. While individual executive function skills are not exclusively used in one area of life, the categorizations below will offer a roadmap, if you will, for where to start when considering how to support executive function in students.

- **Conscious Control** (#EF_ConsciousControl)—One's success in life and human interaction is dependent upon one's ability to consciously control actions rather than being merely reactive. Being able to *focus*, *concentrate*, and *manage conflicting thoughts* are a few of the executive function skills related to conscious control.
- **Engagement** (#EF_Engagement)—Student compliance in the classroom may produce short-term results and the appreciation of teachers but not necessarily long-term learning. Students must grapple with content in order to make sense and meaning of it, a requirement of long-term retention of knowledge (Sousa, 2011). *Thinking about multiple concepts simultaneously*, *identifying cause-and-effect relationships*, and *persisting in a task* are a few of the executive function skills related to engagement.
- **Collaboration** (#EF_Collaboration)—Personal and professional advancement relies upon one's ability to work well with others, including working together to solve problems. Learning is social; it involves engaging with others and others' ideas; it is a process of give and take, and, as one collective mind, of moving beyond one's self to take ideas and innovations to the next level. *Seeing multiple sides to a situation*, *being open to others' points of view*, and *thinking before acting* are a few of the executive function skills related to collaboration.
- **Empowerment** (#EF_Empowerment)—With learning comes independence, a level of autonomy and self-determination that allows one to advocate for one's needs, desires, and ideas responsibly. As teachers give students greater responsibility, choice, and voice in the classroom, students need to be able to rise to the challenge. *Setting goals*, *managing time*, and *self-assessing* are a few of the executive function skills related to empowerment.
- **Efficacy** (#EF_Efficacy)—Learning eventually outfits one to carry out a plan of action, achieve goals, and make a difference. While empowerment comes from others, efficacy comes from a personal sense of one's ability to make a difference: an important quality of a world citizen. *Organizing actions and thoughts*, *creating mental images*, and *predicting outcomes* are a few of the executive function skills related to efficacy.

- **Leadership** (#EF_Leadership)—Ultimately, the learned lead others to achieve personal and collective goals. Leadership does not mean that one leads in every situation but that one can lead in some. It does not necessarily mean that one must take a formal leadership role but rather that one is able to informally lead others. Our world depends upon the development of effective, empathetic leaders. Realizing one's leadership ability is dependent upon all of the executive function skills presented in this book and on combining them in ways to reap the greatest benefits.

As you ponder this collection of executive function skills, please know that it is impossible to pin any executive function skill to just one of the life skills above. Most of the executive function skills are critical to several of the life skills. This categorization is intended to shift focus from attempting to teach these skills as an end goal and, rather, address executive function skills from a "big picture" lens by linking them to more formidable life skills.

Summary of the Power, Promise, and Pitfalls of Executive Function

- Executive function skills are powerful partners in the teaching and learning relationship; therefore, teachers should pay as much attention to building executive function as they do to designing great content lessons.
- Executive function skills are controlled in great part by the prefrontal cortex, an area of the brain that undergoes significant change throughout the first 25 years of life; therefore, teachers should consider growth states of the prefrontal cortex and address students' needs accordingly.
- Chronic stress has a negative effect on the development of the prefrontal cortex and, thus, executive function skills; therefore, teachers should take steps to recognize when stress is a factor in physiological brain development and should not assume that students have control over their executive function skills.
- The prefrontal cortex has the ability to grow and heal based on use; therefore, teachers should provide students with deliberate activities and structures to build executive function skills, which will, in turn, build the prefrontal cortex.

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