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Science of Learning and Development: A Synthesis

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Executive Summary

Human development derives from the continuous interaction between the individual and the context of each individual's relationships and experiences. Development is shaped by a convergence of individual, biological, contextual, cultural, and historical factors.

The story of human potential presented by the human sciences—biological, psychological, and developmental—gives reason for optimism. How we express and fulfill our potential depends on complex relations between nature (our genes, biology, and physiological systems), nurture (the physical and social environments we are exposed to), and how these are interpreted and internalized, all of which vary across time, place, and among individuals.

An understanding of neural malleability and plasticity, the dynamics of resilience, and the interconnectedness of individuals with their social and physical contexts offers a transformational opportunity to influence the trajectories of children's lives.

Key Findings

In synthesizing the research across diverse disciplines, some overarching themes emerge that are important to a science of learning and human development and that can support the realization of better outcomes for all children. This scientific understanding of development opens a path for new, creative approaches that have the potential to solve seemingly intractable chronic learning and social problems. By applying this knowledge to new more personalized educational models and approaches, we can not only prevent the effects of adversity on development, we can promote excellence and equity in educational and developmental opportunity from cradle to career. The following themes emerge:

- The ongoing, reciprocal relations between individuals' biology, their relationships, and the ecologies and contextual influences in which they are embedded determine the expression of their genetic endowment and ultimately their development as individuals.
- Genes are chemical "followers"; their expression is determined by contextual influences at the biological level.
- Epigenetic adaptation determines the expression of our genetic makeup and is part of a system of ongoing two-way exchanges between human beings and the physical and social world that create qualitative changes over time.
- Malleability and neural plasticity are the core principles of human development.
- Each child's development as a learner is nonlinear, has its own unique pacing, and is highly responsive to context.
- Development of children's skills is progressive, and does not occur in isolation; it requires the integration and layering of prerequisite skills.
- Neural integration and interconnectivity of children's cognitive, social, and emotional development is essential for well-being—both anatomically and functionally.

- Contextual influence and ecology cannot be ignored.
- Adversity can affect development, mental and physical health, and learning.
- Resilience and thriving in the face of adversity is possible, and is a product of children’s internal assets and supports from individuals within a child’s social environment.
- Adults’ buffering of stress plays a central role in healthy child development; therefore, building and supporting adult capacity are critically important tasks.
- Schools and other child-serving systems are potentially powerful contexts through which stress can be buffered, neural integration and connectivity supported, and individual development nurtured.
- Culture, cultural responsiveness, and cultural competence are critical components of context and are profoundly important in shaping the experiences through which children grow.

This paper aims to synthesize generally accepted knowledge and strong theory in multiple disciplines and indicate how these areas of research converge. The paper has four purposes. First, it synthesizes and aligns the scientific literature from diverse fields, and explores the role of context and its positive and negative dimensions, including micro and macro examples—highlighting key points of agreement as well as areas for further study. Second, where the research agrees, it provides a foundation for the development of an urgent R&D agenda to translate these sciences into actionable, evidence-based practices for schools and for all child-serving systems. Third, it provides a scientific background for a related practice document that the Learning Policy Institute is preparing to make this research useful and useable for practitioners. Fourth, it intends to catalyze the creation of a supportive policy context to enable widespread adoption of scientifically informed practices and to promote a robust R&D agenda in areas requiring additional exploration.

As this synthesis suggests, our knowledge in multiple disciplines is converging and congruent. Advances in research, the coalescence within bodies of science, and the convergence across bodies of science and disciplines has the potential to be transformative. We are now positioned to draw upon an immensely relevant and diverse body of research to influence instructional and school design, and child-serving, family support, community, and health systems. This knowledge will enable us to improve the conditions in which children grow and develop by providing activating contexts for learning and for the fullest realization of each child’s individual potential. Practices designed with the knowledge of human development as a foundation can enable us to more deeply personalize learning and the learner experience—going well beyond the traditional definitions that have been applied to these terms. This work must build upon the personal and cultural assets that children, families, and communities have, and must be interdisciplinary by its very nature—mirroring the nature of development itself—and applied at the individual student level and within the social contexts that affect child development.

Introduction

The story of human potential presented by the human sciences—biological, psychological, and developmental—gives reason for optimism. How we express and fulfill our potential depends on complex relations between nature (our genes, biology, and physiological systems) and nurture (the physical and social environments we are exposed to), and how these are interpreted and internalized, all of which vary across time, place, and among individuals (Elder, Shanahan, & Jennings, 2015; Knafo & Jaffee, 2013; Lester, Conradt, & Marsit, 2016; Overton, 2015; Spencer, 2007). Development is a cascade of changes over time that emerge through increasingly novel and complex transactions between an individual and his or her social and physical contexts (Bierman & Sasser, 2014; Cox, Mills-Koonce, Propper, & Gariepy, 2010; Dumas, Prinz, Smith, & Laughlin, 1999; Lavigne, Gouze, Hopkins, & Bryant, 2016; Masten & Cicchetti, 2010). In this way, the developing brain draws on relationships and environments to build layer upon layer of representational templates over time (Siegel, 2012).

An understanding of neural malleability and plasticity, the dynamics of resilience, and the interconnectedness of individuals with their social and physical contexts offers a transformational opportunity to influence the trajectories of children’s lives. It enables us to appreciate the interpersonal, micro- and macro-contextual influences on children’s development at the cellular level. This scientific understanding of development opens a path for new, creative approaches that have the potential to solve seemingly intractable learning and social problems.

Two areas in which this understanding is ripest for translation into practice and policy are our nation’s education and early childhood systems. In recent years, there has been growing agreement that children are often ill-served by the factory model of K–12 education and the babysitting model of some early childhood programs. Simultaneously, our understanding of the sciences of learning and individuality has advanced. We know more than ever about how to design relationship-rich environments and teaching methods and practices to develop individuals, buffer students’ stress, accommodate the diverse ways in which children learn, and foster the skills and mindsets needed for healthy development and academic achievement. We know more about the importance of supporting adult wellness and competence in support of children’s development and learning. We also know more about the environments that contribute to unhealthy development and undermine engagement and learning. By applying this knowledge to new, more personalized educational models and approaches, we can not only prevent adversity from harming development, but promote excellence and equity in educational and developmental opportunity from cradle to career.

This paper aims to synthesize generally accepted knowledge and strong theory in multiple disciplines and indicate how these areas of research converge. The paper has four purposes. First, it synthesizes and aligns the scientific literature from diverse fields, and explores the role of context and its positive and negative dimensions, including micro and macro examples—highlighting key points of agreement as well as areas for further study. Second, where the research agrees, it provides a foundation for the development of an urgent R&D agenda to translate these sciences into actionable, evidence-based practices for schools and for all child-serving systems. Third, it provides a scientific background for a related practice document that the Learning Policy Institute is preparing to make this research useful and useable for

practitioners. Fourth, it intends to catalyze the creation of a supportive policy context to enable widespread adoption of scientifically informed practices and to promote a robust R&D agenda in areas requiring additional exploration.

This synthesis and the proposed R&D agenda, together with the supportive policy context we aim to foster, can help bring about profound changes in our 21st century education system and in the ways other child-serving systems and health systems are designed.

Key Findings

In synthesizing the research across diverse disciplines, some overarching themes emerge:

- The ongoing, reciprocal relations between individuals' biology, their relationships, and the ecologies and contextual influences in which they are embedded determine the expression of their genetic endowment and ultimately their development as individuals.
- Genes are chemical "followers"; their expression is determined by contextual influences at the biological level.
- Epigenetic adaptation determines the expression of our genetic makeup and is part of a system of ongoing two-way exchanges between human beings and the physical and social world that create qualitative changes over time.
- Malleability and neural plasticity are the core principles of human development.
- Each child's development as a learner is nonlinear, has its own unique pacing, and is highly responsive to context.
- Development of children's skills is progressive and does not occur in isolation; it requires the integration and layering of prerequisite skills.
- Neural integration and interconnectivity of children's cognitive, social, and emotional development is essential for well-being—both anatomically and functionally.
- Contextual influences and ecology cannot be ignored.
- Adversity can affect development, mental and physical health, and learning.
- Resilience and thriving in the face of adversity is possible, and is a product of children's internal assets and supports from individuals within a child's social environment.
- Adults' buffering of stress plays a central role in healthy child development; therefore, building and supporting adult capacity are critically important tasks.
- Schools and other child-serving systems are potentially powerful contexts through which stress can be buffered, neural integration and connectivity supported, and individual development nurtured.
- Culture, cultural responsiveness, and cultural competence are critical components of context and are profoundly important in shaping the experiences through which children grow.

Organization

Although individual and contextual factors are interconnected, they are analytically distinct (Overton, 2015). We present them sequentially in this synthesis for precision and clarity. Beginning with the individual factors, we discuss the following:

- What we can learn from research on human development, attachment, individuality, self-regulation, learning, and resilience
- The importance of relationships and stress in the mutual reinforcement, protective or harmful, of biological and contextual influences
- How relationships and stress interact in key microsystems and how they are affected by macrosystem factors such as poverty and racism
- How individuals and contexts interact across developmental stages
- The importance of frameworks for organizing developmental constructs

We conclude by discussing existing gaps in knowledge and measurement of these individual and contextual factors and the ways in which these gaps can shape an ambitious R&D agenda.

A Primer on Brain Structure and Function¹

The brain is organized from the inside out. There are four major parts: the brainstem, the diencephalon, the limbic system, and the cortex. The lower, more central regions of the brainstem and the diencephalon are the simplest. They evolved first and they develop first in children, followed by the limbic system, and finally the cortex—the structure that defines us as humans. The brainstem maintains our core regulatory functions, like heart rate and temperature. The diencephalon and the limbic system handle emotions and regulation. The cortex regulates the most complex and highly human functions, like speech and abstract thinking. All of these functions become progressively more integrated and complex as we grow.

The brain has an estimated 100 billion neurons, which are collectively over two million miles long. Each neuron has an average of 10 thousand connections that directly link it to other neurons. Thus there are about one million billion of these connections, making the brain “the

¹ This section is a synthesis of work by Dan Siegel, M.D., and Bruce Perry, M.D., who have synthesized their own and the work of many other researchers, using the following sources:

- Perry, B. D., Pollard, R. A., Blaichley, T. I., Baker, W. I., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation and “use dependent” development of the brain: How states become traits. *Infant Mental Health Journal*, 16(4), 271–292.
- Perry, B. D., & Szalavitz, M. (2006). *The boy who was raised as a dog: And other stories from a child psychiatrist's notebook: What traumatized children can teach us about loss, love, and healing*. New York, NY: Basic Books.
- Siegel, D. J. (2010). *Mindsight: The new science of personal transformation*. New York, NY: Bantam.
- Siegel, D. J. (2012). *The developing mind: How relationships and the brain interact to shape who we are* (2nd ed.). New York, NY: Guilford.
- Siegel, D. J. (2013). *Brainstorm: The power and purpose of the teenage brain*. New York, NY: Penguin Putnam.

most complex structure, natural or artificial, on earth” (Siegel, 2012, p. 15). Electrical impulses transmitted over these connections create the interconnections in the brain; this web of interconnections means that activation of one neuron can influence an average of 10,000 neurons, creating an immense number of “on/off” patterns.

The brain’s development is an “experience-dependent” process. In fact, neurons and neural tissue are the most susceptible to change from experience of any tissue in the body. Experience is a “stressor” to brain growth. Relational connections activate neural pathways, generating “energy flow” through electrical impulses, strengthening the connectivity among brain structures and creating new ones. This energy flow is driven by interpersonal experiences throughout life. Neuronal change is based on repetitive experience; the importance of this molecular gift in children’s development cannot be overestimated. Experiences can shape not only what information enters the mind, but the mind’s ability to process that information. Experience creates representations, and those representations stimulate the brain’s ability to process and make meaning out of new information. If experiences are interpersonally rich, predictable, and patterned, stress makes the brain stronger and more functionally capable, increases connectivity and integration, and increases resilience to stress.

At birth, an infant’s brain is the most undifferentiated organ in the body. Genes and early experience shape the way neurons connect to one another and form the circuits that give rise to increasingly complex mental processes. The differentiation of circuits within the brain involves a number of different processes, including the growth of axons, the establishment of new and more extensive synaptic connections among neurons, the growth of myelin along the length of the neuron (which increases “processing speed”), and the modification and sensitivity of receptor density for the “receiving neuron.” All of this is balanced against the amount of “pruning” (cell death). This pruning occurs naturally, but is greatly increased under prolonged stressful conditions. Enriched environments do the opposite—they lead to enhanced synaptic connections. Interpersonal experience influences the growth of the brain throughout childhood and early adulthood; the early period is particularly important for self-regulatory processes.

From an information-processing perspective, signals come to the brain from inside the body, from other parts of the brain, and from the outside world. The sending areas include deep physiological structures inside the body; limbic structures, including memory; and neocortical structures processing language, emotion, sensation, and perception. The processing function of the brain is to integrate this information so that it becomes more and more useful and gains meaning. To accomplish this, the brain creates templates—“representations”—of these types of stimuli. Templates are drawn increasingly from prior experience, including both emotional and cognitive experience (including some experiences that are not remembered consciously). If an experience is predicted and follows a pattern, the brain tags it as normal and does not continue to focus on it. But if something is not normal or predictable, or is hurtful, the brain pays attention to it. This is particularly important with respect to the templates caused by early traumatic experiences: the brain can become “habituated” to negative templates from prior experience and not recognize them as abnormal.

The brain is a complex system whose own internal processes organize its functioning. This property is called “self-organization.” Subtle and rapid shifts in synaptic strength come about because of new learning from experience. The driving force of development is the movement

from simplicity toward complexity. Think about the baby that rolls over, maintains a sitting position, stands, and ultimately walks, runs, or dances. The brain's drive to complexity is consistent with the principles of nonlinear dynamic systems: such systems have self-organizing properties, are nonlinear, and are recursive. Patterns emerge constantly in interaction with the environment, and some become reinforced and continue to influence future experiences, consistent with Donald Hebb's notion that "neurons which fire together, wire together" (Siegel, 1999). This is how repeated states of activation shape neuronal circuits, which then form enduring states of mind for individuals. These systems are stable and predictable, but also malleable and flexible, having the capacity for variability, novelty, and uncertainty. It is the healthy balance between stability and flexibility that allows us to use experience for adaptation and growth. Pathological states like severe recurrent stress bring greater rigidity in the system.

Theories of Human Development

The Science of Human Development

Our genes are inseparable from other dynamic developmental systems that involve individuals, social contexts, culture, and history (Lerner, in press). "Positive development" emerges from the integration of a number of individual and contextual systems, from the biological and physiological to the cultural and historical (Bundick, Yeager, King, & Damon, 2010; Spencer, 2007). Experience, gene expression, gene regulation, neurobiological systems, biological systems, perceptions, and behavior are interconnected. The neural circuitry in the brain is intricately linked with the other physical systems of the body—the immune, endocrine, metabolic, cardiovascular, and musculoskeletal systems—as well as with ecological systems. Consequently, factors that affect one system also affect the rest (Overton, 2015; Siegel, 2012). For example, factors that affect physical development include the presence or absence of environmental toxins, and access to appropriate nutrition, sleep, and exercise (Kendziora, Osher, & Carey, 2014; Ruiz, Quackenboss, Tulve, 2016). These, in turn, are affected by structural and historical factors (Ard, 2015; Ruiz et al., 2016).

In this relational developmental systems framework, our genes are followers, not the prime movers, in developmental processes (Fischer & Bidell, 2006; Slavich & Cole, 2013). Genes are packages of biological instructions, requiring signals to determine which processes are carried out (Center on the Developing Child at Harvard University, 2016). Genes determine the number of neurons we are born with, but social and physical contexts influence which genes are expressed, how, and when (Jaffee, Price, & Reyes, 2013; Keating, 2016).

Epigenetic signatures (chemical signals derived from environmental influence) affect how easily genes are switched on and off and whether the change is temporary or permanent. This process is called epigenetic adaptation, and it shapes how our brains and our bodies develop. Epigenetic adaptation is part of a system of ongoing, two-way exchanges between human beings and the physical and social world that create qualitative changes to our genetic makeup over time within and across generations (Lerner, in press). Epigenetic adaptation is the biological process through which the environment of relationships, experiences, perceptions, and physical and chemical toxins get under the skin and influence lifelong learning, behavior, neural integration, and health (Bernstein, Meissner, & Lander, 2007). Epigenetic adaptation

can begin during pregnancy and even preconception (through the mother's experiences), and contributes to the transmission of behaviors and experiences to future generations (Jablonka & Lamb, 2005; Keating, 2016; Siegel, 2012). Encourage adaptive epigenetic signatures and buffering the factors that contribute to maladaptive epigenetic signatures are powerful levers to realize children's genetic potential.

The brain is built from the bottom up. "Skills beget skills" (Heckman & Masterov, 2007, p. 447), with increasingly complex circuits building on simpler circuits, and increasingly complex adaptations emerging over time. Foundational social, emotional, and cognitive competencies accumulate in a cascading way, and interact with individual and environmental risk factors and assets to allow children to act in ways that optimize or interfere with their development and their physical and emotional wellbeing (Cox et al., 2010; Nagaoka et al., 2015).

Critical neurobiological processes, including neural integration (the perpetual experience-dependent remodeling of the brain) and neurogenesis (the formation of new brain cells), drive the growth and adaptability that are essential to healthy development and learning. Synaptic connections can grow in number and strength, and neural integration can increase through strong interpersonal connections, development of reflective skills, and focused attention (Siegel, 2010). This developmental integration occurs when the strengths of children and youth are aligned with the resources for positive growth in families, schools, and communities (Benson, Scales, Hamilton, & Sesma, 2007; Lerner, Lerner, Bowers, & Geldhof, 2015). These resources are promotive when they are developmentally appropriate, culturally competent, and a good fit with the child (Allen & Kelly, 2015; Eccles & Roeser, 2009; O'Connell, Boat, & Warner, 2009; Simmons & Blyth, 1987).

Relationships and experiences are the signals to which our genes respond. They are of primary importance for shaping the genetically programmed maturation of the nervous system, which shapes the structure and function of the developing brain (Meaney, 2010; Siegel, 2012). These relationships take place within proximal, bidirectional, interpersonal contexts that are themselves nested within larger micro- and macrosystems. Taken together, these contexts powerfully influence how the adults in a setting interpret and respond to the needs of children and youth (e.g., Brody, Miller, Yu, Beach, & Chen, 2016; Dreier, Mollenkopf, & Swanstrom, 2004; Jennings, Frank, Snowberg, Coccia, & Greenberg, 2013; Massey, 2007; Peterson & Krivo, 2010; Sampson, 2012; Sharkey, 2013).

Three relationship characteristics have the potential to build strong brain architecture: (1) warm, consistent, and attuned relationships in which learning is fostered and scaffolded; (2) positive experiences inside and outside the home; and (3) positive perceptions of these experiences (Brody et al., 2016; Center on the Developing Child at Harvard University, 2016; Chen, McLean, & Miller, 2015; Chen, Miller, Lachman, Gruenewald, & Seeman, 2012; Masten, 2007; Spencer & Swanson, 2013). Relationships that have these characteristics are necessary for developing the foundational emotional, social, behavioral, and cognitive competencies critical to learning and development—including those we often take for granted, such as learning a language and literacy (Halfon, Shulman, & Hochstein, 2001; Ramey, McGinness, Cross, Collier, & Barrie-Blackley, 1982; Ramey, Yeates, & Short, 1984; Sroufe, 2005). Developmental research suggests that these foundational competencies are malleable, and that the importance of the role each plays changes throughout different developmental periods. These competencies include cognitive processes,

emotional processes, social skills, knowledge, and dispositions (attitudes, beliefs, values, mindsets, and orientations toward self and others) (e.g., Jones & Bouffard, 2012; Osher, Kidron, Brackett, Dymnicki, Jones, & Weissberg, 2016). Over time, a combination of skills, knowledge, dispositions, and social and self-awareness, as well as physical and mental wellness, work together to enhance children's wellbeing and opportunities for success in learning and life (Masten, 2014; Nagaoka et al., 2015).

These foundational competencies are individual assets that can interact with environmental factors in a positive cascade. However, there can also be negative cascades, where risk factors interact in ways that impair adaptive socialization (Sasser, Beekman, & Bierman, 2015). Adverse early experiences, including chronic stress and under-stimulating caregiver and child care experiences, make it more difficult for children to develop foundational developmental competencies to navigate the challenges posed by such environments, and can also elicit unhelpful responses from other individuals.

Epigenetic adaptation is not confined to a finite period in childhood. Nor is development a progression of fixed stages, like a ladder. The epigenetic-adaptation perspective views the developing brain and emerging mind as constantly organizing and integrating experience and building connectivity and mental representations of experience and identity across time (Siegel, 2013). The process continues into adolescence and adulthood, allowing malleability in development and behavior for far longer than once believed possible. We know today that there are several periods of brain "remodeling," such as in adolescence, during which fundamental brain processes become more and more integrated through increased connectivity among brain structures (NRC, 2015; Siegel, 2012). This development is exquisitely sensitive to the relationships and experiences that are present when it is taking place, as well as being exquisitely sensitive to the presence of chronic stress.

The contemporary model of epigenetic adaptation runs counter to the genetic reductionist view of evolutionary change that sees genes as the primary mover in human development (see Lerner, *in press*), and counter to trait theories that posit that temperament and personality are determined by genes (see Lerner & Callina, 2014). Dynamic developmental theory (Fischer & Bidell, 2006) suggests that human attributes are only partially biological; they are affected by multiple and constant relations with people and contexts (Almlund, Duckworth, Heckman, & Kautz, 2011; Davidson & McEwen, 2012; NRC, 2015; Osher, Kidron, Brackett et al., 2016; Spencer, 2007).

The reciprocal and dynamic interactions that support the development of the brain provide something that nothing else in the world can provide—experiences that become individualized to, and ultimately shape, a child's unique personality and potential. Such interactions are a product of individual and environmental assets, and create multiple experiences of and opportunities for success. These dynamic and reinforcing experiences shape children's identities, awareness of self and others, and potential (Heckman, 2008; Rose, Rouhani, & Fischer, 2013).

The Science of Attachment

The early child-caregiver attachment relationship is particularly influential on development in infancy, and continues to be important as children develop (Moss & St-Laurent, 2001; Sroufe, 2005). Although prenatal development is important, a significant part of the mammalian brain

emerges after a child is born, and becomes organized over time through social context (Siegel, 2012). The first year of life is especially important, as sensory, social, and emotional interactions provide learning opportunities for the optimization of low-level brain circuits, which are the foundation for increasingly complex circuits that emerge in later years, particularly for self-regulation (Center on the Developing Child at Harvard University, 2016; IOM & NRC, 2015; Knudsen, 2004). Early interactions, which take place in the context of the early child-caregiver relationship, create patterns of organization as neural circuits and hormone levels change in both the infant and caregiver. This establishes blueprints for coordinated interpersonal behavior, attitudes, and expectations about the self, others, and relationships that become the foundation for short-term and long-term functioning (Kim, Strathearn, & Swain, 2016; Knafo & Jaffe, 2013; Sroufe, 2005). Shared experiences, attunement (the capacity of each to sense what the other needs and thinks), and co-regulation provide a foundation for a healthy early caregiver-child relationship. Longitudinal research on attachment reveals that early relational patterns between infants and parents, absent effective intervention, greatly influence how children will interact later on with teachers and with peers (Sroufe, Egeland, Carlson, & Collins, 2005). However, key adults—parents, teachers, and other providers—have the capacity to attune to, reorient attachment to, and establish positive relationships with children and youth into adulthood (Dymnicki, Wandersman, Osher, & Pakstis, in press; Hershberg, DeSouza, Warren, Lerner, & Lerner, 2014; Liebenberg et al., 2016; Siegel, 2012).

Pattern-making is thought to occur through sequences of attunement, misattunement, and reattunement that involve emotional responses, attention, executive functions, the reward and motivation system, and sensorimotor systems (Kim et al., 2016; Schore & Schore, 2008). In the first months of life, social synchrony—the coordination of social behavior between caregiver and infant in gaze, vocalization, affect, and touch—triggers biological synchrony (via heart rhythms and oxytocin levels), which helps parent and infant bond. During that time, the caregiver co-regulates her own and her infant's emotional arousal and physical needs (Feldman, 2015; Kim et al., 2016). Attunement creates a resonance between adult and child. At toddler age, co-regulation gives way to a “caregiver-guided” form of regulation, and this then transitions to more and more ability to autonomously regulate the self. Emotion and the development of the ability to regulate emotional states moves the self, over time, into increasingly complex forms of interrelationship with environment and experience (Siegel, 1999).

Co-regulation, which is important throughout development, is particularly important in the first years of life, as the child develops the capacity to self-regulate (Halfon et al., 2001; Murray, Rosanbalm, Christopoulos, & Hamoudi, 2015). Researchers believe that attachment relationships with parents, family members, and other caregivers build self-confidence through opportunities to: (1) explore surroundings; (2) build language skills, through language-rich and responsive interactions; and (3) build social competence, through successful social interactions (Fernald, 2015; Golinkoff, Can, Soderstrom, & Hirsh-Pasek, 2015; IOM & NRC, 2015; Kuhl, 2010). Neurobiological research suggests that attuned communication between caregiver and child balances excitatory and inhibitory systems in the brain. This balance is critical for the development of the neurobiological systems involved in processing emotion, cognition, modulating stress, and self-regulation, all of which provide the foundation for later healthy functioning (Feldman, 2015; Galbally, Lewis, van IJzendoorn, & Permezel, 2011; Schore & Schore, 2008; Sroufe, Duggal, Weinfield, & Carlson, 2000).

Certain characteristics of the caregiver–child relationship and the home environment can threaten attunement as well as relational and neural integration, and can result in disorganized attachment patterns. Some of the characteristics of the caregiver–infant relationship that result in disorganized attachment are emotional or physical rejection, hostility, lack of appropriate responsiveness, and unpredictability. One cause of this dysregulation is postpartum depression, which affects 10 percent to 20 percent of new mothers and somewhere between 4 percent and 26 percent of new fathers. The percentage can be drastically higher in parents with histories of depression and stress hormone dysregulation (Couto et al., 2015; Kim et al., 2016). Maternal depression threatens the mother’s emotional regulation and maternal sensitivity, and can contribute to over-controlling, intrusive, or disengaged parenting, as well as to irritability, anger, and sadness (Halfon et al., 2001; Petterson & Albers, 2001).

Prolonged periods of unregulated child stress, which are associated with compromised caregiver–infant interactions, can affect a child’s capacity to learn to self-regulate and disrupt the structure and processes of the child’s brain, neuroendocrine system, and immune system (Bucci, Marques, Oh, & Harris, 2016; Halfon et al., 2001; Johnson, Riis, & Noble, 2016). Disorganized attachment endangers the development of foundational competencies (e.g. executive functions, emotion recognition, and social information processing) critical for learning, interpersonal interactions, and school success in later years (Blair & Raver, 2016; Cicchetti, Rogosch, & Toth, 2006; Hovee et al., 2012; Sroufe, 2005). Children with disorganized attachment patterns in their families can meet their needs for later attachment in ways that are positive (e.g., strong adult and peer relations) or negative (e.g., early pregnancy and gang involvement). Positive adaptations may be hindered by poor self-regulatory and attachment skills and inadequate social support, while negative responses can be prevented by the intentional development of self-regulatory skills, increasing self-awareness and social awareness, and new opportunities for adequate social support (e.g., Beijersbergen, Juffer, Bakermans-Kranenburg, & van IJzendoorn, 2012).

There are many interventions that can help families at risk for poor attachment relationships create positive, reciprocal, and nurturing relationships with their young children (Furlong et al., 2012). Some examples include the ABC Intervention (Bernard, Hostinar, & Dozier, 2015), the Positive Parenting Program (Triple P) (Sanders, Kirby, Tellegen, & Day, 2014), and the Regional Intervention Program (Strain & Timm, 2002; Strain, Steele, Ellis, & Timm, 1982).

The Science of Self-Regulation

Self-regulation skills and attributes, referred to here under the umbrella term self-regulation, have a strong base of correlational and causal evidence to support their malleability, developmental progression, and vital contribution to short-term and long-term social, emotional, cognitive, academic, financial, and health outcomes (Blakemore & Bunge, 2012; Siegel, 2013). There is a large base of research showing the importance of the intentional development—from the beginning of life—of self-regulation skills such as executive functions and effortful control. In addition, there is a robust body of research showing that exposure to prolonged, unbuffered stress can disrupt the development of these critical skills (Center on the Developing Child at Harvard University, 2016; Jones, Bailey, Barnes, & Partee, 2016).

Self-regulation encompasses a set of foundational skills that involves interrelated emotional, cognitive, social, and attentional systems that aid in managing cognition, attention, behavior, and

emotions, and support goal-directed behaviors. These systems interact to promote learning and development under healthy conditions, but under conditions of sustained stress they can hinder learning and development (Blair & Diamond, 2008; McClelland & Cameron, 2012; Moffitt et al., 2011; Stevens & Bavelier, 2012). Self-regulation, including executive functions and effortful control, involves complex skills that integrate multiple simpler skills from cognitive and emotional domains. Self-regulation allows one to manage cognition, motivation, emotion, behavior, and attention. Self-regulation encompasses many different regulatory-related attributes that range from basic, automated, physiological functions (e.g., circadian rhythm) to more complex, intentional processes (Gestsdottir & Lerner, 2008). Intentional self-regulated behavior, motivation, and cognition are initiated when a person consciously sets out to attain a goal or when routine activities are impeded. Intentional self-regulation includes well-researched skills such as “delay of gratification” and effortful control, as well as the ability to implement goal-related strategies, optimize goals to meet personal and social values and desired abilities, and compensate in the face of blocked or lost goals (Baltes, 1997; Gestsdottir & Lerner, 2008; Jones et al., 2016). Intentional self-regulation, in learning, is a constructive process whereby people set goals for their learning and then continue to monitor or control their cognition, motivation, and behavior based on the assessment of success or failure in attaining their goals.

Executive functions are part of the intentional self-regulatory system. They are the set of neurocognitive attention-regulation skills involved in the conscious goal-directed modulation of thought, emotion, and action (Blair & Diamond, 2008; Diamond, 2013; Zelazo, Blair, & Willoughby, 2016). As conceptualized, executive functions involve top-down, intentional control of behavior, as well as bottom-up, automatic reactions. They are commonly defined as having three components: cognitive or mental flexibility (switching from one demand to another and considering others’ perspectives), working memory (holding and manipulating information in the short term), and inhibitory control (mastery and filtering of thoughts and impulses to resist habits, temptation, distractions, and thinking before acting) (Center on the Developing Child at Harvard University, 2011; Zelazo, 2015). Executive functions are necessary for a number of more complex self-regulation-related skills such as problem-solving, focus and self-control, perspective-taking, communication, making connections, critical thinking, taking on challenges, and self-directed and engaged learning (Blair & Razza, 2007; Farrington et al., 2012; Galinsky Bezos, McClelland, Carlson, & Zelazo, in press; Jones et al., 2016). Executive functions are so fundamental to learning that some experts have argued they may be even more important for school readiness and success than early literacy and numeracy skills, because they prepare children to be engaged learners, to pay attention, and to follow rules, all of which are essential for school success (Zelazo, 2015).

Self-regulation skills and attributes are themselves critical for success in school and life, but they also underlie or are intricately linked with a number of other foundational competencies, such as attention, memory, and stress management (Blakemore & Bunge, 2012; Center on the Developing Child at Harvard University, 2011; Dweck, Walton, & Cohen, 2011; Murray et al., 2015). They are among the more important prerequisites for developing (with some contextual support) perseverance and contribute to resilience (Flouri, Midouhas, & Joshi, 2014; Gardner, Dishion, & Connell, 2008; Masten, 2007; Stafford-Brizard, 2015). They are considered responsible for many of the skills necessary for higher-order learning and social competence, including impulse control, managing strong feelings, problem solving, decision making, organizing behavior, self-direction, learning from educational experiences and practice, and

conflict resolution (Murray et al., 2015, Stafford-Brizard, 2015). Self-regulation-related skills and attributes underlie interpersonal competencies, and are a critical component of school readiness (Raver, Garner, & Smith-Donald, 2007). Children who are better able to self-regulate have better relationships with teachers and peers and are seen by teachers as more academically and socially competent (Blair & Diamond, 2008). These factors are associated with greater engagement in school (Farrington et al., 2012; Murray et al., 2015; Zelazo, 2015). Self-regulation-related skills and attributes are associated with greater likelihood of graduating from college, and better health and wealth in adulthood (Blair & Diamond, 2008; Diamond & Lee, 2011; Gathercole, Pickering, Knight, & Stegmann, 2004; Seguin, Nagin, & Tremblay, 2004; Vitaro, Brendgen, Larose, & Tremblay, 2005; Zelazo, 2015).

A growing body of research suggests that self-regulation, including executive functions, is a particularly important target for intervention for children who are challenged by attentional issues and impulsivity (Jimenez, Wade, Lin, Morrow, & Reichman, 2016; Loeber et al., 2012; Menting, van Lier, Koot, Pardini, & Loeber, 2016; Polderman, Boomsma, Bartels, Verhulst, & Huizink, 2010; Sijtsma, Verboom, Penninx, Verulst, & Ormel, 2014). Research in diverse fields has found that effective interventions that address self-regulation can help children who have experienced a variety of poverty-related adversities to be better prepared to successfully engage in learning and better succeed in school (Blair & Raver, 2014; Center on the Developing Child at Harvard University, 2016; Diamond & Ling, 2016; Masten, 2007).

Self-regulation of emotion, in particular the regulation and synchrony of emotional states, is central to the overall regulatory and integrative processes of the developing brain (Siegel, 1999; Damasio, 1994). As “the highest order direct expressions of bioregulation in complex organisms,” emotion and the experiences of emotion are crucial components of the developing brain’s integrative processes, and are key to understanding “the relation between an organism and the most complex aspects of an environment: society and culture” (Siegel, 1999). To accomplish this, the developing brain exists in a continuous feedback loop between emotion regulation (emotional self-regulation), executive functions (response inhibition, attention shifting, and working memory), motivation, and the stress response. This feedback loop helps these systems mutually organize each other and establish increasingly complex representations of the meaning of experiences, and thus creates the resulting balance among these systems to facilitate healthy human development (Blair & Diamond, 2008; Cole, Martin, & Dennis, 2004; Siegel, 2013). Indeed, the associations between self-regulation and important child outcomes such as school readiness and academic competence are thought to be due to the coordination and mutual reinforcement of these subsystems (Blair & Diamond, 2008; Jones et al., 2016).

Self-regulation is distinct from attitudes, beliefs, mindsets and values, and from orientation to individuals, informal and formal institutions, and groups. Alone and together, all of these factors contribute to healthy social, emotional, cognitive, metacognitive, and academic development, enable productive engagement with the social and physical world, and modulate the experience of stress (Almlund et al., 2011; Dweck et al., 2011; Farrington, 2013; Farrington et al., 2012; Heckman & Kautz, 2012; Jones & Bouffard, 2012; Nagaoka et al., 2015; Osher, Kendziora, Spier, & Garibaldi, 2014; Salovey & Mayer, 1990; Scales, Roehlkepartain, & Schramko, 2016; Trilling & Fadel, 2009).

Self-regulatory capabilities interact continuously within the microsystems of relationships in which children develop. Transactions between biological and social processes over time, and the balance among the cognitive, emotional, and behavioral self-regulatory systems, are thought to determine the acquisition and strengthening of a child's overall self-regulation system (Murray et al., 2015; McCabe, Cunningham, & Brooks-Gunn, 2004). The neurological and behavioral systems involved in self-regulation continue to develop from birth to young adulthood. Early childhood and adolescence are considered highly sensitive periods for their development (Johnson et al., 2016).

The Science of Individuality

The science of individuality is grounded in dynamic systems theories (Fischer & Bidell, 1998; Kelso, 2000; Thelen & Smith, 2006), and starts with the premise that individuals vary in how they learn, behave, and develop; that these processes vary according to the context; and that there are patterns within that variability (Mischel, 1968; Rose et al., 2013). The individual–context interaction is part of a holistic, integrated, and self-constructing system that includes actions that take place at the cellular level (in cells within microenvironments in the body), the genetic level (in gene–context interactions), and the neurobiological, phenomenological, emotional, and behavioral levels (Overton, 2015). Although individual patterns exist, these patterns change according to context, which includes microenvironments within the same overall context (e.g., schools or families) (Bahns, Pickett, & Crandall, 2012; Osher, Kendziora, Spier, & Garibaldi, 2014; Osher, Kidron, DeCandia et al., 2016). The science of individuality has implications for diverse areas of research, from exploring development of cancer cells to the development of literacy and social behavior in children. Its principles are consistent with a range of fields of study, including research on the differential effects of interventions (Kellam, Koretz, & Mościcki, 1999) and on the historical and phenomenological factors that affect and differentiate individual responses to the experience of adversity (Spencer, 2007), as well as research that suggests that individual differences in developmental plasticity and susceptibility to environmental influences are part of an integrated system that includes a neurobiological component (Bakermans-Kranenburg & van IJzendoorn, 2007; Johnson et al., 2016; Kolb & Gibb, 2011).

A major implication of the science of individuality and the idea of relative plasticity is that there is not one ideal developmental pathway for everyone; there are multiple pathways to healthy development, learning, academic success, and resilience (Ford & Lerner, 1992; Hattie, 2009; Rose et al., 2013; Ungar, Ghazinour, & Richter, 2013). Rather than study averages, research should start with a focus on understanding patterns in individual variation across contexts, and from there build toward generalizable models of growth and learning (Rose et al., 2013).

Plasticity and susceptibility to the environment can work in beneficial or harmful ways (Cole, 2014). Some children (and certain developmental periods) are more vulnerable to adversity and stress, but those same children may also benefit the most from support and enrichment in their environment. For example, more susceptible children can realize better outcomes when securely attached, and more negative outcomes with disorganized attachment (Bakermans-Kranenburg & Van IJzendoorn, 2007; Roisman & Fraley, 2008). The idea of differential susceptibility implies that great opportunity exists in intervening in the lives of children who experience the most dysregulation in the face of stress and adversity. It also implies that although children may be

more susceptible to adversity in the first few years of life (and other sensitive periods), they also are likely more malleable in the context of interventions (Blair & Raver, 2016; Johnson et al., 2016).

The Science of Learning

Education can benefit from the accumulation of research in neuroscience, cognitive science, and the learning sciences; research on social, emotional, and academic learning; and research on the social and emotional conditions for learning. Experts in the learning sciences have used this cumulative body of knowledge to develop a set of principles of how students learn, to guide the design of curriculum, instruction, and assessment (Bransford, Brown, & Cocking, 2000; Goldman & Pellegrino, 2015). These principles can help align instruction with the way the brain works and help personalize learning. The principles address the following:

- Student background and knowledge
- Cognitive load and the limits of working memory
- Metacognition
- Social and emotional and cognitive development
- Motivation
- Interpersonal factors that affect learning
- Social and emotional conditions for learning
- Cultural responsiveness and competence

While these principles are distinct, they are experienced interactively by learners. Ideally, they are operationalized by educators with attention to their interdependence. Learning depends on relations and supports within and among individuals, classroom and school contexts, and other opportunities to learn. Theoretical and empirical research evidence on the interconnection among emotional, cognitive, social, and affective functioning suggests that students learn most deeply when they are in environments that promote their intrinsic motivation to learn and master material; where they see themselves as competent and capable learners; where they have high expectations for themselves as learners and achievers; where they have the capacity to persist at challenging tasks; and where they feel they can take risks, reflect on and learn from their mistakes, and persist through challenges (Deci & Ryan, 2008; Dweck & Master, 2009; Goldman & Pellegrino, 2015; Good, Aronson, & Inzlicht, 2003; Marcovitch & Zelazo, 2009a; Marcovitch & Zelazo, 2009b; Osher & Kendziora, 2010; Rattan, Good, & Dweck, 2012; Wigfield & Eccles, 2000). Hattie and Donoghue's (2016) learning strategies discuss the importance of "skill, will, and thrill." Skill involves student's prior or subsequent achievement; will relates to students' various dispositions towards learning; and thrill refers to students' motivations to learn. Timely, clear, and specific feedback that is focused on the task and on improvement, and is experienced as supportive, can link the social, emotional, and cognitive aspects of learning (Deans for Impact, 2015; Hattie & Timperley, 2007; Steele, 2010). Ecological resources such as social networks, cultural beliefs, cultural assets, and institutional practices shape all of these variables (Lee, 2009).

Neural plasticity is important for the neural connections that directly and indirectly affect learning. The neural systems that underlie learning exhibit plasticity throughout the lifespan, vary between individuals, and respond to environmental stressors, culture, societal norms, and social interactions (Blair & Diamond, 2008; Center on the Developing Child at Harvard University, 2016; Rose et al., 2013; Tomasello, 1999). In addition, consistent with the science of individuality, cognitive development occurs through the acquisition of new knowledge and experiences, and not through a linear age-related progression (Deans for Impact, 2015; Flynn, O'Malley, & Wood, 2004). Neural integration and the mastery of new information is more likely to occur when different parts of the brain are strengthened and exercised through appropriate learning opportunities (avoiding cognitive overload), social support for learning, modeling, scaffolding, reflection, and practice (Deans for Impact, 2015).

There are many examples of the interconnections among these principles. For example, students who are learning to read and comprehend texts are likely to consider what the teacher thinks of them, the importance to them of making sense of the text, their ability to understand the text, and their interpretation of success or failure, all of which are influenced by their prior knowledge, their experiences with reading at school and at home, and their social and academic identities (Lee et al., 2015). Reading comprehension also depends on classroom and school factors—most notably relationship-building and instructional strategies that are developmentally appropriate and personalized (Lee, 2010).

Student Background and Knowledge

Students are not “blank slates.” From prior experiences and interactions, students bring to school beliefs about themselves and learning; epistemological beliefs; prior knowledge of how the world works; content-specific knowledge; beliefs about their own intelligence; and cultural knowledge, skills, and schema that are sometimes incomplete or inconsistent with instruction, language, and discourse practices (Ambrose & Lovett, 2014; Bransford et al., 2000; Hoffman, 2009; Yeager, Johnson et al. 2014). Prior knowledge includes conscious and unconscious knowledge, including incorrect knowledge that needs to be unlearned, and automated beliefs and attributions from negative as well as positive experiences (Clark, 2006, 2009). Students also bring intellectual and metacognitive skills (Ambrose & Lovett, 2014). Students' levels of knowledge and skill affect how they receive and process information, as well as how and when they benefit from direct instruction and feedback (e.g., Nihalani, Mayrath, & Robinson, 2011). When interests and prior knowledge are not taken into account, students may be less engaged. Teachers can leverage prior knowledge, engage students, and support learning (Ambrose & Lovett, 2014).

Cognitive Load and the Limits of Working Memory

Effective instruction must deal with our cognitive load (i.e., the amount of mental effort being used in working memory) and the limits of working memory (Alloway, 2006). The presentation of knowledge affects how knowledge is retained and transferred. This may be particularly important for novice learners, who process and retrieve knowledge less efficiently than experts (Chase & Simon, 1973; Kalyuga, Ayres, Chandler, & Sweller, 2003). Teachers can help novice learners build new knowledge in a discipline most effectively by providing intentional and explicit instruction about key ideas, and combining it with hands-on learning experiences. A

thoughtfully organized framework that helps novice learners see the whole picture can facilitate retrieval and application of new concepts, and deepening of knowledge. Alleviating cognitive load should not mean oversimplifying content: information should be presented in such a way that it is as germane as possible (Paas, Renkl, & Sweller, 2004)

Metacognition

Evidence suggests that most learning is non-conscious and automated, and that students often do not know what and how much they learn from instruction (Clark, 2006, 2008). Metacognition, an active process of reflection, sense-making, and self-assessment, helps students become active participants in the learning process, supports neural integration, and helps students learn from their mistakes, all of which are integral to learning (Marcovitch & Zelazo, 2009b; Müller, Lieberman, Frye, & Zelazo, 2008). Student self-awareness is an important aspect of metacognition (Ehrlinger & Shain, 2014). Strategies that encourage metacognition push students to reflect on the process of learning, including how well they are learning, their affective states, and how new knowledge fits into their existing knowledge. These strategies help students become expert learners (Clark, 2009; De Corte, 2003). Metacognitive approaches to instruction have been shown to increase the degree to which students transfer knowledge to new situations without explicit guidance (Bransford et al., 2000).

Social and Emotional and Cognitive Development

A host of emotional, affective, social, and cognitive processes affect the ability of students to learn (including knowledge acquisition and retention, transfer and application of knowledge beyond the classroom, and performance on standardized tests). Social and emotional competence affects learning and instruction (Arndt, 2012; Immordino-Yang & Damasio, 2007; Osher, Kidron, Brackett et al., 2016) and is critical to students' school and life success (Brackett, Rivers, & Salovey, 2011; Bransford et al., 2000; Fischer, 2009; Immordino-Yang, 2015; Immordino-Yang & Damasio, 2007; OECD, 2015; Rychen & Salganik, 2003). These skills are malleable. They can be taught and developed through cognitive-readiness and social-and-emotional-learning strategies (Osher, Kidron, Brackett et al, 2016).

Contrary to the generally held belief that cognitive functions are separate from emotional, affective, and social functions, research in neuroscience and the behavioral sciences provides evidence that these functions are intricately interrelated (Immordino-Yang, 2011; National Research Council, 2012; Zimmerman, 2008). The interrelationships between emotional, cognitive, social, and affective functioning are apparent at the molecular and behavioral levels (Blair & Diamond, 2008 Center on the Developing Child at Harvard University, 2016; Immordino-Yang, 2011). At the neurobiological level, neural circuits involved in regulating emotions (e.g., anxiety) overlap with those that affect body regulation (e.g., heart rate) and sensation (e.g., physical pain) and support cognition (e.g., executive control). These functions sometimes reinforce each other and sometimes interfere with each other (Center on the Developing Child at Harvard University, 2016; Dalgleish, 2004; Immordino-Yang, 2011). At the behavioral level, emotion affects motivation, engagement (e.g., flow), and academic performance (Meyer & Turner, 2006). The interrelationship between functions helps explain why the cognitive processes that contribute to learning, memory, and knowledge transfer and application cannot be separated from the emotional, social, and affective processes that also contribute to

learning—such as confidence, motivation, persistence, self-control, anxiety, and curiosity (Clark, 1998; Davidson, Amso, Anderson, & Diamond, 2006; Fischer & Bidell, 2006; Immordino-Yang & Damasio, 2007).

The social and cultural contexts of learning affect emotions in important ways. The neurobiological processes involved in learning are interconnected with a nest of peer and adult relationships and opportunities that shape personal experience and cultural knowledge, and can affect learning, engagement, motivation, challenge, boredom, and frustration (Hagenauer, Hascher, & Volet, 2015; Hammond, 2016; Immordino-Yang, 2011; Osher et al., 2014). Each internal and external system contributes uniquely to an individual's ability and motivation to formulate ideas, perceptions, and understandings about his or her environment. Within the student, this process occurs through self-assessment, self-reflection, and self-regulation—processes that are affected by children's social and emotional competencies.

Motivation

Motivation affects engagement and performance (Clark, 1998; Colquitt, LePine, & Noe, 2000). Although encouraging motivation is challenging in many settings, it is particularly challenging in school contexts where participation is compulsory, where learning opportunities lack personalization, and where the benefits of learning are unclear to students. Three factors that appear to increase or decrease motivation are (1) perceived ability to accomplish a task, (2) value of the goals, and (3) mood and emotion (Clark, 1998; Hattie & Donoghue, 2016). Students are more motivated to learn and are more effective learners when they believe that their intelligence and ability can be improved through hard work (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013; Linnenbrink & Pintrich, 2003), when they are able to identify strengths and weaknesses in their own learning and understanding (Koriat, 1993), and when they see value in the task (Linnenbrink & Pintrich, 2003). Intrinsic motivation is powerful (Davis, Winsler, & Middleton, 2006) and has been associated with deeper engagement, focus, creativity, confidence, and achievement (Patrick, Turner, & Strati, 2016). Students are more motivated to learn when they feel a sense of control and efficacy in their learning (Elliott & Dweck, 1988; Ryan & Deci, 2000; Zusho, Pintrich, & Coppola, 2003). Students are also more motivated when they have a sense of purpose (Dweck et al., 2014). Research suggests that when students see a prosocial purpose to an academic task, they are more likely to persist despite difficulty or boredom (Yeager, Henderson et al., 2014). Research also shows that students are more motivated when they experience support and belonging (Deans for Impact, 2015; Martin & Rim-Kaufman, 2015; Midgley, Feldlaufer, & Eccles, 1989; Yeager, Walton, & Cohen, 2013).

Interpersonal Factors That Affect Learning

Learning has strong interpersonal components, which include interactions with teachers and classroom members. The most effective instruction and learning experiences acknowledge the fundamentally interpersonal nature of learning. Both peers and teachers are key for students to work within their zones of proximal development (Vygotsky, 1978). The quality of teacher-student and peer relationships affects learning independent of pedagogical strategy (Dupéré, Leventhal, Crosnoe, & Dion, 2010; Wentzel & Muenks, 2016; Wubbels, Brekelmans, Mainhard, den Brok, & van Tartwijk, 2016). However, some instructional strategies explicitly leverage these relationships. Teacher-driven examples include explicit modeling, scaffolding, and

reciprocal teaching. Student-driven examples include cooperative learning and cross-age peer tutoring. Another example is situated learning when knowledge is co-constructed with others and dependent on the specific context and situation (e.g., Boaler, 2002; Shanahan & Shanahan, 2008).

Social and Emotional Conditions for Learning

The social and emotional conditions for learning (called conditions for learning) are those aspects of the learning environment that are most proximal to learning and development (e.g., safety, connectedness, and support; challenge and engagement). These conditions are a subset of school and classroom climate, and a product of interactions among all members of a class or school community, how these interactions are interpreted, and the school's culture (Garibaldi, Ruddy, Osher, & Kendziora, 2015; Pianta & Hamre, 2009). The conditions for learning are related to the emotional and affective salience of instruction and how students view the meaning and purpose of education, how safe and comfortable students feel, and students' willingness to take academic risks. They provide conditions that support the development of critical foundational skills such as self-regulation, the fostering of academic persistence, and students' self-direction (Osher & Kendziora, 2010).

Conditions for learning and opportunities to learn affect learning directly (e.g., through their effects on working memory and engagement) and indirectly (e.g., through effects on teacher stress and ability to teach). For example, anxiety, which can be affected by a lack of safety, impairs working memory (Shackman et al., 2006). Engagement, which can be enhanced by academic challenge and teacher support, can facilitate flow, which involves optimizing absorption, focus, and enjoyment (Csikszentmihalyi, 1990; Nakamura & Csikszentmihalyi, 2002; Schmidt, Shernoff, & Csikszentmihalyi, 2014). Feedback is powerful when the classroom climate welcomes errors and focuses on learning and mastery as opposed to performance (Hattie & Yates, 2014). Similarly, interpersonal relationships within learning environments affect learning directly (e.g., cooperative learning) and indirectly (e.g., through the effects of bullying on learning) (Swearer, Espelage, Vaillancourt, & Hymel, 2010). Research has repeatedly demonstrated positive associations between classroom and school conditions for learning and achievement (Allen et al., 2013; Berkowitz, Moore, Astor, & Benbenishty, 2016; Bryan et al., 2012; Fall & Roberts, 2012; Fan, 2012; Reyes, Brackett, Rivers, White, & Salovey, 2012; Thapa, Cohen, Guffey, & Higgins-D'Alessandro, 2013; Wang & Holcombe, 2010).

Students' social behaviors within learning environments affect and are affected by school staff members' perceptions of students and students' perceptions of teachers. Staff function as natural raters who reward or sanction students' behaviors (Kellam & Rebok, 1992). Teacher expression of explicit expectations of and behaviors toward students affect students' self-concept, engagement, motivation to succeed, and school-related behaviors (Osher, Kidron, DeCandia, Kendziora, & Weissberg, 2016; Rattan et al., 2012). Interpersonal relationships between and among students and their teachers, in particular students' perceptions of teacher empathy and trust, also play an important role in student engagement and capacity to persist through challenging academic tasks (Master, Butler, & Walton, 2017; Okonofua, Paunesku, & Walton, 2016). The mutually reinforcing interactions between and among students and teachers are entwined with the way the nervous system responds to learning; the degree to which students tap

their cognitive, emotional, social, and affective resources; and even special education diagnoses and placements (Bransford et al., 2000).

When students perceive conditions for learning as unfavorable (e.g., a lack of safety, connection, or challenge) students find it harder to engage and can become frustrated, have lower self-concepts and expectations, and lag behind academically (Claro, Panunesku, & Dweck, 2016; DiLalla, Marcus, & Wright-Phillips, 2004; Good et al., 2003; Hammond, 2016; Osher et al., 2014). This process can be internalized and unconscious, and can affect how students approach new learning challenges (Clark, 2006).

Cultural Responsiveness and Competence

Cultural responsiveness and competence can help address the challenges faced by culturally and linguistically diverse students from non-dominant or marginalized groups by providing emotional supports that allow them to feel that the school and classroom are places for learning and that they belong. Culturally and linguistically diverse students often experience disconnects between curricula and pedagogy on the one hand, and their experience, cultural capital, and needs on the other (Cartledge, 2008; Gay, 2010). These disconnects place particular cognitive and emotional demands on students, who have to master new knowledge without the benefits of culturally embedded explicit or implicit prior knowledge that teachers may take for granted (Clark, 2006; Lee, 2007)—knowledge that helps students from dominant groups master material. English learners provide an example of students who may experience these disconnects (Campbell, Adams, Davis, 2007; DeKeyser & Juffs, 2005). Studies of college students provide another example of the effects of these disconnects: when students were taught new facts about familiar individuals they retained twice as much as students who were taught the same number of facts about unfamiliar individuals (Ambrose & Lovett, 2014). These cultural disconnects make it harder for students to perceive themselves as learners (or as successful learners) and to visualize the connection between their schoolwork, their lives, and promising futures (Oyserman, Bybee, & Terry, 2006; Oyserman & Destin, 2010; Oyserman & Fryberg, 2006).

Culturally responsive approaches can use culturally mediated and situated pedagogy to address the emotional, motivational, interpersonal, and learning needs of culturally and linguistically diverse students to build upon their strengths and create a learning environment where they feel they belong and where they are emotionally and intellectually safe, supported, and challenged (Gay, 2010; Powell, Cantrell, Malo-Juvera, & Correll, 2016; Rickford, 2001). Rather than ignoring the assets that students bring with them (e.g., their cultural knowledge) or viewing it as a deficit (Valenzuela, 1999), culturally responsive approaches leverage cultural resources additively. These approaches acknowledge students' cultural displays of learning and meaning-making, and use teaching methods that use cultural knowledge as a scaffold to connect what students know to new concepts and content in order to promote effective information processing (Hammond, 2016; Lee, 2007; Lee, Spencer, & Harpalani, 2003). Culturally responsive approaches can also support learning by reducing the chances that educators will overestimate students' prior knowledge or students' familiarity with culturally embedded schemas. Strategies such as cultural modeling (Lee, 2007), which make this prior knowledge explicit and incorporate it into daily instruction and other learning experiences, can help students integrate new knowledge and connect in-school and out-of-school learning. For example, in the case of reading, cultural modeling can help identify and build upon students' everyday knowledge,

including their perceptions of their competencies and their interests, while scaffolding discipline-specific reading skills (Lee, 1995, 1997, 2000, 2004).

Cultural competence has been defined as a set of congruent behaviors, attitudes, and policies that enables schools, agencies, or providers to work effectively (ideally proficiently) in bicultural and multicultural interactions (King, Sims, & Osher, 2007). Cultural competence can help schools and agencies systematically address the disconnects, challenges, and adversities that culturally and linguistically diverse students and their families routinely face due to their culture, race, ethnicity, gender, and social class. These barriers include institutionalized processes and individual behaviors, and are related to disparities in educational opportunities and outcomes (Artiles, Kozleski, Trent, Osher, & Ortiz, 2010; Osher, Dwyer, & Jackson, 2004). Institutionalized processes include resource allocation, rituals, policies, protocols, and practices. Individual behaviors include harassment, macroaggressions, and negative stereotyping. These processes negatively affect student goals, attention, effort, and self-efficacy (Lane, Nadel, & Ahern, 2000; Solórzano, Ceja, & Yosso, 2000; Spencer, Fegley, & Dupree, 2006; Zajonc & Marcus, 1984), and drain the psychic energy available to address particular tasks (Brondolo et al., 2003; Pennington, Heim, Levy, & Larkin, 2016; Sue et al., 2007). Stereotype threat provides an example: it can increase feelings of anxiety, negative thinking, and mind-wandering, and can impair working memory and other executive resources required for successful task execution (Appel, Weber, & Kronberger, 2015; Johns, Inzlicht, & Schmader, 2008; Pennington et al., 2016; Steele, 2010; Szymanski, Kashubeck-West, & Meyer, 2008). While many individuals persevere, these barriers can create stress, place extra demands on working memory, drain cognitive resources, and impact health (LeBrón, Schulz, Mentz, & Perkins, 2015; Smith, Hung, & Franklin, 2011).

Design Considerations

Education can benefit from the translation and application of the scientific principles regarding learning and development elaborated in this paper in efforts to improve short- and long-term learner outcomes through deeper personalization of learning and the learner experience. This process has started to happen, as educators and researchers have started to mine the knowledge about social, emotional, cognitive, and contextual influences on engagement and learning generated by the evolution of the science of learning and development over the last two decades. Key aspects of this knowledge include research on how instruction can support learning and knowledge construction by (1) focusing on supporting learners' capacities to attend to, organize, elaborate, and remember knowledge; (2) supporting the development of the fundamental and complex concepts and skills involved in thinking, decision making, analysis and problem solving; and (3) applying a cultural and contextual lens to learning (Mayer, 1996; Murphy & Knight, 2016; Hoy, Davis, & Anderman, 2013).

This knowledge can be employed to increase the personalization, relevance, and meaning of learning while building important affective and cognitive competencies, skills, and mindsets. These competencies address the demand from employers for graduates with 21st century problem-solving and interpersonal skills and with educational backgrounds that emphasize communication, collaborative problem-solving, and the development of an academic growth mindset (Demming, 2015; Heckman, Stixrud, & Urzua, 2006; Miller, 2015). Evidence suggests that educational activities that focus on interrelated aspects of student development can result in

deeper understanding of core academic content, higher graduation rates, and higher rates of postsecondary enrollment and persistence (Rickles, Zeiser, Mason, & Garet, 2016; Yang, Zeiser, Siman, 2016; Zeiser, Taylor, Rickles, Garet, & Segeritz, 2014).

Applying the Science of Learning (and Development) to Instructional and School Design

Research in cognitive psychology, social-affective neuroscience, education, and special education point to a set of factors that curricula and instructional design need to address. These factors include knowledge about:

- Personalizing and differentiating learning by addressing individuality and difference
- Addressing the different stages of learning
- Distinguishing between and addressing short- and long-term learning goals.

Addressing Individuality and Difference. Variation in learning and attention is the norm, not the exception. Children's developmental and learning trajectories vary as a product of the interactions of their attributes and social contexts as well as in their development over time (Fischer & Bidell, 2006; Lerner, in press; Rose et al., 2013). Instructional design can identify and develop culturally and ecologically grounded practice that can support deep personalization of learning and the learner experience at the individual and group levels.

Instructional design should utilize statistical and qualitative techniques and methods to address the jaggedness of learning—the multiple and nonlinear pathways individual children take to develop their skills and knowledge (Fischer, 2009; Rose et al., 2013). Research, which can strengthen our ability to understand individual variation in students and diversity of learning, can be enriched by employing sophisticated data analytic techniques in combination with crowd-sourcing, analyses of positive deviance, and rapid-cycle improvement science methodologies.

Education design and policy cannot bet on individual resilience alone. It must address the key drivers of positive learning outcomes, which include effective pedagogy, curricular design, and the creation of classroom and school environments that support personalization and learning. Educational design should be informed by what is known about the science of human development; a full appreciation of context; the research on cognitive, social, and emotional development; and the research on resilience. Design and policy should also build upon what can be learned from research approaches that employ cultural and ecological lenses to identify strategies that work for children, families, teachers, schools, and agencies (Lee, 2009). This can include building upon knowledge regarding how people who face multiple adversities leverage resources to intentionally promote individual and collective resilience (Lee, 2009; Masten, 2007; Spencer, 2007). The use of these cultural and ecological lenses can help address the challenges of attribution biases created by observer perspectives that do not address or understand the ecological and phenomenological factors that affect adversities, adaptations to those adversities, and learning and development (Jones & Nisbett, 1972; Lee, 2010; Ryan, 1972; Steele, 2010). Using cultural and ecological lenses can also help combat negative mindsets of students who experience adversity and their families (e.g., Bohner & Dickel, 2011; Bomer, Dworin, May, &

Semington, 2008; Lee, 2010), and some of the perceptual factors that contribute to implicit bias (Warikoo, Sinclair, Fei, & Jacoby-Senghor, 2016).

A consideration of instructional and school design approaches based on the Science of Learning and Development principles could include:

- Creating student-centered environments and pedagogical approaches (Murphy & Knight, 2016).
- Establishing small, personalized inquiry-based learning communities (Brown & Campione, 1996).
- Ensuring that every student is known and has strong, trustful, and supportive connections to adults, including one specific advisory and mentoring relationship (Aneess, 2003; Braddock & McPartland, 1993; Darling-Hammond, Ramos-Beban, Altamirano, & Hyler, 2016; Eccles et al., 1993; Friedlaender et al., 2014; Lee, Bryk, & Smith, 1993).
- Ensuring that expectations and belief in students are explicitly expressed and enacted through meaningful challenge (Osher & Kendziora, 2010; Steele, 2010), so that students believe they are capable of a high level of achievement.
- Providing, and supporting the ongoing development of, a school staff that is high performing, well prepared, culturally responsive, and knowledgeable about the science of learning, individual child development, and individual variability (Gay, 2010; Ladson-Billings, 1994), and has the capacity to care for and attune with every student (Quinn, Osher, Hoffman, & Hanley, 1998).
- Ensuring that all students have an individualized and personalized learning plan and opportunities that include instructional and personal development goals, and support for realizing these goals.
- Aligning, embedding, and intentionally teaching cognitive readiness skills such as self-regulation, including executive functions and social and emotional learning—universally and also intentionally for students who are at various levels of risk (Dymnicki, Kendziora, & Osher, 2012; Jones & Bouffard, 2012; Osher, Sprague et al., 2008).
- Explicitly valuing self-direction, engagement, intrinsic motivation, curiosity, and citizenship.
- Using problem-based and experiential learning and cognitive apprenticeships (Bouck, Okolo, Englert & Heutsche, 2008; Murphy & Knight, 2016; Schoenfeld, 1998).
- Employing a disciplined use of data that includes consistent bidirectional student and teacher feedback as well as data on how students and others are experiencing the social and emotional conditions for learning.
- Addressing the needs of students who have experienced trauma through a universal trauma-sensitive approach combined with student-specific trauma-informed approaches (Cole, Eisner, Gregory, & Ristuccia, 2013; Osher, Kidron, DeCandia et al., 2016).

- Using a whole-school approach to student support that builds upon a rich foundation (Osher et al., 2004) that is trauma sensitive, culturally competent, and consistent with approaches to multi-tiered systems of support (MTSS) principles (Kingston, Mihalic, & Sigel, 2016), including Positive Behavioral Interventions & Supports (PBIS) (Bradshaw, Pas, Debnam, & Johnson, 2015; Bradshaw, Reinke, Brown, Bevans, & Leaf, 2008); and that aligns instruction, PBIS, and social and emotional learning (Bear, Whitcomb, Elias & Blank, 2015; Bradshaw, Bottiani, Osher, & Sugai, 2013; Osher, Sprague et al., 2008).
- Preventing discipline disparities and the use of exclusionary practices, rules, norms, policies, or discipline codes (Anyon, 2015; Hawkins, Smith, & Catalano, 2004).

Deeper learning and project-based learning provide examples of instructional and curriculum design that successfully combine cognitive, affective (social and emotional), and academic development in service of the science of learning and development. They represent pedagogical approaches that develop the skills students need to succeed in today’s complex world. The Hewlett Foundation (2013) defines these competencies as mastery of academic content, thinking critically to solve complex problems, working collaboratively, communicating effectively, learning how to learn, and developing academic mindsets. Others, such as the New Pedagogies for Deep Learning partnership have defined these skills as character, citizenship, collaboration, communication, creativity, and critical thinking (Fullan, McEachen, & Quinn, 2016). These approaches represent more than a list of discrete practices, such as the integration of digital technology (Hattie & Donoghue, 2016); deeper learning approaches involve fundamentally different partnerships in which teachers, students, families, and community members work in partnership to co-design learning activities. Students experience multiple opportunities to reflect upon their growth and learning and use peer and adult feedback along with other criteria to evaluate their progress.

Project-based learning involves completing tasks that result in a realistic product or presentation to the audience, and draws from multiple approaches: design-based instruction, inquiry-based learning, service learning, and collaborative learning. Design-based instruction asks students to create products that require them to apply their knowledge, go through multiple stages of revisions, and collaborate with their peers. Inquiry-based learning involves cooperative small-group learning to complete a collective task. Service learning projects give students the chance to contribute to their communities as they learn (Darling-Hammond et al., 2015; McKay-Jackson, 2014; Villegas & Lucas, 2002; Willis-Darpoh, 2013). Collaborative learning is another strategy that is most effective when it is well planned and actively facilitated by teachers, and when it encourages and builds on positive interdependence, individual accountability, face-to-face interaction, social skills, and group processing (Gillies, 2014; Hattie & Yates, 2014; Johnson & Johnson, 1989, 1999). Both service learning and collaborative learning integrate the teaching and reinforcement of student social and emotional competencies, which supports academic growth (Durlak et al., 2011; Jones & Bouffard, 2012; Dynarski et al., 2008; Osher, Kidron, Brackett et al., 2016).

Stages of Learning. Several instructional strategies and learning experiences are grounded in what we know about how novices and experts learn. Merrill (2002, 2006) recommends a cycle of instructional phases that includes activation, demonstration, application, and integration of learning in addressing real-world problems or tasks. Merrill recommends making this cycle

visible to students and teachers, and using the cycle to provide practice opportunities and feedback to help students become fluent in a subject (Anderson & Schunn, 2000).

Some specific strategies focus on enabling students who are novice in particular areas of knowledge to receive declarative (i.e., factual) knowledge and explicit guidance on procedural (i.e., performance) knowledge in order to avoid misconceptions, partial understandings, and ineffective problem-solving strategies (National Research Council, 2005), and to ultimately learn to apply the knowledge to new situations. Research suggests that experts are only aware of about 30 percent of their own decision-making and analysis tasks (Feldon, 2007); as experts, teachers may not provide students with sufficient guidance. Cognitive task analysis (CTA) is a method that uses structured interviews and observations to extract procedures and knowledge that may have become routine or tacit (Clark & Elen, 2006; Clark, Feldon, & Yates, 2006; Feldon & Clark, 2006). This information can help teachers provide an accurate and complete demonstration of how to perform a task or solve a type of problem, provide immediate corrective feedback, and provide declarative and procedural knowledge to help learners apply their new understanding to future novel problems (Sweller, Kirschner, & Clark, 2007; Tofel-Grehl & Feldon, 2013). The use of CTA to improve instruction and guidance has been demonstrated to improve student performance and perceptions of success (Feldon, Timmerman, Stowe, & Showman, 2010; Tofel-Grehl & Feldon, 2013).

Students' needs for support change as they become more cognitively engaged and develop expertise (Hattie, 2011; Hattie & Donoghue, 2016). The expertise reversal effect provides an example: instructional techniques that reduce cognitive load for low-knowledge learners may be less effective or even have negative effects for more knowledgeable learners (Kalyuga, 2007; Lee & Kalyuga, 2014). These principles can be applied to project-based learning. When teachers employed explicit strategic questioning strategies with students who were involved in collaborative learning, students were engaged in more elaboration and obtained significantly higher scores on follow-up reasoning and problem-solving tasks (Gillies & Haynes, 2011). For learning to occur, students must receive feedback that will take them to the next stages of learning. This should include information that can facilitate more efficient cognitive processing (Hattie & Timperley, 2007).

Distinguishing Between Short- and Long-Term Learning Goals. Teachers and schools are often under pressure to produce short-term results quickly. That is not always the way to support long-term learning. Instructional design needs to address this in a manner that attends to the pressures on students, teachers, and schools, as well as the motivational challenges that occur when payoffs are longer term. Three examples of this are (1) the importance of developmental progress and the importance of establishing foundational competencies like self-regulation, including executive functions, (2) the impacts of desirable difficulties, and (3) the function of different brain states.

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- *Developmental progression and integration.* Acquisition of deeper learning competencies such as problem solving and metacognition (Hattie, 2011) often requires the establishment of foundational competencies like self-regulation (Siegel, 1999), which some students may lack. The students most affected will be those whose development of foundational skills and mindsets has been affected by the context of adversity and by the lack of preparedness of adults. Hence design should develop ways to support the acquisition of foundational cognitive, social, emotional, and academic skills like self-regulation in age-appropriate ways that also support the student’s participation in deeper learning.
- *Desirable difficulties.* Design should also address the implications of the desirable-difficulties framework that distinguishes between short-term and longer term learning and growth. Desirable difficulties intentionally create difficulties and challenge for learners, which enhance long-term retention and transfer, but at the cost of increased short-term errors (Clark & Bjork, 2014). However, difficulties need to be by design, while many difficulties are undesirable during instruction (and beyond): “Desirable difficulties, versus the array of undesirable difficulties, are desirable because they trigger encoding and retrieval processes that support learning, comprehension, and remembering. If, however, the learner does not have the background knowledge or skills to respond to them successfully, they become undesirable difficulties” (Bjork & Bjork, 2011, p. 58).
- *Brain states.* Curricula and instructional design should also address findings from the field of neuroscience that there are two interdependent but distinct brain states that support two different types of learning (Gotlieb, Jahner, Immordino-Yang, & Kaufman, in press). One brain state supports task-oriented focus, an action-oriented mindset, and contextualized cognition. The other, the default mode network (DMN), supports imagination, creativity, meaning-making, personally relevant cognition, retrospection, and prospective thinking (Andrews-Hanna, Smallwood, & Spreng, 2014; Immordino-Yang, Christodoulou, & Singh, 2012). Teachers, due to accountability pressures and other aspects of job press, often want students to be task and productivity focused. Research suggests that DMN and DMN-related mind-wandering decreases efficiency and productivity in the moment (Mooneyham & Schooler, 2013; Smallwood & Schooler, 2015). However, DMN and DMN-related mind-wandering play essential roles in creativity and meaning making and are (in relationship to neural networks that support attentional control) critical to the development of cognitive control, self-regulation, memory suppression, mindfulness, and meta-awareness (Gotlieb et al., in press). Hence, exclusively activating an outward task focus may bias students’ minds away from integrating academic experiences into their own personal understanding—a bias that could potentially undermine long-term learning, retention, and persistence. In the words of Gotlieb and colleagues, “preparing students to undertake creative intelligence tasks means scaffolding them in the ability to focus intently on a task at hand and also in consciously, appropriately, and temporarily disengaging from the task to situate its broader purpose in a larger, personally meaningful goal” (Gotlieb et al., in press).

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The Science of Resilience

Resilience is a common phenomenon—there is an “ordinariness of resilience” (Bethell Newacheck, Hawes, & Halfon, 2014; Lerner, Agans, DeSouza, & Hershberg, 2014; Masten, 2001). Resilience at the individual level is sometimes viewed as a personality trait. Genetic makeup may enable some individuals to exhibit resilience (Yehuda et al., 2006). But resilience can be better understood as a bio-social-ecological process characterized by equifinality, differential impact, and contextual and cultural moderation (Ungar et al., 2013). Diverse proximal processes lead to different, but equally viable, development and well-being—equifinality. Proximal processes affect development through the nature of the risks and supports available (Spencer, 2007; Ungar et al., 2013). Exposure to risk is endemic to the human species. However, the nature of risk and the resources available to respond to risk vary according to cultural and ecological contexts (Lee, 2009). Resilience is defined locally, and different contexts and cultures provide varied access to varied processes and resources that support resilience—contextual and cultural moderation (Tol, Song, Jordans, 2013; Ungar et al., 2013). Resilience is not immutable (Cicchetti, 2013; Rutter, 2002); resilience (whether of a person, group, or organization) is the use of internal and external resources as a positive adaptation mechanism when confronted with significant internal or environmental adversity (Luthar, Crossman, & Small, 2015; Masten & Obradović, 2006; Rutter, 2013; Ungar, 2011; Yehuda, Flory, Southwick, & Charney, 2006). Positive adaptation is a process that relies on flexibility and adaptive capacity for change in internal and external systems (Masten & Obradović, 2008). Resilience encompasses not only positive adaptation in the face of adverse conditions but also seizing learning opportunities in the face of short- and long-term setbacks (Claro et al., 2016).

There is a neurobiological component to resilience. Internal adaptive systems include the learning systems of the brain, the mastery motivation system, the stress response systems, and the self-regulatory systems, as well as the integration of these internal systems (e.g., integration of neural circuitry involved in cognition, emotion, and behavior) (Masten & Obradović, 2006). The mastery motivation system compels individuals to master tasks and skills, including finding people who will help them do so, and is thought to be a driver of resilience from an early age (Anthony & Cohler, 1987; Masten, 2014). The stress response system involves the regulation of the hypothalamic-pituitary-adrenal (HPA) axis through oxytocin and cortisol levels in response to external stimuli (Ozbay, Fitterling, Charney, & Southwick, 2008). Research into the neural and psychobiological roots of resilience and resilience-promoting relationships is an emergent area of resilience research (Khanlou & Wray, 2014). However, evidence suggests that resilience is a bio-psycho-social-ecological process wherein promotive internal and external systems facilitate a child’s potential for positive outcomes (Jaffee, Caspi, Moffitt, Polo-Tomas, & Taylor, 2007; Masten & Obradović 2006).

Early biological and contextual supports contribute to early patterns of adaptation, which predict—and provide a foundation for—later, more complex patterns of adaptation (Yates, Egeland, & Sroufe, 2003). Adaptation is not a fixed process; internal and external factors, particularly during periods of transition, present new opportunities for adaptation or maladaptation throughout the lifespan (Klika & Herrenkohl, 2013; Ungar, 2011; Jaffee et al., 2007). Resilience is also culturally, socially, and historically embedded (Masten, 2011). For example, economic activity such as child labor or gang activity may be viewed as facilitating

resilience in contexts that are lacking in other promotive contexts, such as high-quality schools or prosocial peers (Ungar, 2011).

Researchers have documented substantial heterogeneity in resilience (Bethell et al., 2014; Southwick, Bonanno, Masten, Panter-Brick, & Yehuda, 2014; Theron, Liebenberg, & Malinidi, 2014) and how it relates to social support and context (Luthar, Sawyer, & Brown, 2006; Masten, 2011). Children's responses to adversity in their environment will vary as a function of individual dispositions, socialization practices, the type and timing of the adversity, and the countervailing supports available to them in those same or other environments (Goldstein & Brooks, 2012; Masten & Tellegen, 2012; Rutter, 1987; Spencer, 2007). While multiple systems contribute to the development of resilience, it is unlikely that every individual will draw from the same exact combination and experience of these systems. For example, one child might draw upon secure adult attachment, peer systems, and bonding to school in service of resilience, while another might draw from stress management and self-regulation skills in addition to spiritual/religious systems (Masten, 2007). This has important implications for the intentional development of resilience.

Resilience is shaped by multilevel dynamics—interactions across levels of analysis, including interactions between the gene and its environment, the individual and his or her relationships, and the individual and the media (Jaffee et al., 2007; Masten, 2007; Ungar, 2011). Internal assets (Benson, Scales, & Syvertsen, 2011) associated with coping are thought to contribute to adaptation. Internal assets include social and emotional competencies, self-regulation, growth mindsets, cognitive functioning, ego control, self-efficacy, agency, internal perceptions of control, perceptions of whether a stressor is stressful, and the ability to develop healthy relationships with individuals who can provide support (Claro et al., 2016; Lavoie, Pereira, & Talwar, 2016; Masten & Obradović, 2008; McEwen, 2006; Masten, Gewirtz, & Sapienza, 2013; Rutter, 1987).

External assets are located in a child's microsystem—supportive individuals and relationships in families, schools, informal settings, and community resources such as religious and cultural organizations (Lee, 2009). External supportive (adaptive) systems include the attachment system (i.e., consistent and supportive adult relationships inside and outside the home) and the family (e.g., expectations), the school (e.g., school culture, cultural sensitivity, staff attunement to the needs of students, teaching practices that involve scaffolding, reflection, and encouraging peer interaction), peer relations (e.g., reciprocal friendships), community (e.g., cohesiveness, support in the face of child and community experiences of adversity), cultural resources (e.g., spiritual connections), and societal systems (e.g., media-based resources) (Anthony & Cohler, 1987; Blair & Raver, 2014; Cicchetti, 2013; Masten et al., 2013; Masten & Obradović, 2006; Quintana et al., 2006; Sampson Raudenbush, & Earls, 1997; Spencer & Swanson, 2013). Research has repeatedly found that children who do well in the face of adversity have had at least one stable and responsive relationship with a parent, caregiver, or other adult (Center on the Developing Child at Harvard University, 2016). This finding has led resilience researchers to recommend policies and programs to better support parents—especially mothers, but increasingly fathers (Luthar, 2015; Luthar & Zelazo, 2003).

The research on resilience has also established a strong link between stress and psychological resilience (i.e., mental health), but psychological and physiological resilience are distinct from

each other (Lavoie et al., 2016). Children and youth who do not exhibit the psychological symptoms associated with adversity may in fact experience compromised physical health, yet this component of development often goes unseen and unmeasured (Brody et al., 2013; Lavoie et al., 2016).

Relationships as Drivers of Human Development: Positive Supportive Contexts

Relationships between and among children and adults are one of the primary processes through which the biological and the contextual influence and mutually reinforce each other (e.g., Bronfenbrenner & Morris, 2006). Secure and responsive relationships with adults, along with high-quality, positive learning interactions (and environments), are foundational to healthy development (NRC, 2015). Attachment, social synchrony, and attunement allow caregivers to care for the physical and emotional needs of infants and children. These processes start with early attachment relationships but continue as children become increasingly self-sufficient, interdependent, and independent. Children continue to benefit from readily available relationships with peers and other adults (e.g., teachers) to the degree that the relationships continue to be attuned to their emotional needs (Bergin & Bergin, 2009; Cornelius-White, 2007). These early and ongoing relationships contribute to the child's balanced capacity to regulate emotions, to feel connected to other people, and to establish an autobiographical narrative (Siegel, 2012). Warm and responsive interactions with caregivers at home and at school that involve support, coaching, co-regulation, and modeling promote balance between self-regulatory systems and allow children to learn to regulate emotions, behavior, and cognition (Elias, Parker, Kash, Weissberg, & O'Brien, 2007; Hamre & Pianta, 2005; McCabe et al., 2004; McClelland & Cameron, 2012; Murray et al., 2015). As children get older, early organizational patterns of social behaviors in the attachment relationship build on previous patterns of interactions with caregivers, and extend to behavioral patterns with peers and teachers.

According to the field of interpersonal neurobiology, relational integration, which is the linkage of different parts of the relational system, is established through attuned, compassionate communication with the caregiver. The caregiver's perceptions of and responses to the child's mental state, which are distinct from the child's behavior, are important for building shared experiences and emotions (Siegel, 2012). Research suggests that the ability to use mental-state language and to sense the child's mental state is related to attachment patterns and to the metacognitive monitoring capacity necessary for the development of self-regulation (Fonagy, Steele, & Steele, 1991; Fonagy, Steele, Steele, Moran, & Higgitt, 1991; Main, 2006). Relational integration facilitates the growth of neural integration—the linkage of different parts of the brain through the development of the affective regulatory functions in the child (i.e., development of emotion, memory, behavior, and relationality) (Schore & Schore, 2008; Siegel, 2012). Neural integration is important for developing interconnectivity and synaptic strength, and is associated with the development of higher order cortical functions and near-term and later well-being (Di Martino et al., 2014; Smith et al., 2015; Teicher & Samson, 2016; Teicher, Samson, Anderson, & Ohashi, 2016).

Parents

Decades of research demonstrate that the parent–child dyad and the family (which includes all primary caregivers) play a foundational role in the development of children’s social, emotional, and cognitive skills (National Academies of Sciences, Engineering, & Medicine, 2016). While the parental role is particularly pronounced in early childhood, it continues throughout the life course. Parents are both structurally and psychologically important. Structurally, they have rights (unless terminated), can direct and allocate the resources they control, and can structure and manage the environment around children (Grusec & Davidov, 2016; Huston & Bentley, 2010). Psychologically, parents play a key role in five relational domains, each of which has its own developmental course and set of regulatory mechanisms: protection, mutual reciprocity, control, guided learning, and group participation. Each domain is activated under different conditions, involves a different parent-child relationship, requires different parenting responses, and is associated with different outcomes (Grusec & Davidov, 2016; Grusec & Davidov, 2010).

While every interaction matters, a recent NRC Consensus Panel identified six key parenting practices as particularly important (IOM & NRC, 2015):

- Contingent responsiveness—adult behavior that occurs immediately after a child’s behavior and is related to the child’s focus of attention
- Showing warmth and sensitivity
- Routines and reduced household chaos
- Shared book reading and talking to children
- Practices that promote children’s health and safety
- Use of appropriate (less harsh) discipline

Parents affect, are affected by, and respond to, their children. At the same time, children are selective in what they hear, see, and do. The impact of parenting interventions depends on the meaning children assign to those interventions, and these meanings are affected by parental attunement with the child and the child’s earlier experiences with the parents. There are some universally harmful practices, which include harsh punishment, lack of psychological support, and, as children mature, lack of autonomy. Parental inputs are effective when children feel that their parents care for them, are sensitive to their needs, understand them, and have their best interests at heart (Grusec & Davidov, 2016).

The role of parents continues to be important through adolescence and young adulthood, though the range and depth of parental control are affected by the child’s extending and more complex engagement in social fields that include school, peers, and, in some cases, work. For example, youth have more teachers than they did in elementary school and they are more likely to interact with peers in more distant and less supervised settings. For many adolescents, the opinions of those peers become more important than those of family during middle adolescence (Berndt, 1979; Blakemore & Mills, 2014), and this happens at a time when youth perception of risk is lower than that of adults. Still, parental monitoring and guidance during adolescence may be particularly important as opportunities for participation in risky behaviors that can affect social,

emotional, cognitive, and health outcomes increase (Brizio, Gabbatore, Tirassa, & Bosco, 2015; Hoeve et al., 2009; NRC & IOM, 2001; Steinberg, 2008; IOM & NRC, 2015).

Adults can have a large impact on the social cognitive development and life course trajectories of adolescents through attachment support, by monitoring their children's behavior and by creating and supporting their children's access to healthy social environments (Blakemore & Mills, 2014; Hoeve et al., 2009; Hoeve et al., 2012; Laursen, Coy, & Collins, 1998). Doing this well requires skill (and in some cases, support). Adolescents want and strive for autonomy, their own identity, and a more important role in family decision making (Beveridge & Berg, 2007). Since parents and children may perceive risk and their children's competence differently (Holmbeck & O'Donnell, 1991), parents who are more accurate in their ability to understand their adolescents' thought processes are likely to experience better outcomes in conflicts (Hastings & Grusec, 1998). In addition, parents who have better relationships with their children also realize better results from monitoring (Abar, Jackson, & Wood, 2014; Hoeve et al., 2009).

Both structural factors and differences among children affect the outcomes of parental behavior. Poverty (discussed elsewhere) is a key structural factor that can affect parents' levels of control. However, many families that struggle with poverty are able provide their children with effective care in the five key relational domains, leveraging both their skills and social capital (Smith, Brooks-Gunn, & Klebanov, 1997; Stack, 1974). At the same time, parents who struggle with poverty may have fewer social, cultural, and liquid financial assets than more affluent parents, who can leverage those resources to improve learning and health outcomes for their children (Matthews & Gallo, 2011; Osher & Chasin, 2016). Although cognitive stimulation and positive parenting (operationalized as warmth and lack of harsh discipline) are both important, these two relational processes may vary in their relative importance for education and mental health. Cognitive stimulation in the home may have a stronger impact on intellectual development than parental warmth and non-harsh discipline, while warm and non-harsh discipline has a greater relative impact on children's behavior and psychological adjustment (Guo & Harris, 2000; Huston & Bentley, 2010; Kohen, Leventhal, Dahinten, & McIntosh, 2008; Yeung, Linver, & Brooks-Gunn, 2002). Parental conflict, which occurs across classes, can be harmful, because it leads to decreased monitoring of children, less expressed warmth and affection, and inconsistent communication and discipline styles (Katz & Woodin, 2002; Troxel & Matthews, 2004).

Parents may need additional support to parent effectively, whether due to stress, motivational issues, skills, or resources (e.g., Semke, Garbacz, Kwon, Sheridan, & Woods, 2010), and there is an array of effective parenting interventions that address some or all of these needs. Examples from early childhood include variations of home visiting, multidimensional treatment foster care, and conjoint behavioral therapy approaches (Avellar & Supplee, 2009; Clarke, Sheridan & Woods, 2010; Leve, Fisher, & Chamberlain, 2009). Examples for adolescents include multi-systemic components that, when delivered with fidelity and in a way that is family driven and culturally competent, can address the multiple social fields that an adolescent may be involved in (Furlong et al., 2012; Osher, Osher, & Blau, 2008; Osher et al., 2011; Sandler, Schoenfelder, Wolchik, & MacKinnon, 2011; Szapocznik, Muir, Duff, Schwartz & Brown, 2015).

Teachers

A substantial body of research converges on the benefits to students of having positive relationships with teachers; these relationships have the same characteristics as positive caregiver attachment relationships: sensitivity, attunement, consistency, trustworthiness, cognitive stimulation, and scaffolded learning. Relationships with teachers and other adults that include adult modeling of appropriate behavior can help modulate children's stress reactivity, as well as provide working models for students (about the process of learning, and about teachers as reliable and trustworthy), and for teachers (about students as learners) (Hamre & Pianta, 2005; Jennings & Greenberg, 2009; Jones, Bub, & Raver, 2013; Mayer, 2014). Students who have close relationships with teachers are more confident and positive in their approaches to learning (IOM & NRC, 2015); positive student-teacher relationships can help students better achieve, become engaged, regulate their emotions, build social competence, and be willing to take on academic challenges. Having a high-quality relationship with a teacher can also protect students who are at higher levels of risk for poor outcomes (Bergin & Bergin, 2009; Berry & O'Connor, 2010; Roorda, Koomen, Spilt, & Oort, 2011), and buffer the effects of victimization and other adversity (Gutman, Sameroff, & Eccles, 2002; Hamm, Farmer, Dadisman, Gravelle, & Murray, 2011; Hamre & Pianta, 2005; Hong & Espelage, 2012; Norwalk, Hamm, Farmer, & Barnes, 2016). A high-quality relationship may also contribute (with other teacher behaviors) to reducing stereotype threat (Steele, 2010).

Teaching is a high-stakes profession in which success depends upon teacher capacity, which is a product of teacher skills and the support provided to teachers. Teachers need the capacity to understand subject matter and pedagogy; organize classes; engage students; provide useful feedback; establish strong, positive, trustful relationships with culturally and linguistically diverse students; and manage their classrooms—factors that involve technical, pedagogical, and social and emotional skills. For example, the inability to manage a classroom can escalate student behavioral problems (Kellam, Ling, Merisca, Brown, & Ialongo, 1998) and affect academic engagement by breaking consistent patterns of academic activities (Osher, Bear, Sprague, & Doyle, 2010). Teacher effects on student outcomes appear to be driven by the quality of their relationships with students and by the extent to which they create opportunities to learn (including time on task), emotional security, student concepts of themselves as learners, motivation, and positive peer interactions (Gregory & Korth, 2016; Wubbels et al., 2016).

Teaching is also a high-stress profession. Teacher stress is affected by the teacher's ecology, which includes the level of principal support, job press, and teacher ability to manage student feelings and behaviors (Brackett, Palomera, Moja-Kaja, Reyes, & Salovey, 2010; Johnson, Kraft, & Papay, 2012; Montgomery & Rupp, 2005). Findings from evaluations of school-based interventions, including ones that monitor students and teacher cortisol levels, suggest that teachers' stress affects their interaction with students, student stress levels, teacher behavior, and student academic outcomes (Flook, Goldberg, Pinger, Bonus, & Davidson, 2013; Jennings et al., 2013). Teacher stress can be reduced through intervention. Mindfulness interventions provide an example. Notably, well-designed research has demonstrated that changing teacher stress levels also reduces student stress biomarkers (i.e., their cortisol levels) (Jennings et al., 2013; Oberle & Schonert-Reichl, 2016; Roeser et al., 2013).

Peers

Peers are important socializing agents for children and adolescents—directly through social learning, and indirectly through their effects on teachers and other adults. Peers socialize each other through social learning, reference group effects, and peer pressure. Peer socialization has been studied at the play group, classroom, school, and community levels (Dishion & Tipsord, 2011; Snyder, Schrepferman, Bullard, McEachern, & Patterson, 2012; Stearns, Dodge, & Nicholson, 2008). Peer interactions can provide opportunities to practice and refine self-regulation, executive functions, interpersonal skills, and communication skills in ways that adult interactions do not. Children respond both behaviorally and neurobiologically to their peers (Kingery, Erdley, Marshall, Whitaker, & Reuter, 2010; Silk et al., 2014; Will, van Lier, Crone, & Güroğlu, 2016). Peer interactions reinforce risk-taking and antisocial behaviors through modeling and reinforcement. Negative peer experiences, including peer victimization and peer rejection, affect and are affected by dysregulation of the stress response, and can therefore have long-term consequences on physical and mental health (Vaillancourt, Hymel, & McDougall, 2013). Peer support can buffer the negative effects of adversities such as being bullied. Teachers and other adults intentionally and unintentionally play a role in structuring peer relationships, and this is affected by their ability to attune to students (Farmer, Lines, & Hamm, 2011; Hamm, Farmer, Dadisman, & Gravelle, 2016).

Scaffolded peer interactions, including social dramatic play, can be important for the development of executive function skills (Blair & Raver, 2014; Center on the Developing Child at Harvard University, 2016; Milteer, Ginsburg, Council on Communications and Media & Committee on Psychosocial Aspects of Child and Family Health, 2012; Vygotsky, 1967). Preschool tends to be the time when young children begin to spend time in groups and begin to develop peer relations outside of one-on-one interactions (Hay, Payne, & Chadwick, 2004). Peer acceptance or rejection at this early stage is formative, and rejection may lead to behavioral disorders later in childhood and adolescence. Making a friend during the early childhood stage appears to protect young children from both later rejection and a tendency toward aggression (Hay et al., 2004). In contrast, young aggressive children who are rejected by peers are at greater risk for later antisocial behavior than similarly aggressive youth who are not rejected (Coie, Terry, Lenox, Lochman, & Hyman, 1995).

As children get older, peer relationships become even more central and complex, and serve as venues to acquire socially relevant behavioral norms, perspective taking, social communication, and concepts of self in relationships (Goldstein, Kaczmarek, & English, 2002; Rubin, Coplan, Chen, Buskirk, & Wojslawowicz, 2005). Peer relationships help adolescents understand themselves and their values, and are therefore important for identity development during this stage (Parker, Rubin, Price, & DeRosier, 1995). At the same time, harmful peer relationships, including experiences with peers who engage in antisocial behavior and victimization, can have negative influences on learning and development. Research has repeatedly found associations between negative peer affiliation and adolescent risk-taking; these associations have sometimes been stronger than other factors in the family, school, and community (Albert, Chein, & Steinberg, 2013; Gardner & Steinberg, 2005).

The Neurobiology of Stress

As with relationships, stress is a process through which the biological and the contextual influence and mutually reinforce each other, literally at the level of the cell (Cole, 2014). When we are threatened, our bodies protect us via a stress response system. The Academy of Pediatrics (AAP) has described three types of stress responses (Burke Harris & Renschler, 2015; Center on the Developing Child at Harvard University, 2016). A positive stress response “is characterized by brief increases in heart rate and blood pressure, and mild or brief elevations in stress hormone levels.” A tolerable stress response “activates the body’s alert systems to a greater degree as a result of a more severe or longer-lasting threat,” and with the presence of buffering relationships likely does not have long-term effects on development. A toxic stress response can occur when stress is frequent, prolonged, and unbuffered. Toxic stress “can disrupt the development of brain architecture and other developing organs” if not buffered by supportive, responsive relationships (Center on the Developing Child at Harvard University, 2016, p. 12). Toxic stress responses can compromise children’s potential to manage the developmental tasks of a sociocultural context, and increase the likelihood of failure to meet the expectations of society for one or several domains of development (Masten, 2014).

Advances in neuroscience allow scientists to understand how stress affects the development of the brain. During the stress response, hormone and neurochemical systems are activated in the body. The HPA system produces cortisol and the sympathetic-adrenomedullary (SAM) system produces adrenaline, both of which help the body prepare for stress (National Scientific Council on the Developing Child, 2005/2014). Stress hormones increase our heart rate, blood pressure, inflammatory reactivity, and blood sugar levels (Center on the Developing Child at Harvard University, 2016). To prepare our minds and our bodies to meet a threat, this “fight or flight” response triggers increased vigilance and alertness and reduces non-essential functions such as complex thinking. These responses can be life-saving in the face of an acute threat but damaging when activated for long periods of time—particularly on the developing limbic system and immune systems of the body (Center on the Developing Child at Harvard University, 2016).

Chronic stress-induced changes in neural signaling patterns and physical brain structures set off a complex biological cascade that affects learning and mental and physical health. Exposure to chronic, unbuffered stress is associated with changes in brain architecture, including smaller volume of the prefrontal cortex and hippocampus, larger volume in the amygdala, altered brain chemistry, and inflammation associated with higher risk of chronic diseases such as obesity, asthma, hypertension, heart disease, and diabetes (Bucci et al., 2016; Burke, Hellman, Scott, Weems, & Carrion, 2011; Danese & McEwen, 2012). The brain, neuroendocrine stress response, cardiovascular system, and immune system can adapt to early adversity even before a child is born (Evans, Kim, Ting, Teshler, & Shannis, 2007; Johnson et al., 2016). In these ways, chronic stress becomes biologically embedded in a child (Bucci et al., 2016; Walker, 2016).

A dysregulated stress response system is one of the few systems of the body that can affect the development of all four structures—brainstem, diencephalon, limbic system, cortex—in the brain and, in particular, the integration of these structures (Perry & Szalavitz, 2006; Siegel, 2012; Teicher et al., 2016). Indeed, research on the consequences of developmental trauma has found that the major neural impact on the brain is the impairment in the growth of the integrative

regions that promote the connectivity of the connectome—in other words, the integrative regions that promote neural integration (Di Martino et al., 2014; Teicher & Samson, 2016; Teicher et al., 2016). These studies show, for example, impairments in the growth of the corpus callosum, the hippocampus, and the prefrontal cortex—regions that link differentiated areas to each other. These impairments may be the origin of the process by which trauma (itself an impairment to relational integration) leads to impaired neural integration, which is needed for self-regulatory functions to develop (Teicher & Samson, 2016). Recent reports from the Human Connectome project suggest associations between a range of measures of well-being and the interconnectivity of the connectome—i.e., how linked the differentiated areas of the brain are to each other (Collins, 2015; Smith et al., 2015).

Learning to cope with stress and adversity is an important part of healthy child development, and when the stress response is activated within the context of strong, supportive, buffering relationships, it can be brought to baseline quickly and long-term physiological effects blocked entirely. When this happens, children can develop a positive stress response. When stress is unbuffered, children’s development and coping can become overwhelmed. Under these circumstances, children’s stress responses move rapidly to fear, defense, and self-protection (Center on the Developing Child at Harvard University, 2016).

Increasing and cumulative stress, as is experienced by children who face a build-up of “adverse childhood experiences” (ACEs), can be “toxic” to development, health, and learning. The common definition of ACEs involves stressful or traumatic events experienced before age 18 that fall into three broad domains: abuse, neglect, and household dysfunction (Burke Harris & Renschler, 2015). The traditional ACE categories that have informed much of the work in this area are physical, emotional, and sexual abuse; physical and emotional neglect; divorce or separation; mother treated violently; substance abuse; parental mental illness; and incarceration of a relative (Bucci et al., 2016). In recent related work, experts have expanded these categories to include ecological risk factors that include community stressors; personal victimization; economic hardship; hunger; disturbances in family functioning; loss of a parent; challenging peer relationships; discrimination; poor health; overemphasis on achievement; and stressful experiences at school, with the child welfare system, and with juvenile justice (Burke et al., 2011; Luthar, Barkin, & Crossman, 2013; Wade, Shea, Rubin, & Wood, 2014); these risk factors are related to macrosystem factors such as poverty and institutionalized racism (Cutler & Glaeser, 1997; Lee, 2010; Spencer, 2007).

ACEs cut across socioeconomic lines, and the original empirical work on ACEs used a largely middle class sample (Felitti et al., 1998). Later research employed a more diverse sample (Giovanelli, Reynolds, Mondri, & Ou, 2016). Poverty places individuals at greater levels of risk for ACEs due to the myriad related adversities (Giovanelli, et al., 2016; Mersky, Topitzes, & Reynolds, 2013; Shonkoff et al., 2012; Slopen, McLaughlin, & Shonkoff, 2014; Thompson & Haskins, 2014; Wade et al., 2016), but ecological risk factors that include and extend beyond poverty affect how children experience and respond to ACEs. Together, these factors may contribute to the finding that in some urban school districts up to 70 percent of children have had personal exposure to violence, and 80 percent have been direct witnesses to violence (PTSD in our nation’s classrooms, 2015). For these children, exposure is less of a one-time “incident,” and more of a “constant presence,” or a trigger activating a toxic stress response. Children adapt to

these settings—in ways that are sometimes adaptive, sometimes maladaptive, and sometimes a mix (Bennett & Olugbala, 2010).

ACEs produce a dysregulation of the stress response, the recovery and healing (from) which is context-dependent (Park & Schepp, 2015; Perry & Szalavitz, 2006). Stable, responsive relationships with adults buffer children from developmental disruption, help build key capabilities, and enable them to manage stress and thrive in the future (Bennett & Olugbala, 2010). Positive experiences, supportive relationships, and adaptive skills build the foundation for lifelong resilience (Center on the Developing Child at Harvard University, 2016).

Impact of Adversity on Health

There is a strong and graded link between childhood adversity and long-term health outcomes, including several major categories of chronic disease, lung cancer, diabetes, various autoimmune diseases, depression, and elevated rates of high-risk behavior (Felitti et al., 1998). These associations, which stem from a dysregulated stress response and inflammatory hormones such as cortisol and cytokines, can reshape brain structure and function and immune system efficiency (Walker, 2016). The most sobering statistic relates to premature mortality in individuals affected by multiple traumas: individuals with six or more ACEs had a life span that was shorter by an average of 20 years (Felitti et al., 1998).

Over time, dysregulation in the stress response can affect biological functions associated with immune function, growth, cardiovascular function, metabolism, and sleep (Center on the Developing Child at Harvard University, 2016). Chronic stress is associated with chronic mental health conditions, which have replaced chronic physical illness in the top five most significant pediatric health issues that affect learning (Walker et al., 2007). These include mood syndromes, such as depression, anxiety, and somatic disorders; PTSD; and learning difficulties such as ADHD (Johnson, Riley, Granger, & Riis, 2013; Luthar et al., 2013; Shonkoff et al., 2012).

There is also evidence of a compounding effect of trauma that has been found to increase the risk of health, social, and emotional problems associated with a toxic stress response (Felitti et al., 1998). Among the pathways, there is the potential for damage to the ventral tegmental area (VTA) of the brain, which is a dopamine pathway involved in motivation, reward, and “numbing” sensitization to risk, contributing to dramatic increases in risk-taking behaviors like substance abuse and suicidal behavior (Brenhouse, Lukkes, & Andersen, 2013; Hosking & Winstanley, 2011; Krishnan et al., 2007; Lovic et al., 2013; Wei et al., 2012). Chronic stress may have a direct impact on physical health and well-being, but it also is associated with unhealthy self-modulation adjustments such as smoking and substance misuse, as well as social isolation, unemployment, and inactivity, all of which contribute to poor physical health and well-being (Batley, 1994; Brunner & Marmot, 2006; Davidson, Devaney, & Spratt, 2010; Felitti & Anda, 2010; Perry & Szalavitz, 2006). Research shows that, for middle class youth, chronic stress is related to drug and alcohol abuse, internalizing and externalizing symptoms, somatic disorders, and low rates of female abstinence (Luthar et al., 2013).

Over the long term, early intervention has powerful implications for educational outcomes and healthcare costs. Studies have revealed that high-quality early intervention can bolster later life educational outcomes, yielding a return on investment in excess of the stock market (Campbell et

al., 2014; Heckman, Moon, Pinto, Savelyev, & Yavitz, 2010a, 2010b). Chronic diseases, as a category, account for roughly 86 percent of U.S. healthcare expenditures, despite being preventable with early identification and proper treatment (Centers for Disease Control and Prevention, 2016). Research reveals improved health outcomes in some of the costliest categories of chronic non-communicable illness: cardiovascular and metabolic disease (Campbell et al., 2014; Heckman et al., 2010a, 2010b).

Impact of Adversity on Learning

The structure and function of brain centers affected by chronic stress, in particular the limbic system, are modulated by the activities of the HPA axis, and are involved in key learning systems, including self-regulation, attention, memory, stress reactivity, and language (Essex et al., 2011; Gunnar & Quevedo, 2007; Tottenham & Sheridan, 2009). Chronic stress is associated with impairments in the functioning of these systems even before children start school. In the absence of intervention, lower cognitive stimulation in the home and anxiety can significantly affect children's school and learning readiness (Center on the Developing Child at Harvard University, 2016; Shackman et al., 2006; Hackman & Farah, 2009; Raver, 2004; Walker et al., 2011).

Self-regulation is one of the most important capabilities vulnerable to stress and adversity (Blair & Raver, 2012; Center on the Developing Child at Harvard University, 2016; Goodman, Miller, & West-Olatunji, 2012). Self-regulation is affected by the level and frequency of stress, the availability of protective buffering supports, and underlying health and mental health issues (Center on the Developing Child at Harvard University, 2016). As children get older, previous developmental challenges can accumulate and set off a cascade of challenges to learning, both directly and through transactions with others at school (Blair & Diamond, 2008). This results in a continuum that ranges from reactive or impulsive behavior at one end to proactive or goal-directed behavior at the other (Center on the Developing Child at Harvard University, 2016; Perry, 2001).

Children's responses to chronic stress, such as hypervigilance, defiance, and a compromised ability to regulate behavior, can affect how peers and teachers interact with them, further affecting learning readiness and cognitive engagement. For example, young children who lack self-regulation are less likely to develop supportive relationships, engage in school, and pay attention in class, and they are more likely to withdraw and to develop antisocial behavior as they grow older (Cole et al., 2013; Raver & Knitzer, 2002). Absent supportive relationships, new traumatic experiences may re-traumatize children and result in school disengagement and failure (Bethell et al., 2014). This feedback loop can result in a prolonged reinforcement of a dysregulated stress response, elevating the risk for other mental, emotional, behavioral, health, and academic problems (Center on the Developing Child at Harvard University, 2011).

Overcoming the effects of adversity on learning requires attention to both reducing sources of stress and strengthening capabilities in children and the adults caring for them. Resilience can be socially constructed (Kendziora & Osher, 2004; Ungar, 2004a, 2004b) and developed (Masten, 2007), and practices that follow theories of interpersonal neurobiology, such as mindfulness practices, create opportunities to reorient patterns of connectivity and adaptation well into adulthood (Siegel, 2013). Classrooms and schools designed to be rich in interpersonal connection

and to promote individual developmental assets can change the trajectory of children's learning and their lives.

Intergenerational Transmission of Adversity

The role of intergenerational transmission of both adaptive and maladaptive systems is rooted in biological and social processes that begin even before the child is born, when the neurons in the brain that build the foundation for synaptic connections are still developing (Halfon et al., 2001; Shonkoff & Phillips, 2000). These processes are related to changes in maternal brain structure and function, including elevated stress hormones and oxytocin levels (Kim et al., 2016; Walker et al., 2011). These changes, in turn, influence the development of the fetus and the attachment relationship in infancy (Center on the Developing Child at Harvard University, 2016; Kim et al., 2016), which is dependent on sensitive responsiveness to the child's signals (Fearon et al., 2006; Feldman, 2015). In the first year of life, the physical and behavioral interactions between caregiver and infant trigger a process of bio-behavioral synchrony (i.e., sensitivity to each other) that involves the release of oxytocin and physical contact. This process builds a child's capacity for social development and mediates socialization, stress management, emotion regulation, and well-being (Feldman, 2015; Galbally et al., 2011).

Caregiver adversity can disrupt this synchrony by weakening the emotional response system of the brain and lowering the caregiver's sensitivity to the child's social cues (Kim & Watamura, 2015). Disruptions are linked to social psychopathologies, including autism, social anxiety, depression, and schizophrenia (Feldman, 2015). As children grow, exposure to trauma and adversity in the home and in other settings continues to affect biology and behavior. Children who experience trauma and adversity show biomarker and brain structure and activation differences that increase their vulnerability to risk behaviors (e.g., being a perpetrator or victim of violence, suicide, drug addiction) later in life (Dixon, Browne, & Hamilton-Giachritsis, 2005; Park & Schepp, 2015; Patterson, DeBaryshe, & Ramsey, 1990). Some children exposed to trauma, such as parental mental illness or alcohol abuse, physical or emotional neglect, or violence, show cognitive impairments, attention problems, language deficits, academic difficulties, withdrawn behavior, externalizing problems, mental health problems, and difficulty with interpersonal relationships (Center on the Developing Child at Harvard University, 2016; Park & Schepp, 2015).

Early dysregulation in emotions, cognition, and behavior at school entry can contribute to unsupportive interactions that reinforce negative beliefs about belonging and intelligence, and questions about the purpose of school itself. Absent appropriate intervention with both the child and school staff, these factors can contribute to disciplinary problems, grade repetition, dropping out, incarceration, substance abuse, mental disorder, and long-term physical health problems (e.g., diabetes, lung cancer), all of which can place the next generation at risk (Chandler, 2016; Hawkins, Catalano, & Miller, 1992; Kellam & Rebok, 1992; Kellam et al., 2008; NRC & IOM, 2009).

Children can adapt to hostile environments in ways that can undermine learning and support their involvement in unhealthy or high-risk behaviors (Crick & Dodge, 1994). Some of the proximal contributors to chronic stress and the intergenerational transmission of adversity are the family, the neighborhood, and the school. For instance, neighborhood disadvantage is associated with a

build-up of biological “wear and tear” (i.e., allostatic load) over the life course, especially in men (Danese & McEwen, 2012; Fisher, Busch-Rossnagel, Jopp, & Brown, 2012; Geronimus, Hicken, Keene, & Bound, 2006; Gustafsson et al., 2014).

Parents and families can make a positive difference—for example, through monitoring and authoritative discipline—even under disadvantageous conditions. Research documents how parents leverage their social and cultural capital to promote adaptive behavior, and prevent engagement in high-risk behavior and buffer its effects (Furstenberg, 2003, 2004; Furstenberg, Cook, Eccles, Elder, & Sameroff, 1999). However, this is not possible for all parents, and research documents its effects: ineffective parental behaviors and disruptive family management styles mediate the onset of health-compromising behaviors such as smoking and obesity (Anderson, Butcher, & Levine, 2003; Park & Schepp, 2015; Patterson et al., 1990). Examples are a lack of supervision of a child’s nutrition and energy intake, harsh parenting, irritability, and lack of supervision. These outcomes are related to macrosystem factors. Education and health disparities, housing segregation, economic disadvantage and the lack of sufficient support for families contribute to the increased likelihood of caregivers’ poor mental and physical health outcomes, intimate partner violence, malnutrition, and exposure to known toxins such as tobacco, alcohol, and mercury—during pregnancy, but even dating back to the mother’s own childhood (Cutler & Glaeser, 1997; Jargowsky, 1996; Massey, 1985).

Policies and structural factors contribute to the intergenerational transmission of adversity. For example, the disproportionately high level of arrests of African-American males (Chandler, 2016) creates adverse childhood experiences and affects (1) children of incarcerated parents, through such factors as the absence of supportive males in the household and male role models in the community, but also (2) the students who go to school with them (Foster & Hagan, 2015; Hagan & Foster, 2012). Both students who have incarcerated parents and students who attend schools with children who have incarcerated parents experience poorer behavioral and academic outcomes (Eddy, Cearley, Bergen, & Stern-Carusone, 2014; Haskins, 2016; Murray, Farrington, & Sekol, 2012; Parke & Clarke-Stewart, 2001; Turney & Haskins, 2014). Similarly, the disproportionate use of exclusionary and harsh discipline in schools can affect lifelong outcomes for black males, including their beliefs about themselves, increased disengagement from school and dropping out, increased likelihood of fathering a child in adolescence, diminished likelihood of postsecondary school attainment and employment, and diminished ability to support a family emotionally and financially (Aizer & Doyle, 2013; American Psychological Association Zero Tolerance Task Force, 2008; Bertrand & Pan, 2011; Osher, Woodruff, & Sims, 2002; Skiba et al., 2011; Skiba, Michael, Nardo, & Peterson, 2002). These factors, in turn, affect generations to come (Foster & Hagan, 2015; Osher et al., 2002; Pettit & Western, 2004; Wakefield & Uggen, 2010).

Preventing the negative impacts of chronic stress on children and the adults who care for them can prevent the intergenerational transmission of adversity. The societal cost and benefit is enormous, and therefore requires intervention at the level of family, society, and policy, including culturally competent and family-driven approaches (Johnson et al., 2013; Osher, Sprague, et al., 2008; Osher & Osher, 2002). Evidence suggests that well-designed developmental contexts, with the right intervention and prevention strategies, can provide the level of support, enrichment, and stimulation needed to buffer the effects on adults and children

of chronic stress and other ecological challenges (Cox et al., 2010; Gestsdottir, Urban, Bowers, Lerner, & Lerner, 2011; Klika & Herrenkohl, 2013; Sawhill & Karpilow, 2014).

Ecological Contexts of Development: Illustrative Examples

Human behavior and development take place in nested ecological systems, which affect development both directly and indirectly (Bronfenbrenner & Morris, 2006; Garbarino, 1992). Ecological contexts include settings that both (1) place individuals at risk and (2) provide assets that can protect individuals from those risks, buffer their effect, or promote positive learning and development. Bronfenbrenner (1989, 1994) identified nested ecological systems:

- *Microsystem*—Development takes place within social contexts where the developing child directly interacts with others face to face (e.g., home and school)
- *Mesosystem*—Development is affected by the interaction between and among primary systems (e.g., between the school and families)
- *Exosystem*—Development is affected by events that are not directly connected to the child but that affect what happens in the microsystem settings (e.g., the effects of job stress on parents)
- *Macrosystem*—Development is affected, sometimes directly and sometimes indirectly, by cultural and structural factors that affect the microsystem, mesosystem, and exosystem (e.g., the effects of institutionalized racism)
- *Chronosystem*—Development is affected both immediately and ultimately by historical changes (e.g., the effects of the great depression) (Elder, 1998).

Ecological contexts encompass an array of environments and societal structures that include schools, families, poverty, racism, and the juvenile justice system (Durlak, Weissberg, & Pachan, 2010; Evans, 2004; Greenberger, Chen, & Beam, 1998; Holman, Garfin, & Silver, 2014; Osher et al., 2014; Steinberg, 2009; Repetti, Taylor, & Seeman, 2002; Tseng & Seidman, 2007; Waldfogel, Craigie, & Brooks-Gunn, 2010; Zimmerman, Salem, & Maton, 1995). Ecological contexts and the individuals embedded in the contexts are characterized by continual interactions within and across levels and by great variation of internal as well as external risk and protective factors. In Margaret Beale Spencer's language: "Risks and protective factors may take a variety of forms given variations in race/ethnicity, gender, faith community, body type, immigration status, skin color, privilege, health quality or disability status, cultural traditions, social class, and temperament. All are linked to the character of the context and the individual's history of experiences and even the group's history in the nation" (Spencer, 2007, p. 840). For each individual there is a net level of stress experienced that is the effect of the stresses experienced and the supports available to deal with those stresses (Spencer, 2007).

Research on epigenetic adaptation illuminates the effects of microsystems on development (e.g., Cole, 2014; Slavich & Cole, 2013). Sociological studies show how contexts (e.g., exosystem contexts such as job or neighborhood stressors and macrosystem contexts such as racism) relate to parental behavior (e.g., Brody et al., 2006; Brooks-Gunn, Duncan, Leventhal, & Aber, 1997; Kohen et al., 2008; Odgers et al., 2012; Perkins & Sampson, 2015). Prevention science provides

empirical evidence of the importance of contextual factors by showing that intervention-related changes in contexts are related to intervention-related changes in outcomes, as well as how local contexts can shape the successful implementation of interventions (e.g., Dymnicki et al., in press; Han & Weiss, 2005; Jones, Brown, & Aber, 2008).

Developmentally rich social contexts provide enriching opportunities and healthy relationships with adults, practice and reinforcement of foundational competencies, and opportunities to take on leadership roles and participate in collaborative and productive peer interactions. As with other developmental contexts, structural and social features of schools and early childhood educational settings can heighten human potential and buffer the effects of poverty and other adversity on development through positive relationships and by direct targeting of self-regulation, executive functions, and social and behavioral skills (Jones et al., 2016; Osher et al., 2014; Osher et al., 2015). Developmentally unsuitable contexts exacerbate stress; hinder the reinforcement of foundational competencies; and impel maladaptive behaviors by failing to foster healthy relationships with adults, lacking developmental fit, limiting enrichment and stimulating experiences, and reducing the chances of interacting with peers who are positive influences (Farmer, Dawes, Alexander, & Brooks, 2016; Jones & Molano, 2016; Osher et al., 2002). Educational settings, for example, that are not engaging, motivating, safe, and filled with attuned, committed adults and opportunities for enriching experiences can place children and youth at risk or amplify existing risk (Osher et al., 2014; Cairns & Cairns, 1994; Kellam et al., 2008). If a negative context is recurring and continuous, the brain ceases to recognize it as abnormal and habituates to it (Siegel, 1999).

Complex interconnections between and within ecological contexts are explored in Spencer's phenomenological variant of ecological systems theory (2007), and have been documented in longitudinal studies of youth development (e.g., Alexander, Entwisle, & Olson, 2014). For example, children and youth cope with stress and adversity in ways that may be adaptive or maladaptive. The adaptations young people make to one context carry over to other contexts in ways that can be beneficial or harmful. The result will depend on the degree to which the contexts are aligned with each other, as well as the capacity of adults to understand the origin of the behavior and to provide the child with attuned, developmentally appropriate, and culturally competent support (Ungar, 2004b). This support can help children and youth to, for example, develop a capacity to code switch, which can help them adapt to environments that have differing behavioral expectations and pose differing challenges (Jakonen, 2016; Molinsky, 2007; Sharkey, 2006).

The following sections discuss three key microsystem contexts (families, early care and childhood settings, and schools) and two macrosystem factors (poverty and racism).

Microsystem Contexts

Bronfenbrenner (1994) defined a microsystem as “a pattern of activities, social roles, and interpersonal relations, experienced by the developing person in a given face-to-face setting ... that invite, permit, or inhibit engagement in sustained, progressively more complex interaction with, and activity in, the immediate environment” (p. 39). Microsystems include families, early care and learning settings, schools, peers, religious institutions and faith communities, afterschool programs, youth development programs, drop-in centers, recreational activities,

camps, cultural institutions and settings, gangs, health institutions, social service institutions, and juvenile justice institutions. Each of these provides opportunities for social learning and can affect social, emotional, and cognitive development through the quality of relationships and the extent to which children and youth experience safety, connectedness, engagement, challenge, and opportunities to develop competencies and access supports—both positively (e.g., enrichment and social and emotional learning) and negatively (e.g., bullying and engagement in high-risk behaviors). The three most universal or normative contextual settings are families, early care and childhood settings, and schools.

Families

Research on families has traditionally focused on the biologically linked nuclear family, with a particular emphasis on the role of parents—especially the mother. However, family configurations vary, and there are many different players who provide parent-like support. Regardless of family structure, family members fulfill common functions—they provide bonding, safety, and connection.

Family structure has become more fluid and heterogeneous in the last half century. In 2014, 26 percent of children younger than age 18 lived with a single parent—up from 9 percent in 1960 (Pew Research Center, 2015). Parents may be monoracial or interracial, may be same-sex or different-sex, and may be adoptive, biological, or a mixture of both (Powell, Hamilton, Manago, & Cheng, 2016). Parents also vary in terms of age and culture. Children’s residences also vary; some children live in foster care or custodial care as a result of caregiver maltreatment and abuse, adjudication or conviction, disability or incapacity, incarceration, or death.

The factors that determine successful parenting are not family structure, but rather the family’s resources, social supports, emotional climate, and stability, and the quality of caregiver-child interactions and relationships—the prerequisites for successful family functioning that provide bonding, connection, and safety necessary for healthy development (Grusec & Davidov, 2010; Patterson & Hastings, 2007). Housing features, such as insufficient space or privacy and environmental toxins, and housing insecurity are examples of resource-related factors that can affect the quality of social, emotional, and cognitive developmental context insecurity (Bassuk et al., 1997; Diette & Ribar, 2015; Kipke, Simon, Montgomery, Unger, & Iversen, 1997; Matthews & Gallo, 2011; Wigle, Arbuckle, Walker et al., 2007; Wigle, Arbuckle, Turner et al., 2008). These resource-related factors can contribute to increases in student mobility and challenges with self-regulation (e.g., Herbers, Reynolds, & Chen, 2013; Masten & Tellegen, 2012). Although family structure does not drive impacts directly, in some situations, family structure can contribute to a caregiver’s ability to parent. For example, all other factors being equal, it is easier to spend time with and monitor children in two-parent homes. Single parents, on the other hand, typically have less time to spend with their children because they often juggle more competing demands for their time (Carlson & Corcoran, 2004; Cenege & Brewer, 2013; Grusec & Davidov, 2010). While the challenge is greater, many single parents use their personal and social assets to address this challenge—for example, by leveraging support from their families and social networks (Gerstel, 2011; Perry-Jenkins, Newkirk, & Ghunney, 2013).

Although research focuses primarily on parents, other household members play a key role. Three key players are grandparents, siblings, and other kin. In 2010, 7 percent of children lived in

households headed by a grandparent (U.S. Census Bureau, 2010). Seventeen percent of these children living with grandparents were being raised in homes with no biological or adoptive parent present. Some of these children were children of incarcerated parents, who often face social, emotional, and academic challenges (Eddy et al., 2014; Parke & Clarke-Stewart, 2001). Grandparents can offer important support systems, including stability for parents and their children in times of need (Powell, Hamilton et al., 2016). Research on grandparents is limited. Some research identifies behavioral or cognitive challenges in children living with grandparents (e.g., Pittman, 2007; Pittman & Boswell, 2007; Smith & Palmieri, 2007), but these findings may be confounded with the effects of children's experiences with parents, as in the case of children whose parents are incarcerated (e.g., Arditti & Salva, 2015; Murray et al., 2012; Ruiz & Kopak, 2014). The preponderance of available research on the effects of grandparents suggests that they can be positive influences on their grandchildren (Powell, Hamilton et al., 2016). Siblings can also be important sources of support. As children, siblings may spend more time with one another than with their parents (Lucey, 2010), and they can be strong influences on each other's development (Brody, Kim, Murry, & Brown, 2003; Dunn, 1988; McHale, Updegraff, & Whiteman 2012). Sibling effects can be positive or negative, can be direct or indirect (through effects on parents and teachers), and may affect social, emotional, and cognitive development. Kin who do not live in the household may affect family capacity and extend its boundaries by providing social, cultural, and financial capital (Stack, 1974).

Effective ecological approaches to intervention exemplify ways of reaching out to the extended family network and to other social networks (Henggeler & Sheidow, 2012). For example, high-fidelity wraparound leverages the role of grandparents, siblings, other kin, and friends in supporting healthy family functioning and child development in order to provide immediate as well as sustainable social supports (Bruns, Pullmann, Sather, Brinson, & Ramey, 2015; Kendziora, Bruns, Osher, Pacchiano, & Mejia, 2001; Suter & Bruns, 2009).

Early Care and Childhood Settings

Early care and education settings are, next to the family, the most important social contexts in which early development unfolds. Child care experiences are enormously important. Child care settings affect development through interactions with the child's individual developmental attributes and experiences in the child's home (Bradley & Vandell, 2007). Early childhood education (ECE) programs provide young children with opportunities to learn and grow during a highly sensitive period of brain development. Research demonstrates that children tend to enter early care within the first few months of life and spend approximately 36 hours a week there, and that parents change arrangements fairly frequently prior to school entry due to changes in maternal employment (Phillips & Lowenstein, 2011). Experiencing quality ECE is a function of access and economic status, and research suggests that the magnitude and sometimes the direction of child-care effects on development may be markedly different for children from higher risk contexts (Berry et al., 2014).

ECE quality varies around an average that is mediocre with regard to the capacity to promote positive developmental outcomes (IOM & NRC, 2015; Phillips & Lowenstein, 2011). Several factors are implicated in this variation. The big driver of quality is the adult-child interaction, as ECE providers are important influences on the development of young children (IOM & NRC, 2015; Phillips & Lowenstein, 2011). Adult-child interactions are a product of provider quality,

training and preparation, staff turnover, and staffing ratios. Investment in a well-recruited, well-trained, and well-compensated staff is important (National Scientific Council on the Developing Child, 2007), as is teacher training and support. Another factor that affects (and reflects) quality is the high rates of suspensions and expulsions from ECE programs (U.S. Department of Education, Office of Civil Rights, 2014): Expulsion rates are 13 times higher in federally funded child care centers than in K–12 classrooms (Gilliam & Shahar, 2006). These rates are particularly high among African-American children, who are 3.6 times more likely to receive one or more suspensions than white preschoolers, and for boys, who are 3 times as likely to be suspended as girls. While there is some evidence to suggest that mental health consultation in early childhood settings can help staff address students who are behaviorally troubling (Brennan, Bradley, Allen, & Perry, 2008), implicit bias has been implicated as a cause (Gilliam, Maupin, Reyes, Accavitti, & Shic, 2016; NAEYC, 2016).

Effective child-care settings provide social and structural supports needed for children to learn and grow. They provide ample opportunities for frequent, warm, and responsive interactions with adults through language-rich, relationship-rich, and safe learning environments (Center on the Developing Child at Harvard University, 2016; Espinosa, 2002; Hamre & Pianta, 2005). This often includes experiential learning (such as pretend play), which is thought to enable children to incorporate and use knowledge (Blair & Raver, 2014). Pretend play, when combined with other instructional strategies, such as child-centered classrooms and playful learning that brings joy to the learning process, is an important context for learning and development in early childhood (Lillard et al., 2013; Snow, 2016).

An increasing body of research suggests that child care settings that have a clear focus on social and emotional learning and on developing self-regulatory skills (including executive functions) can build greater school readiness, and that these efforts can be enhanced by more intensive, targeted social interaction and social and cognitive skills training (Bassok, Latham, & Rorem, 2015; Diamond & Lee, 2011; Flook, Goldberg, Pinger, & Davidson, 2015; Schindler et al., 2015). Evidence from the evaluation of Tools of the Mind, for example, suggests that among kindergarten-age children in high-poverty schools, practices that encourage self-regulatory skills (here including teacher-led scaffolding and peer interactions, weekly individualized learning plans, child-directed activities, sociodramatic play, and a comprehensive curriculum) improve executive functions, attention, and stress-response physiology, as well as academic ability (Blair & Raver, 2014).

While interventions are important, science points to two key characteristics of high-quality ECE that can help meet children’s needs. These are human factors that promote language-rich environments and warm and responsive adult-child interactions to build “receptive and expressive language and interpersonal skills,” and structural factors such as high adult-child ratios, small group sizes, developmentally appropriate curriculum, and safe physical environments to support positive interactions and effective instruction (Center on the Developing Child at Harvard University, 2016, p. 25).

Schools

Student achievement is affected by the interaction between individual student and teacher attributes and the conditions of learning and teaching (Osher et al., 2014). Learning is a social

process, and has affective, phenomenological, and cultural dimensions. Learners differ in their experiences, strengths, and needs. Relationships between and among teachers and students, which are shaped by their social and emotional competencies and the cultural congruence of their interactions, affect all learners' academic engagement, learning, and performance.

Schools create positive conditions for learning when students experience emotional, intellectual, and physical safety; connectedness; support; challenge; engagement; respect; agency; learner-centered instruction; and learner-friendly classrooms and facilities (Arndt, 2012; Berkowitz et al., 2016; Blair, 2002; Blair & Razza, 2007; Cornelius-White, 2007; Osher & Kendziora, 2010). Schools can address the specific needs of the most vulnerable children to improve and leverage their strengths, while simultaneously creating conditions and opportunities that support the engagement and learning of all children, through targeted universalism (Powell, 2008).

Emotionally close, trustful relationships with nurturing adults and high teacher responsiveness foster positive development and learning (Hamre & Pianta, 2005; Ladd, Birch, & Buhs, 1999; Jones et al., 2013). Teachers' explicit expression of high expectations and belief in students' capabilities correlate with successful achievement (Osher & Kendziora, 2010; Steele, 2010). Positive relationships with teachers help promote self-regulation, which supports children's classroom behavior, which in turn contributes to positive classroom climates. Positive classroom climates are associated with a host of student skills and dispositions, including greater cognitive and academic competence, self-esteem, school satisfaction and engagement, and less acting out, as well as positive school-oriented behaviors, including higher attendance (Hamre & Pianta, 2005). These same processes occur outside the classroom with other school staff.

Strong relationships with adults and positive classroom climates can counter the effects of chronic stress. Conversely, negative interpersonal transactions that include infrequent positive teacher support and attention during academic learning, teacher praise, and opportunities to respond (Gunter & Continuo, 1997; Sutherland & Morgan, 2003; Sutherland & Oswald, 2005; Van Acker, Grant, & Henry, 1996; Wehby, Symons, & Shores, 1995), as well as teacher stereotype priming (Steele, 2010), can increase stress and reduce the potential for buffering. Heightened stress and anxiety can reduce working memory, and lead to trouble paying attention in class, completing work, and inhibiting behavior, especially for students with repeated difficulty regulating behavior in social situations in school and at home. These social and classroom behaviors lead to negative perceptions and expectations on the part of both the student and the teacher regarding the student being poorly regulated and unable to learn. This can contribute to negative reinforcement, negative student self-identities, student learned helplessness, and a teachers' sense of inefficacy (Mayer, Davis, & Schoorman, 1995; Patterson et al., 1990). Psychological distress or appraisals of events as stressful or challenging are, in turn, associated with impairments in self-regulation (Duckworth, Kim, & Tsukayama, 2013; Monroe, 2008).

Classroom climates characterized by conflict aggravate this feedback loop and are associated with poor peer relations, more aggression, and poorer academic focus (Jones et al., 2013; Jones et al., 2008; Osher et al., 2014). Over time, negative experiences in school can lead children to withdraw and become less motivated, leading to greater gaps in school performance and achievement (Spier, Garibaldi, & Osher, 2012; Ursache, Blair, & Raver, 2012). This process of disengagement can contribute to poor attendance and grades in core classes, repeating grades,

and discipline problems, including suspension, that can, in turn, lead to dropout and school failure (Kendziora et al., 2014).

Instructional supports that foster enjoyment of learning and strategies to promote social and emotional competencies in the classroom can lead to better regulation, positive self-representations, and more positive responses from others (Blair & Diamond, 2008; Hamre & Pianta, 2005; Murray et al., 2015). Classroom management strategies that promote the use of language and positive interactions as a way to increase engagement and maintain appropriate levels of arousal, as well as intentional practice with self-regulation skills, are conducive to the development of emotion regulation, executive functions, and academic skills (Ursache et al., 2012; Zelazo et al., 2016). For example, reflective reprocessing of information prior to responding is thought to be necessary for the development of executive functions, and can be encouraged through instructional practices (Zelazo, 2015). Research shows that training of executive function skills through meditation, problem-solving tasks, and video gaming can induce changes in brain structure and function (including neural activation patterns, resting state functional connectivity, and neurochemistry), in behavior, and in the likelihood that executive function skills will be activated in the future (Blakemore & Bunge, 2012; Galinsky et al., in press; McDermott, Westerlund, Zeanah, Nelson, & Fox, 2012; Schmitt, McClelland, Tominey & Acock, 2015; Stevens & Bavelier, 2012).

Institutional practices such as exclusionary and disciplinary policies and practices run counter to strategies to support young people's development, particularly when there are discipline disparities. The use of exclusionary discipline contributes to student disengagement, grade retention, dropout, and arrests (Fabelo et al., 2011; Mallett, 2015). Exclusionary discipline can also have negative consequences for learning and engagement of students who are not suspended (Hagan & Foster, 2012; Perry & Morris, 2014; Wakefield & Wilderman, 2013). Harsh discipline also can increase young African-American women's vulnerability to harassment, sense of safety, and disengagement from school (Crenshaw, Ocen, & Nanda, 2015). Even one suspension increases the risk of repeating grades, school dropout, and incarceration, and reduces the likelihood of postsecondary success (Arcia, 2006).

Disproportionalities are pronounced in schools and child-serving systems for children and families of color, and these contribute to disproportionately poor outcomes for children and youth (Chapin Hall Center for Children, 2008; Hines, Lemon, Wyatt, & Merdinger, 2004)—as does the excessive use of seclusion, restraint, punishment, institutional placement, and placement changes (Bullard, Fulmore, & Johnson, 2003; Burrell, 2013; Fox, 2004). These problems start early. For example, the Civil Rights Data Collection reported that 48 percent of African-American preschool students have been suspended (U.S. Department of Education, Office of Civil Rights, 2014).

But school leaders can shape physical structures, policies that segregate and group students, rules, norms, and social relations to reduce disproportionality and opportunities for victimization, bullying, violence, racism, and intolerance. School leaders can engender a sense of safety, trust, and support; encourage prosocial behaviors; (Eccles et al., 1993; Henry, 2008; Henry, Farrell, Schoeny, Tolan, & Dymnicki, 2011; Osher et al., 2014).

These same ideas apply to the other child-serving systems, which interact with schools and also affect children's learning outcomes (either at the level of the microsystem or mesosystem). A growing body of research suggests that schools should be a part of community-wide collaborative efforts to provide developmental consistency across contexts and address the mental health needs (including help with stress and coping) and physical needs of children to facilitate learning (Osher, 2002; Osher & Chasin, 2016; Walker et al., 2011). Research documents and policy calls for a focus on well-being and positive youth development (Bonnie, Johnson, Chemers, & Schuck, 2013; Children's Bureau, 2014; Interagency Working Group on Youth Programs, 2016).

Many staff in these agencies are challenged by adult stress and capacity, cultural and linguistic competence, lack of attunement to the development needs of children, and an inability to respond to the impacts of trauma on children and adults (Baird & Kracen, 2006; Nelson-Gardell & Harris, 2003; Regehr, Hemsworth, Leslie, Howe, & Chau, 2004). Adults, both in schools and other agencies, need effective preparation, training, and support. They, too, benefit from respectful and supportive leadership, and from strategies that address stress and provide guidance on managing classroom and other setting dynamics (Brackett & Rivers, 2014; Farmer et al., 2016; Greenberg et al., 2003; Jennings & Greenberg, 2009; Roeser et al., 2013).

Macrosystem Factors

Research often neglects to analyze the impact of macro-level factors at the microsystem and exosystem levels (Spencer, 2007). However, children experience macrosystem factors regularly and directly, as do the people they interact with. The macrosystem is both cultural and structural. Macrosystem factors are institutionalized and operationalized through rituals, policies, protocols, routinized practices, and opportunity structures. Macrosystem factors affect, and are experienced through, attitudes, behaviors, and practice routines that affect how children experience and react to environments. Children react both consciously as they interpret experiences and unconsciously through neurobiological processes. Structural macrosystem factors include labor market segmentation and early childhood policy. Cultural macrosystem factors include individualist concepts of child development and victim-blaming approaches to understanding social problems (e.g., Ryan, 1972)—both of which ignore or deemphasize the impacts of history and context on family resources and child outcomes (Lee, 2010).

Two key macrosystem factors are poverty and racism. Both separately and together, these factors make the experience of stress and adversity more likely for children and adults who must deal regularly with the consequences of poverty and racism in their daily lives (e.g., racial microaggressions). These effects may be visible in the moment (e.g., a racial slur) or they may be emergent and only visible analyses (e.g., racial disparities that are the product of multiple small and often subtle steps) (Osher, 2015). They can also be indirect, such as the impacts of housing segregation on resources available for schools under local funding formulas and the creation of cohort effects among and between students and teachers. However, indirect does not mean unimportant. For example, an analysis of the impacts of housing segregation by two economists who accounted for family background co-variables found that a one-standard-deviation reduction in housing segregation would eliminate about one third of the difference between black and white urban Americans in high school graduation, employment, and single-parent status (Cutler & Glaeser, 1997).

Poverty

Poverty is an ecological risk factor that makes it less likely that children will benefit from appropriate experience and enrichment opportunities and makes it *more likely* that they will experience stress-producing adversity and health challenges. Poverty is only a distal risk factor for multiple proximal contextual drivers that have been conceptualized as ACEs (Felitti et al., 1998). They include fewer opportunities for positive stimulation and more frequent exposure to negative stimulation at home, in child care, at school, and in the community (Blair & Raver, 2016; Yates et al., 2003). Poverty gets under the skin through the response to stress, and affects social, emotional, cognitive, and physical development (Blair & Raver, 2012, 2016; Thompson & Haskins, 2014). Poverty may make poorer outcomes more likely both through deprivation and threat (McLaughlin, Sheridan, & Lambert, 2014). Examples of the array of proximal contextual drivers include food insecurity, which can affect the immune system and brain development (Johnson et al., 2016; Walker et al., 2011), homelessness, which can affect executive functions (Masten, Fiat, Labella, & Strack, 2015), and exposure to neighborhood-based risk factors (Osypuk, 2013).

Factors that contribute to fewer opportunities for positive stimulation include caregiver stresses, a lack of child development knowledge, and a lack of the resources to provide cognitive stimulation (Duncan, Magnuson, & Murnane, 2016; Johnson et al., 2016; Osher & Chasin, 2016). Children are less cognitively stimulated when they experience fewer books in the home and less directive speech, prompting, and positive language, and when they are exposed to fewer words (Blair & Raver, 2016). A lack of money to buy learning tools and activities and to obtain help with housework and maintenance activities can constrain the enriching interactions between caregiver and child. Crowded homes can limit parental responsiveness and speech (Evans, 2004). ECE settings and schools may amplify these effects, as economically disadvantaged children are more likely to be exposed to less access to robust academic opportunities (Gustafsson et al., 2014), a disproportionate number of underprepared teachers (U.S. Department of Education, Office of Civil Rights, 2014; Tennessee Department of Education, 2009), and policies that run counter to how children learn and develop (Chongmin & Gottfredson, 2011; Goldhaber, Gross, & Player, 2011; Hanushek, 2004; Kupchik & Ward, n.d.; Nance, 2013).

When children experience high levels of stress and that stress is not adequately buffered, the consequences to development and learning can be great. Neural and behavioral responses to stimulation cause children to be reactive and defensive rather than reflective and approach-oriented (Lee, Siegle, Dahl, Hooley, & Silk, 2015; Marusak, Martin, Etkin, & Thomason, 2015). The stresses of poverty can also contribute to lowered caregiver warmth and sensitivity among some parents who experience multiple stressors and lack access to support in dealing with these adversities (Blair & Raver, 2016). A lack of caregiver warmth and sensitivity can reduce opportunities for buffering stress and heighten the stress response in children and undermine the development of foundational competencies such as self-regulation (Blair & Raver, 2016), as children adapt to harsh or inconsistent parenting, particularly in chaotic environments (Deater-Deckard, Wang, Chen & Bell, 2012; Mills-Koonce et al., 2016; Patterson et al., 1990). Poverty-related risk factors increase the odds that children will demonstrate more behavioral problems and less social and emotional competence (West, Denton & Reaney, 2001). The effects of poverty on the stress response are thought to underlie findings that show an association between

poverty and diminished self-regulation including executive functions (Blair & Raver, 2016; Hackman & Farah, 2009). Animal studies suggest that deprivation can disrupt developmental integration in ways that affect the brain at the molecular, neural, cognitive, and behavioral levels (Johnson et al., 2016; Siegel, 2012).

While poverty makes poor outcomes more likely, family assets and families' leveraging of other assets such as religious institutions can protect children from the negative consequences of poverty. Family assets include social networks (DiMaggio & Garip, 2012) and cultural resources that help families address the impacts of poverty. The seminal examination of parenting in Philadelphia by Furstenberg and colleagues (1999) identified the diversity of parenting strategies in high-need neighborhoods and how parents used their knowledge and social capital to protect their children and maximize their success. Warmth and sensitivity in the caregiver relationship can act as a critical buffer of the effects of poverty on the stress response (see section on the neurobiology of stress).

Racism

Racism, which affects people of color in manifold ways, is both ubiquitous and omnipresent. It is operationalized across ecological systems (Lee et al., 2003) and experienced both directly and indirectly. Institutionalized racism drives (and has driven) structural inequalities that are related to poverty, inequality, and an absence of wealth accumulation (Massey, 2007; Pager & Shepherd, 2015; Reardon & Bischoff, 2011). Processes that lead to associations between racism and children's learning and development are historical, and occur at the individual level as well as in the microsystem, mesosystem, exosystem, and macrosystem (Dupree, Spencer, & Spencer, 2015; Swanson, Cunningham, Youngblood, & Spencer, 2009). The stresses created by the experience of racial aggressions and microaggressions can become embedded in a child. They can affect children and adolescents' perceptions of themselves and others, and how they deal with what they feel and experience. However, many children and their families demonstrate instrumental and psychological resilience by building on individual, family, and cultural strengths (Lee, 2009; Spencer, 2007).

Racism affects students directly through the identities they create, stereotype threat, and microaggressions, as well as through the adjustments they make in order to succeed and maintain a sense of dignity (Anderson, 1999; Henderson, 2000; Steele, 2010; Stevenson & Stevenson, 2013). Racism affects the microsystem through structural inequities in child-serving institutions. The Civil rights data collection (U.S. Department of Education, Office of Civil Rights, 2014) data demonstrate the impacts of structural inequities in education, which include not only disparities in discipline but disparities in opportunities to learn and enrichment. Racism affects the education-related aspects of the mesosystem when there are problematic interactions between educators and families of color (e.g., Harry, Klinger, & Hart, 2005). It affects the exosystem through well-documented disparities in health care, mental health, housing, child welfare, educational resources, work opportunities, opportunities for civic participation, justice, and policing (e.g., Fisher et al., 2012). It affects the macrosystem when policies and cultural forces sustain or legitimize racial privilege (Pager & Shepherd, 2008).

Institutionalized racism creates contextual factors that enhance the likelihood that children, adolescents, and young adults will experience compounded deprivation, which Perkins and

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Sampson (2015) operationalize as the combination of individual deprivation (e.g., poverty) and social emotional deprivation (e.g., low collective efficacy). These experiences can have durable effects on verbal abilities (Sampson, Sharkey, & Radenbush, 2008), if they are not effectively buffered by internal and external assets (Spencer, 2007). They can affect individual and social identities, which can contribute both to positive and negative adaptations.

In addition to threatening the physical well-being of children and their caregivers, victims of inequities and racism face the effects of implicit biases (Amodio & Devine, 2009; Hannon, DeFina, & Bruch, 2013) which can subject them to stress (Albert et al., 2010) and undermine confidence and self-concept, as well as expose them to professional and administrative decisions that lead to poorer, more punitive, and more exclusionary services (Gregory, Skiba, & Noguera, 2010; Smedley, Stith, & Nelson, 2003). In addition, they face the effects of explicit bias (which limits job and housing opportunities), racial microaggressions, and the regular experiences of discrimination (Pager & Shepherd, 2008).

Together, structural and cultural inequities and racism create adverse conditions for promoting healthy development for minority children, and increase both parental and child stress (Stevenson & Stevenson, 2013). Although many individuals develop adaptive strategies and demonstrate resilience, research suggests that the physiological burden of allostatic load remains (Chen, Miller, Body, & Lei, 2015). These conditions can limit opportunities and negatively affect outcomes, and have been associated with stress-related mental and physical illnesses across the lifespan (Center on the Developing Child at Harvard University, 2016; Fisher et al., 2012).

Individual–Context Relations Across Development

Child development progresses along a continuum, and varies widely between individuals and developmental tasks. At the same time, some brain functions do predictably undergo rapid change in certain developmental periods. Rapid improvements in certain brain functions such as executive functions, for example, occur in early childhood; more complex executive function skills continue to develop through childhood and into adulthood (Davidson et al., 2006). Similarly, some interactions between the individual and the context occur more prominently at certain points in development, which can trigger more rapid improvements in specific functions. The next section highlights some of the most important developmental milestones in the first three years of life, early childhood, middle childhood, and adolescence. These culturally determined phases of the life span involve both biological changes and differential participation in a variety of social fields that have their own behavioral demands (Kellam & Rebok, 1992).

The First Three Years

Early life experiences can have longstanding influences on learning and development. In the first three years of life, infants and toddlers devote their time to forming attachment relationships (including developing trust of others), learning to function autonomously (including developing trust in themselves), and acquiring self-regulatory attributes that allow them to be flexible problem-solvers (Yates et al., 2003). The first three years of life are widely believed to be a sensitive period for the developing brain. In the early years the brain's plasticity is strongest; 700–1,000 new neural connections form every second, and the volume of gray matter increases

rapidly (Center on the Developing Child at Harvard University, 2016). This early period of formation and pruning of neural circuits shapes the architecture of the developing brain before the circuits are fully mature and stabilized (Center on the Developing Child at Harvard University, 2016; Fox, Levitt, & Nelson, 2010). Emotional development, including the ability to experience, express, and manage emotions and impulses, begins in this stage, in conjunction with motor control and cognition (Tarullo, Obradović, & Gunnar, 2009; Fox et al., 2010). The early years are also a sensitive period for the development of language and visual systems (Dawson Ashman, & Carver, 2000). Even though the first three years of life are considered a sensitive period for changes in neural networks, developmental systems, including the brain and relationships, continue to be malleable beyond these years (Dawson et al., 2000).

Early childhood is an important time to build resilience within and across developmental systems at multiple levels in the child, family, and community (Cicchetti & Curtis, 2007; Masten & Cicchetti, 2010; Reynolds & Ou, 2003). Parent responsiveness, proper nutrition, and early interventions to address cognitive, social, and academic concerns during this period are associated with long-term benefits; parental depression and maltreatment, social deprivation, and exposure to toxic substances are associated with long-term challenges (Dawson, et al., 2000). Early caregiver relationships are the most proximal and prominent contextual influences on development in these years, and can serve to promote optimal brain function and behavior. Attunement is associated with executive function, early language processing skills and vocabulary growth, and other immediate and long-term outcomes (Bindman, Pomerantz, & Roisman, 2015; Weisleder & Fernald, 2014).

Early Childhood

The preschool period has garnered a great deal of attention following evidence presented by James Heckman (Heckman & Masterov, 2007) and others showing that early investments that address social, emotional, and cognitive deficits even before kindergarten entry can have large payoffs for individuals and society. Indeed, neurobiological, emotional, and behavioral foundations in very early childhood set the stage for the development of school readiness skills and for positive developmental outcomes over the life course (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson 2002; Schweinhart et al., 2005). With the proper supports, early childhood marks a period of dramatic increase in executive functions and cognition–emotion integration (Blair & Diamond, 2008; Espinet, Anderson, & Zelazo, 2012).

The cognitive, emotional, and behavioral integration at this stage helps children successfully navigate the social demands of preschool. As children begin preschool, they enter into relationships with teachers and peers that can mutually reinforce social behavior (Hay et al., 2004; Raver, 2004; Newman, 2000). The skills necessary to be accepted by peers—emotion regulation, executive functions, social understanding, and prosocial behaviors (such as helpfulness and sharing)—are the same skills that afford children opportunities to form positive relationships with teachers and to learn (Carlson & Moses, 2001; Hay et al., 2004; McDowell, O’Neil, & Parke, 2000; McElwain & Volling, 2002). Early experiences can set off a cascade of relationships, behaviors, self-perceptions, stress responses, and emotions that mutually reinforce each other over time in sometimes adaptive, sometimes maladaptive ways (Fox et al., 2010; Ladd, 1999; Nagaoka et al., 2015; Newman, 2000).

Antisocial behaviors (such as aggressiveness and impulsivity) and attention deficits, often associated with chronic stress, as well as affective responses (e.g., shyness) undermine opportunities to connect with others, thereby diminishing opportunities to learn and depreciating the child's and teacher's perception of the child as a learner. For example, children who exhibit antisocial behavior in preschool participate in fewer classroom activities and teachers provide them with less instruction and less positive feedback, potentially setting off a cascade of less engagement, learning, and attention that can lead to poor academic performance and early dropout (Raver & Knitzer, 2002). As a result, emotional, social, and behavioral competence can be more important for early school success than cognitive competence or family background (Raver & Knitzer, 2002), and intentional efforts to promote these skills have been found to be successful (Menting, Orobio de Castro, & Matthys, 2013). An intentional focus on the development of self-regulation in young children through activities such as scaffolded social and emotional learning, creative play, and the encouragement of positive social connections can build brain functions involved in self-regulation and support the deepening of cognitive functions (Center on the Developing Child at Harvard University, 2016).

Middle Childhood

Research often treats middle childhood, the period roughly between ages 6 and 12, as a transitional period. Pruning continues through middle childhood (Halfon et al., 2001). By middle childhood, other brain circuits, including certain key memory processes, are relatively mature (Sander, Werkle-Bergner, Gerjets, Shing, & Lindenberger, 2012, in Blakemore & Bunge, 2012). Yet middle childhood is marked by its own meaningful changes in brain development and social contexts: brain structures and functions, predominantly in the prefrontal cortex (which supports cognitive self-regulation and executive function), undergo rapid growth between ages 7 and 9 (Johnson et al., 2016).

Middle childhood is a time when children are experiencing increasing independence in new and challenging contexts, and changes in the nature of their social interactions. In the United States, the typical key developmental tasks during middle childhood are self-regulation, acquiring skills and knowledge related to learning, and developing interpersonal skills (Nagaoka et al., 2015). These tasks emerge out of the formation and development of friendships, increasing autonomy and behavioral expectations, and increasing academic demands. As children become self-regulated and the caregiver-child relationship becomes more collaborative, the nature of the attachment relationship changes from proximity to availability (Bosmans & Kerns, 2015). Attachment relationships also expand to other adults, especially teachers. These adults expect children to learn critical academic skills such as reading and writing and basic mathematics, and to develop contextually appropriate behavioral and attention skills. From these experiences and expectations, children learn and are expected to practice social and emotional competencies, including empathy, emotional expressiveness, interpersonal negotiation strategies, and cooperation with rules. These competencies facilitate relationships with adults and peers, afford increasingly diverse opportunities in the home, school, and other structured settings, and drive academic success (NRC & IOM, 2009). These competencies become more sophisticated as children develop social skills and knowledge through friendships, and develop social perspective-taking abilities—understanding that a single event may have multiple interpretations (Goldstein et al., 2002; Parker & Gottman, 1989; Selman, 1980).

Children who do not develop social, emotional, and cognitive competencies and representations of self as successful learner are more likely to exhibit poor social skills, such as impulsivity, aggressive behaviors, poor social problem-solving skills, and school disengagement (IOM & NRC, 2009). Fortunately, an increasing body of research indicates that social and emotional learning strategies can help many elementary and middle school students develop these competencies (Durlak et al., 2011; Gestsdottir et al., 2011; Jones & Bouffard, 2012; Osher, Kidron, Brackett et al., 2016).

Middle childhood also is a time when mental health disorders and antisocial behaviors begin to emerge that have consequences for later outcomes (NRC & IOM, 2009; Patterson et al., 1990). Research suggests that middle childhood marks the first symptoms of conduct and anxiety disorders, obsessive compulsive disorder, and depression (NRC & IOM, 2009). For example, boys arrested between the ages of 10 and 12 have twice as many lifetime convictions as those whose first arrest occurs later in adulthood (Farrington, Gallagher, Morley, St. Ledger, & West, 1986). Feedback loops between maturational shifts in the child, such as social cognitive abilities, and between an expanding social environment that reinforces representations of self and others, help explain divergence in developmental trajectories during these years (Berry & O'Connor, 2010; Eisenberg et al., 1987; Mah & Ford-Jones, 2012;). However, research on the iatrogenic effects of punitive, reactive, and segregating interventions suggests that some of the poor long-term outcomes may be a product of developmentally inappropriate responses to troubling and antisocial behavior (Dishion & Dodge, 2005; Dishion, McCord, & Poulin, 1999; Gatti, Tremblay, & Vitaro, 2009; Petriclerc, Gatti, Vitaro, & Tremblay, 2013).

Adolescence

After early childhood, adolescence is the time of the brain's most dramatic growth spurt. Adolescence is the period from age 10 to 24 (Siegel, 2013), during which many changes in developmental systems occur. These include co-occurring changes in brain development, hormone levels, physical health, and contextual demands and opportunities. For many, adolescence is a time for risk taking, social reward seeking, and novelty seeking (Chambers, Taylor, & Potenza, 2003; Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Crone & Dahl 2012; Dishion, 2000; Gifford-Smith, Dodge, Dishion, & McCord, 2005; Steinberg, 2008; Yeager, Fong, Lee, & Espelage, 2015); it is also a time of opportunity, creativity, exploration, and optimism about one's role in the world (Geisz & Nakashian, 2016). It is a period of great plasticity and malleability, and thus a time to optimize individual development and potential—a time for honing decision-making skills, expanding processing skills and self-evaluation, managing emotions, and embracing new forms of abstract thinking. It also brings changes in physical and skeletal health that have implications for later cardiovascular and bone health (Patton, Renn, Guido, & Quaye, 2016).

During adolescence, intentional skill development is particularly important and effective. It is a period in which environments and relationships, particularly those outside the family, in the school and community, play a uniquely important role in integration and development. One of the greatest misconceptions of this period is that adolescents do not need adults; adolescents crave relationship and connection, to both peers and adults. Peers can influence each other in promotive and inhibitory ways. They can encourage a sense of connection, model positive behaviors, and encourage prosocial norms (Patton et al., 2016). Peers can also encourage each other to engage in risk-taking and problem behaviors, particularly when in groups

unaccompanied by adults (Gardner & Steinberg, 2005; Gifford-Smith et al., 2005; Hovee et al., 2012; Hoyt & Scherer, 1998; Kroneman, Loeber, & Hipwell, 2004; Silva, Chein, & Steinberg, 2016).

Adolescence is a highly sensitive period for the development of regions of the brain involved in social cognition and self-awareness (Blakemore, 2010; Blakemore & Mills, 2014; Fuhrmann, Knoll, & Blakemore, 2015; Nagaoka et al., 2015; Steinberg, 2005). The part of the brain associated with social and emotional functioning experiences a surge around puberty that creates changes in social motivation, including a focus on social status and social rewards (Crone & Dahl, 2012). The frontal lobe, which governs cognitive control, continues to mature and is still developing in adolescence and early adulthood. A remodeling of the brain's dopaminergic system occurs around the time of puberty, in which amounts of dopamine fall sharply from levels in the early development phases (Sisk & Foster, 2004; Sisk & Zehr, 2005; Teicher, Andersen, & Hostetter, 1995). The dopaminergic system overlaps and interacts with the brain's social networks and the networks for processing affective and motivational stimuli (Nelson, Leibenluft, McClure, & Pine, 2005).

One way of viewing the adolescent period of brain remodeling is through the lens of neural integration. Research suggests that the brain has two fundamental processes: one of pruning in early adolescence, the other of myelin formation in middle to late adolescence (Giedd, 2008; Pfeifer et al., 2013; Shaw et al., 2011; Sherman et al., 2014). Pruning enables regions of the brain to become more differentiated; myelin enables these remaining regions to become more linked. With myelin, for example, conduction speed of the action potential is 100 times faster, while the refractory period (i.e., resting time after firing) is 30 times shorter, making the overall communication among neurons 3,000 times more coordinated. The implication of this research is that pruning and myelination lead to increases in differentiation and linkage, and in this way adolescent brain remodeling leads to greater integration in the brain. This adolescent brain remodeling is thought to contribute to higher capacities for regulation and other higher order cortical functions through neural integration (Stevens, Skudlarski, Pearlson, & Calhoun, 2009).

As discussed, the various risks of adolescence include the onset of serious psychiatric disorders (Johnson, Kemp, Heard, Lennings, & Hickie, 2015). One view is that the pruning process may reveal underlying vulnerabilities in the neural connectivity of the individual. When stress arises from this diminished functioning, even more pruning may occur, as cortisol, the stress hormone released with prolonged stressors, can be neurotoxic. Shifts in the dopaminergic reward system may also be at play in the risk of developing addictive problems and other risk-taking behaviors during this period (Ross & Peselow, 2009). The functioning of these sub-systems in the brain and neural integration depend upon adolescents' developmental contexts.

Although there is variation in the contextual demands placed on individual children, the specific tasks of adolescence move many children from the dependencies of childhood to the emerging identities and responsibilities of adulthood. Brain and hormonal changes, along with contextual changes, allow many adolescents to more intentionally contribute to adaptive regulation with their context. For example, they can select positive goals, use cognitive and behavioral skills to optimize their own potential, and compensate for challenges and failures (Baltes & Baltes, 1990; Freund & Baltes, 2002; Gestsdotir & Lerner, 2008). Consequently adolescence is a time of increasingly goal-oriented learning, identity formation, autonomy assertion, and a growing sense

of values (Boots, 2016; Erikson, 1968; Nagaoka et al., 2015). Adolescents are also flooded by emotion, whether it is driven by puberty, social anxiety, or memories. As a result, many of the tasks of adolescence are about the balance between honing attributes like self-regulation, sense of purpose, and belonging (pre-frontal cortex) versus handling some of the overwhelming emotions that drive risk taking and impulsive behavior (amygdala).

Unfortunately, middle schools and high schools often are organized in a way that does not fit the developmental needs of youth in this age group (Eccles & Roeser, 2009; Juvonen, Le, Kaganoff, Augustine, & Constant, 2004; Lee & Smith, 1997). Although adolescents need more autonomy and connectedness, they often experience a loss of autonomy, as rules become harsher and connections to adults—who now must work with more students—become more difficult to maintain.

Providing enriching opportunities in homes, schools, and communities helps adolescents fulfill their potential and experience increasing independence. In addition, investing in adolescence means investing in the next generation of parents and other adults who will be contributing to the positive development of young children. All adolescents need positive and sustained relationships with competent and caring adults who can provide exposure to life-skill-building activities; opportunities to actively participate and take leadership in family, school, and community activities; and provide clear standards for behavior and norms (Bond, 1999; Geisz & Nakashian, 2016; Lerner, 2004). In addition, studies of young adults suggest that mindfulness training may promote increases in neural integration. These studies have found that mindfulness training is correlated with increased interconnectivity of the connectome, and growth of the corpus callosum, the hippocampus, and the prefrontal region (Cole, 2014).

Organizing Translational Frameworks

Translational developmental frameworks are essential for organizing and applying developmental constructs at the individual level as well as at the microsystem, mesosystem, exosystem, and macrosystem levels. Frameworks can help prioritize the developmental constructs that are most promotive at different stages of development universally, as well as for specific contexts, settings, tasks, and situations, with attention to variation among children.

Human development theorists across fields and areas of study have already come up with many ways of organizing development into frameworks that define the individual factors that help children grow and learn. These organizing frameworks can help support the translation and application of the science. The constructs that make up these frameworks are not trait-like in character and have common core principles. They include the following:

- Malleable and measurable
- Scientifically grounded in a strong research base
- Acknowledge the developmental impact of adversity
- Integrated (develop together)
- Nonlinear
- Progressive and refined by the acquisition of important developmental skills

- Delineated where there are dependencies between lower and higher skills
- Linked with important developmental outcomes (e.g., academic achievement, social competence) whose associations are grounded in a strong research base

This should be reflected in a translational framework design that embraces two key principles: context dependency and a nonlinear developmental continuum (Stafford-Brizard, Cantor & Rose, under review). Frameworks designed around these principles should represent the complexity of the developing child and adolescent; they should avoid the assumption that a developmental path is linear and defined by a perspective of fixed ages and stages, and they should not exclude relevant contextual factors like time and environment because individuals cannot develop independently.

Context dependency should be a critical component of any translational framework. The context around a developing child or adolescent influences behavior, development, and even biological makeup (Knafo & Jaffee, 2013; Lester et al., 2016). Children’s performance varies in relation to the amount of support they are given (Fischer, Yan, & Stewart, 2003), their emotional state (Fischer, Bullock, Rotenberg, & Raya, 1993), and the culture and climate around them (Haynes & Comer, 1993; Hoy, Tarter, Woolfolk Hoy, 2006). Variability occurs in individual development due to contextual and environmental factors.

Knowledge of developmental patterns will provide explanations for variations in student performance and will shed light on critically important pathways that students follow to achieve higher order developmental skills and greater performance on multiple dimensions. Using methods and tools grounded in dynamic systems theory, the order and patterns can be identified within this variability and can ultimately be measured. A context-dependent translational framework should more fully represent the dynamic nature of development as opposed to a fixed ladder of stages that is often modeled on averages and void of context.

Conclusion

The future of our education and child-serving systems needs to be built upon what we now know about the development of the brain, and the power of contextual factors in that development. Both systems were designed without knowledge of the forces that drive the neural processes that shape the emergence of our uniquely human mind. This knowledge, when understood and applied, contribute to positive adaptation, resilience, learning, health, and well-being. Although much research still needs to be done, it is now possible to offer a scientifically grounded view of the mind as an emergent, self-organizing, embodied, and relational process that regulates the flow of energy and information (Siegel, 2013) in interaction with other minds at home, at school, and in the community. Looked at this way, it is possible to visualize a powerful role for early childhood centers, schools, and child-serving systems in modeling, shaping, modulating, and monitoring this developmental process collaboratively with children and their families.

As this synthesis suggests, we are positioned now to draw upon an immensely relevant and diverse body of research to influence instructional and school design and child-serving community and health systems, to improve the conditions in which children grow and develop, and to create activating contexts for learning and the fullest expression of each child's individual

potential. At its core, the use of practices designed with the knowledge of human development as a foundation can realize a deep personalization of learning and the learner experience, going well beyond the traditional definitions that have been applied to these terms. This personalization must build upon the assets that children, families, and communities have, and must be interdisciplinary—mirroring the nature of development itself—and applied at the individual level.

Dramatic improvements in outcomes and equity depend on public and political will, sound policy in service to whole-child practices based on rigorous science, implemented with quality, measured with an understanding of formative progression, and adopted at scale with cultural competence and equitable outcomes as explicit goals. To ensure that approaches to whole-child personalization are scaled successfully, we must develop a comprehensive set of strategies to drive demand for and adoption of successful tools, methods, and measures, which must include a common taxonomy of definitions and measures across the continuum of ages into young adulthood and support for effective implementation across diverse contexts.

It is important to develop a robust translational R&D agenda that supports a synthesis and integration of current scientific knowledge within and across disciplines, while addressing important gaps in knowledge, practice, methods, and measures. This agenda can help ensure that the new knowledge and its potential translates into improved outcomes at scale. This agenda should promote examples of successful translation of science to practice, describe the research or policy agenda that previously brought these examples about, address remaining large gaps for further translation, and identify collaborative opportunities for application and piloting.

Measurement Considerations

There are limitations in our ability to measure the array of individual and contextual factors that influence child development. First, we do not take into account the individuality of how a child develops in our decisions about what we study and measure. Second, we do not understand the complex interactions among the child, his or her setting, and the adults and other children in that setting—and the intertwined role of these in the child’s development. Third, we do not adequately measure or understand the effects of stress on learning and development. Fourth, we do not adequately measure or understand the ways in which resiliency is supported by cultural resources and informal supports. These three limitations affect our ability to use measurement to inform intervention, practice, and policy.

First, we must return to the fundamental principle that children differ in their strengths and needs and in their developmental trajectories: researchers’ increasingly refined ability to measure individual variability allows them to change course from studying statistical averages to understanding patterns of individual variation. In addition, the *specificity principle* states that specific contexts exert influence on specific aspects of children’s development at specific times and in specific ways (Bornstein, 2006). Recent advances in statistical methodologies make studying individual and contextual variability more accessible, and allow us to analyze patterns of variability. To capitalize on these statistical methodologies and to understand how interventions and practices differentially affect children at different times, researchers need reliable data on individuals in more than one context and on multiple occasions. Decisions about when outcomes are measured and how often (i.e., the temporal metric of change) should be

considered carefully and based on a theoretical understanding of a particular change process (Lerner, Schwartz, & Phelps, 2009). Existing measures have often been normed on dominant groups and have not sufficiently attended to cultural variation, the intersection of multiple identities, and measuring cultural resources that support resilience. Research to validate measures and attend specifically to measurement invariance is needed.

Second, there are gaps in our understanding of the features of settings that are most relevant to child development and learning—and in our understanding of how these features interact and their malleability. Measures of settings (e.g., preschool quality, school climate) do currently exist. For example, the U.S. Department of Education developed a [publicly available measure of school climate](#) to measure the learning environment, and provides other vetted measures of school climate. We also lack understanding of the transactional and synchronous associations between individuals, their peers, and the adults in their lives. Social network analysis is one tool that is useful for measuring social dynamics beyond individual perceptions. But we lack the tools to measure these complex interactions, lack an understanding of the change sensitivity of existing measures, and have not adequately explored the differences in temporal metrics of change across individuals and contexts. Lerner and colleagues (2009) discuss this issue and propose some solutions.

Third, measuring chronic stress can be useful in understanding whether interventions succeed in restoring physiological homeostasis to a dysregulated nervous system. Although there are screening tools for adverse childhood experiences (e.g., Purewal et al., 2016), we do not yet have a valid and reliable measure for the gradient of stress, including toxic stress. Acknowledging this limitation, an effort by a working group out of the Center on the Developing Child at Harvard University to develop such a tool is currently underway. This tool may also include biomarker panels for toxic stress that can inform risk assessment before it is visible to the human eye (<http://developingchild.harvard.edu/science/the-jpb-research-network-on-toxic-stress/>).

Measuring Social and Emotional Competencies and Attributes

Measurement of social, emotional, and cognitive competencies that go beyond the learning of content, mindsets, and dispositions is relatively new, and still lacks conceptual clarity, alignment, common taxonomy, reliability, validity, and evidence of measurement invariance. Even the terms “non-academic” or “non-cognitive,” which are frequently used, are inadequate descriptor for these critical dimensions of human development (Osher, Kidron, Brackett et al., 2016). Those who advocate for assessing nonacademic skills² are beginning to design more practical, reliable, valid, and conceptually clear measures. Prompted by general agreement that these skills are crucial, educators and policymakers are striving to assess them despite the inherent difficulties. Still, some experts have strong reservations about the use of existing measures for accountability (Duckworth & Yeager, 2015, Osher, Kidron, Brackett et al., 2016) rather than for formative assessment and continuous quality improvement.

One challenge is issues related to the reliability and validity of existing measures. Self-report measures and performance tasks are two methods for assessing nonacademic skills. Self-report

² These skills are also referred to by other names, such as noncognitive, social and emotional, 21st century, soft, life, executive function-based, and character skills.

and teacher questionnaires are subject to misinterpretation by the reporter, lack of insight into students' internal states, have reference bias, and are vulnerable to faking, particularly as they are applied across cultures and language groups (Denham, Bassett, Sirotkin, Brown, & Morris, 2015; Jones, Zaslow, Darling-Churchill, & Halle, 2016; Miller, 2012; Scales et al., 2016; West et al., 2015). But performance tasks are subject to misinterpretation by the researcher as well, and often do not reflect typical behavior in real-life situations (Duckworth & Yeager, 2015). A second challenge is the lack of alignment between constructs. A third challenge is a lack of conceptual clarity about what is being measured. The field conceptualizes, describes, and measures competencies, mindsets, and dispositions in ways that vary with the discipline, context, developmental stage, and purpose that prompted their development. Competencies and skills often are conflated with mindsets and dispositions and with related constructs such as trauma, resilience, youth development, and developmental assets (Osher, Kidron, Brackett et al., 2016). This lack of conceptual clarity leads researchers, practitioners, policymakers, and other stakeholders in various fields to grapple with how to identify which competencies to target, how to measure their success, and how to identify which competencies, interventions, and programs may or may not be targeted and changed. A fourth challenge is a lack of sensitivity (i.e., sensitivity to integration and sequencing) in existing measures. This issue calls for research techniques that draw on triangulation and mixed methods.

Researchers can improve the current measurement tools—especially formative tools—to address these concerns before educators and policymakers decide to use them for accountability. Acknowledging the limitations in current measurement tools, the multidisciplinary work group for [*Establishing Practical Social-Emotional Competence Assessments of Preschool to High School Students*](#) is collaborating to make key advancements in student social and emotional competence assessment. At minimum, researchers, educators, and policymakers alike should be explicit about the limitations and use the results with caution. The absence of high-quality, effective measurement of whole-child development is one of the greatest limitations in applying the extensive scientific knowledge we have about children's growth and learning. This requires urgent prioritization as part of an R&D agenda (see below).

Measuring Academic Skills

Although performance-based assessments of academic subjects are usually spared the scrutiny given to “nonacademic” assessments, researchers, educators, and policymakers often underestimate the degree to which achievement tests are subject to similar limitations. In fact, emotion and affect are central to test-taking, and the research shows that context affects success on these tests (Aronson, 2002; Bruner, 1996; Hickey, 1980; Hong, 1999; Masten et al., 2005; Wolf & Smith, 1995). For example, negative stereotypes and perceptions of authority figures as unreliable undermine performance (Duckworth & Yeager, 2015; Good et al., 2003; Steele & Aronson, 1995). Moreover, current achievement tests do not reflect the previously described principles put forth by the learning science community today.

Part of the issue is that educators lack the training to efficiently, validly, and reliably administer less familiar and newer assessments such as performance task evaluations, and do not have sources for obtaining valid and reliable formative probes of important and complex learning outcomes. But there are also other limitations. Proponents of the evidence-centered design (ECD) framework (Mislevy, Steinberg, & Almond, 2002) argue that assessment should, but

currently largely do not, follow the principle that assessments should be thought of as “the broad set of processes and instruments by which we arrive at inferences about learner proficiency” (Riconscente, Mislevy, & Corrigan, 2015, p. 41), and that “assessment is the process of reasoning from particular things people make, say or do to draw inferences about their knowledge, skills, and abilities” (p. 40). Advances in assessment design that follow this principle and capitalize on technology, such as simulations and digital games, are being developed, and show promise for putting the science into practice (Riconscente et al., 2015). But more assessments that follow this principle need to be designed and validated using longitudinal data. Researchers are beginning to advance this work, which will be critical to the field of assessment and evaluation of learning and learner progress moving forward.

Toward a Translational R&D Agenda: Gaps in Knowledge and Practice

Human Plasticity

We still have much to learn about neural and behavioral plasticity, including the specific time of sensitive periods and how and when stress affects them. These sensitive periods are not just a function of age; rather than focusing on developmental stages, there needs to be more of a focus on the multiple influences on the processes by which individuals grow and learn (Raeff, 2017). Different neural systems have different sensitive periods, and these vary as a function of individual experiences (Johnson et al., 2016). Although most scientists would agree that intervening early is better, there may be some interventions that act more efficiently on the brain in later years. For example, providing school-age children and adolescents with anemia with iron supplements has been shown to yield greater benefits on cognitive functions than providing iron supplements to infants and young children (Johnson et al., 2016). Having a better understanding of the developmental sequencing of biological processes and skill acquisition is necessary for understanding plasticity. This question has implications for the translation of research into policy and for the translation of science into practice. For example, there is a debate in the research and policy fields about whether adolescents’ brains are mature enough to provide the inhibitory control needed for managing high levels of emotional arousal and reward seeking, and whether adolescents can learn control through experience (Johnson et al., 2009; Murray et al., 2015). In addition, more studies are needed in later childhood and adolescence, with specific attention paid both to culture and to the complex social networks that children operate in during these developmental periods (Berg, Osher, Moroney, & Yoder, n.d.; Hay et al., 2004).

Intergenerational Transmission

There is a need for more research on the neural plasticity of the maternal brain and factors that affect this plasticity (Kim et al., 2016). In addition, a small body of research has studied the paternal brain and identified an understudied phenomenon: paternal postpartum depression (Kim & Swain, 2007). Research on how the paternal brain and the father–infant attachment relationship affects child development can provide a better understanding of how to improve the early care environment to inform intervention (Kim et al., 2014).

Causality

Because the brain is so intricate and has so many parts working together, and because environmental stressors are so often co-occurring, we do not have a good understanding of causal processes, including what parts of the brain are causing what behaviors and whether intervention is affecting biology, behavior, or both. We also need to learn more about how settings, implementation readiness, and the quality of implementation moderate and mediate intervention effectiveness. We can gain this knowledge through precise interventions when they are combined with well-designed qualitative studies of implementation.

Susceptibility

We do not have a thorough understanding of the genetic and environmental relations that make a child more or less vulnerable or susceptible to characteristics of his or her environment, including the causes and variation in stress responsivity (Johnson et al., 2016). To better understand this, we need to better understand the feedback loops and dynamic links between exposures to chronic stress and outcomes—including models for how self-regulation and stress interact over time and how this interaction affects the promotion of resilience.

Resilience and Thriving

Childhood resilience is complex and multifaceted. We need to take a multilevel and multisystem approach to research and policy to better understand how to build a comprehensive approach to resilience in children (Lavoie et al., 2016; Luthar et al., 2015; Masten, 2007). This approach can draw upon social neuroscience (Cacioppo, 2002), as well as culturally sensitive phenomenological approaches (Spencer, 2007). We need to identify simple, scalable ways to minimize maltreatment and promote enrichment by primary caregivers. We need to take to scale actionable interventions we already know create and sustain developmentally nurturing child environments (Luthar et al., 2015).

Culture

We also have to learn more about the impact of culture and cultural moderators on learning and development. For example we need to know more about how culturally and linguistically diverse students develop positive academic and racial/ethnic identities (Gutiérrez & Rogoff, 2003; Langer-Osuna & Nasir, 2016) as well as how we can better address the neurobiological consequences of discrimination (e.g., Berger & Sarnyai, 2015). We also need to know how and why culture and cultural resources as well as discrimination contribute to risk and protection, resilience, and neurobiological processes in the caregiver and child (Cacioppo, 2002; Feldman, 2015; Lee, 2010).

Learning

Although studies of cognitive science and deeper learning point to some promising directions, more needs to be learned about the conditions for learning and precisely how and under what conditions cognitive, social and emotional, and metacognitive skill-building can be developed, which pathways for adaptive integration of skills are most fruitful, and how to combine such practices with rigorous, personalized instructional practices. It will be important to embed this

knowledge in the training and preparation of leaders and teachers, including providing opportunities for personal skill development, apprenticeship, coaching, and practice. In education, there is a need for researchers and educators to develop ways to balance multiple priorities that include: individualized learning within cohesive classrooms, setting high standards for teachers without standardizing practice, taking time to build strong trustful relationships, and incorporating culturally responsive practices. There continues to be a need for further research on universal trauma-sensitive approaches, community schools, and community-wide approaches to supporting learning, positive youth development, and whole-child development. This knowledge base will help us design 21st century schools that personalize both context and learning, and do so in ways that intentionally promote cognitive engagement, social and emotional skills and mindsets, and deeper learning competencies.

Assessment

There is a need for novel and innovative measures that follow the learning principles outlined in this paper. These must be scalable and must reconcile accountability with the importance of measuring formative growth, human development dimensions, and deeper learning (Sawyer, 2008). In academic subjects, this means assessing the extent to which knowledge is integrated, coherent, and contextualized (Sawyer, 2008). More needs to be done to develop and implement formative assessments that capture individual pathways to cognitive and emotional engagement and social, emotional, and academic learning over time. Especially for academic assessment, this includes assessments administered repeatedly over time that are sensitive to individual differences and that capture the process of reasoning (Riconscente et al., 2015). There is still much more work to be done to measure settings (including the classroom, home, the afterschool environment, and others), in a valid, reliable way that includes simultaneous measurement of social interactions. There is also a need for greater attention to how to capture interactions between individuals and settings using appropriate temporal metrics (Lerner et al., 2009). Finally, we do not yet have a scalable assessment of the whole child, despite increasing attention to the whole child in schools and local efforts. Capturing whole-child development in formative measures is potentially one of the most fruitful areas for R&D.

Beyond K–12

The science of learning and development is not only relevant for preK–12 education. Because neural plasticity continues into adulthood, opportunities for skill development and behavioral adaptation remain open throughout early adulthood. What the science tells us about learning and development beyond preK–12 is beyond the scope of this paper. Further, our current understanding of the specific needs, risks, and opportunities for learning and development among 18-to-24-year-olds—particularly those who experience chronic stress—is underdeveloped. Of particular interest is the topic of “opportunity youth”—young people between the ages of 16 and 24 who are neither enrolled in school nor participating in the labor market. Deepening and leveraging the science of learning and development for this population represents a ripe area for future study, and is essential to promoting learning and development in children who will become parents and providing them a pathway back to school or toward active participation in the workforce.

As this synthesis suggests, our knowledge in multiple disciplines is converging and congruent. Advances in research advances, the coalescence within bodies of science, and the convergence across bodies of science and disciplines has the potential to be transformative. We are now positioned to draw upon an immensely relevant and diverse body of research to influence instructional and school design, child-serving, family support, community, and health systems. This knowledge will enable us to improve the conditions in which children grow and develop by providing activating contexts for learning and for the fullest realization of each child's individual potential. Practices designed with the knowledge of human development as a foundation can enable us to more deeply personalize learning and the learner experience—going well beyond the traditional definitions that have been applied to these terms. This work must build upon the personal and cultural assets that children, families, and communities have, and must be interdisciplinary by its very nature—mirroring the nature of development itself—and applied within the social contexts that affect child development and at the individual student level.

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