

Building Meaning Builds Teens' Brains

Connecting adolescents' concrete work to big ideas may help shape their neural networks over time.

Mary Helen Immordino-Yang and Douglas R. Knecht

Big understandings are the building blocks of lifeworthy learning. —David Perkins

The science of learning and development is opening up promising lines of educational thinking and practice (Immordino-Yang, 2015). For adolescents in particular, emerging longitudinal research from Mary Helen's team at the University of Southern California is revealing that the changing connectivity among the brain's major networks across early to middle adolescence is predictive of success in school, self-actualization, relationship satisfaction, and other positive indicators in early adulthood (Gotlieb, Yang, & Immordino-Yang, in preparation). This raises critical questions: What do these neural networks do? How can we know when young people are building them? What kind of learning experiences strengthen connectivity across these networks?

Presently, we (Mary Helen and Doug) are

collaborating across our institutions to explore these questions by conducting research that bridges dynamic classroom spaces with the controlled settings of the neuroscience lab. This joint project rests on the fundamental premise that human beings construct *narratives* about the world and their experiences in it—in effect, whether in math class or at the dinner table, people tell themselves stories about who they and others are, how the world works and why. And we are building on a key insight from Mary Helen's research: Among teenagers, these meaning-making narratives are related to the activity and changing connectivity of the networks in their brains—the very networks that predict long-term outcomes.

When the USC team talked to teenagers about how they think and feel about themselves and the things they witness in the world, and asked the kids to think about stories that invoke those big issues during brain scanning, the researchers could make general predictions about the teens' future development as a



person and scholar based on the depth and range of what they said and their brain activity. While these findings do not present a silver bullet, the fact that the findings *held above and beyond the predictive power of metrics like IQ and family socioeconomic status*¹ suggests that they reveal something foundational about adolescents' learning.

At first pass, this may seem like sci-fi or developmental determinism, but in fact it is the opposite of deterministic. The conversations with teenagers revolved around important matters like how they choose their friends, think about their parents, and understand their ethnic identity; how they see their current schooling as contributing to their future; what academic subjects they enjoy most and why; why gang violence exists in their neighborhood and what could improve the situation; and how they feel when learning about true stories the researchers shared of teens from around the world (for instance, the story of Malala Yousafzai as a young teen in Pakistan). Over the course of these private conversations, the participating teenagers revealed, through the narratives they told, their *dispositions of mind*: their inclinations to engage reflectively with issues and ideas, their tendencies to be curious and compassionate, and their proclivities to use what they learn to inform their emerging values. As the research team followed the teens over time into young adulthood, they could see how the patterns of thinking and feeling associated with these dispositions appeared to be influencing the growth of the networks of their brains.

What's more, a related series of studies by Mary Helen's team (Riveros et al., in preparation) is

showing that dispositions toward constructing such narratives can be developed, providing hope that changing educational practices to support the development of these dispositions could positively impact learners across ability levels and demographic lines. The implications for education could be powerful.

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The Stories Teens Tell

Although our coordinated neuroscientific and classroom studies are still in progress, educating for dispositions of mind is not new—in fact it is highly consistent with a century of educational research and theory (for example, Dewey, Montessori, Bruner, Perkins, Gardner), as well as with Doug's decades of experience working with successful progressive public secondary schools. But tying these dispositions to neural development, life success, and mental health gives this effort new urgency, and points us due north in an attempt to reimagine adolescents' schooling. Evidence suggests that educators can learn to recognize, model, and support the development of these dispositions if they know what kind of narratives to listen for and what kind of learning experiences lead to these patterns of thinking.

Consider the following quotes from young people participating in private interviews in Mary Helen's research lab, explaining why they

believe there is violent crime in their neighborhood:

"Why does it happen? Because they take actions or do things that don't benefit them. They just get caught up in the moment. . . ."

"I guess it's just bad decisions that they make and they have to suffer the consequences."

"They have, like, a lot of emotions. They're really mad so they just kill somebody. Like, overly aggressive, yeah. . . ."

Now contrast the previous three quotes with the following three:

". . . [Violence] is a cycle. Like if you really look at it . . . it happens probably because their family is in a gang and they just follow it 'cause that's their role models, where they came from. . . ."

"Everyone has a history. Like, everybody has an action or a choice, or some sort of history, some sort of thing happened to them that affects how they act in the future. . . ."

". . . Because many people say how Watts [a Los Angeles neighborhood] is really bad, and sometimes people who live there believe it, so they start doing the bad things [people] say they probably do. . . . I think, like, people do what other people think they do."

Our research suggests that the difference between the first three and the last three quotes is subtle but potentially critical—for psychological growth, social-emotional well-being, and for the brain. The first three youths' statements are correct, reflecting the proximal reasons for criminal acts. However, unlike the second three quotes, the ones in the first set do not reveal awareness of the bigger picture or the broader historical or cultural context in which individuals commit crimes. Yes, at the crime scene, the perpetrator "gets caught up in the moment,"

is “overly aggressive,” and makes a “bad decision.” But some teens talked also about how this criminal moment doesn’t happen in a vacuum; it is situated in a complex personal and community “history,” a “cycle” that is perpetuated by relationships, expectations, and what people come to “believe.”

The subtle distinction is between *concrete narratives* that address the emotions, actions, and consequences of the “here-and-now” (or “there-and-then”), and *abstract narratives* that incorporate reflections on the broader systems, processes, and contextual factors that transcend what is directly observable in a situation. This distinction turns out to be key, whether youth are talking about gang violence, school disciplinary practices, their hopes for the future, or what they are learning in academic classes.

This is not just about engaging students cognitively to build higher-order thinking skills or to think abstractly and metacognitively, though, of course, these are necessary aspects of deeper learning. Instead, adolescents on the path to higher levels of academic achievement and self-actualization showed cognitive and emotional dispositions toward both concrete and abstract *meaning-making* in their narratives. They constructed a compelling story for themselves that integrates information about the individual situations, facts, actions, and emotions that seem most salient, and then effortfully deliberated on this story by connecting to larger patterns, systems, beliefs, or values they have been exposed to that seem pertinent. The result is a narrative that explains the here-and-now in terms of a bigger, deeper, personally

relevant, and intellectually satisfying understanding.

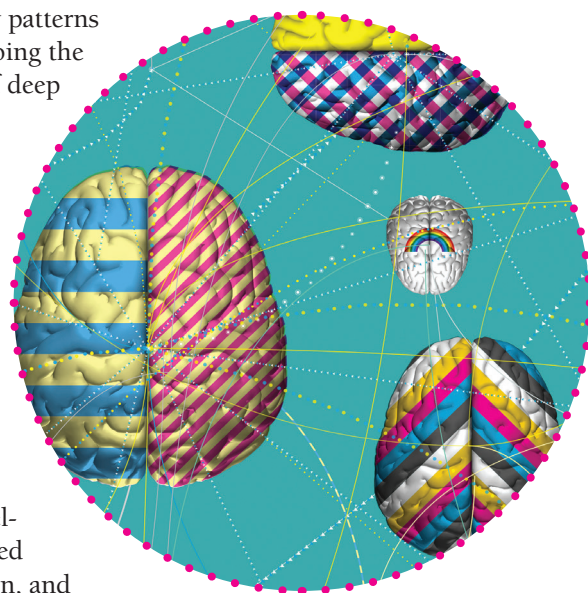
Make no mistake: It was not enough for participants to just have an emotional response, or to parrot words that indicated some level of interest, empathy, or understanding, saying what one thinks one should say. For kids to show these developmental effects over time, they had to also show the brain activity patterns that suggested they were doing the emotionally driven work of deep thinking for themselves.

Whole Brain, Whole Learner

Current studies are revealing that adolescents undergo major developmental changes in their brain *networks*—that is, in how the different regions of their brains “talk” to one another, co-regulate, and coordinate. These developmental changes are shaped by experience and education, and support intelligence and mental health (Immordino-Yang, Darling-Hammond, & Krone, 2018). Tighter communication across brain regions during this developmental period is thought to support teenagers’ blossoming abilities to infer, reflect, and make connections, and to enable the higher-level cognition that undergirds abstract narratives, including personal, cultural, and emotional meaning-making. It is important to note that, through their co-regulation and coordination, *each of the brain’s networks contributes to social, emotional, and cognitive functioning*—there is no one network or region that processes only one of these. It is the networks’ interdependence that strengthens the rationale for a whole

learner approach to education, and likely explains why, when done well, such an approach is so powerful.

Why is the narrative building process so compelling to teenagers, and so tied to their growth and well-being? In adolescence, the emotional engine that drives the hard work of learning comes from connecting the



goings-on, procedures, and tasks of the here-and-now to newly emerging big-picture ideas that, in essence, become a person’s abstract narratives. Crucially, these stories are connected to individuals’ sense of self and values, *and* to their scholarly skills, resulting in agentic scholarly identity, durable understanding, and transferable capacities. To get a sense of why, we return to the brain.

Changing Neural Networks

Mary Helen’s research builds on many others’ work to reveal three main components of narrative-building, supported by three of the brain’s major networks: affective

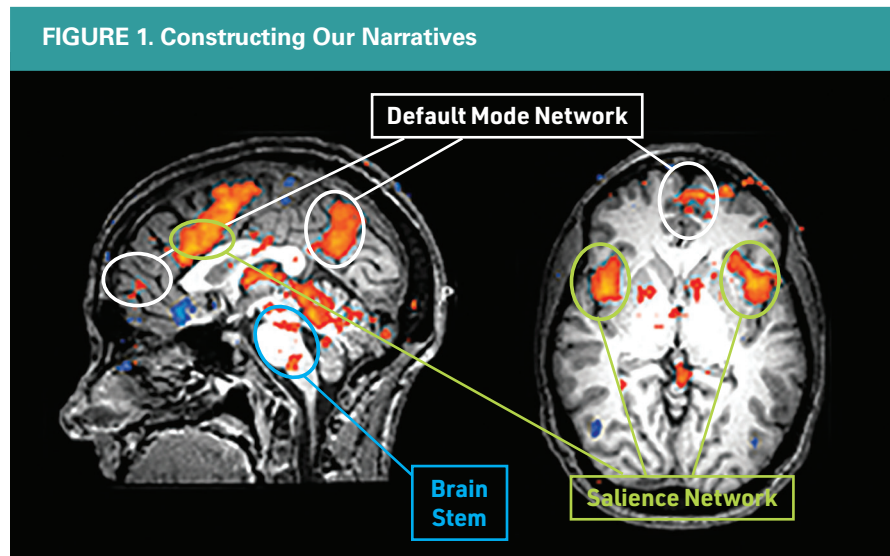
salience, effortful attending, and broader reflection (see fig. 1).

Affective Salience

Whether via concrete or abstract narratives, noticing the emotional implications of the stories and feeling emotionally moved was associated with increased brain activation in regions that communicate sensation in the “guts” and heart and that are involved in sensing internal body states. Among these are the brain regions that tell you when you have a stomachache or that your heart is pounding after running up the stairs, and those that make you feel a jolt of arousal when you notice something you care about, like that a favorite song is playing or that you’ve made an error. These regions together constitute the brain’s *Salience Network* (SN). The SN weighs the relevance and perceived importance and urgency of information to facilitate further thinking. One can think of the kids’ emotional engagement and SN activity as fueling motivated thinking, either concrete or abstract, like the outboard motor that both pushes the boat and steers it.

Effortful Attending

Concrete talk was associated with increased activity in the *Executive Control Network* (ECN). The ECN facilitates attention, allowing people to hold information in mind, shift strategies as necessary, and focus on the completion of goal-directed tasks. This network is important for ignoring extraneous information and distractions, regulating emotions, maintaining goals and focus, and controlling impulses. Tellingly, the results also showed that the more a teen had talked concretely in the interview—understanding the proximal issues at hand and



Thinking deeply is essentially telling complex, emotionally engaging stories to ourselves.

In research conducted by Mary Helen Immordino-Yang, individuals watched videos depicting true stories while undergoing fMRI scanning. When participants reported finding the story emotionally meaningful and personally relevant, the orange areas in the brain images above showed *coordinated activation*. These areas fall within the *Default Mode Network* and *Salience Network*, in addition to the brain stem, which is critical for consciousness, attention, and basic survival functions like breathing and heartrate. (The *Executive Control Network* was also involved but isn’t visible in these views.)

So, what does this coordinated activity mean? *The way individuals make meaning is cognitive and emotional at once—like a good story. And deep, meaningful thinking actually taps into basic survival processes, in essence making the thinker feel more alive, like their work is personal, and like what they think and do matters. No wonder adolescents can become so inspired and motivated when their work feels connected to big, life-relevant ideas!*

Source: Image adapted from Immordino-Yang, M. H., Darling-Hammond, L., & Krone, C. (2018). Data from Immordino-Yang, M. H., McColl, A., Damasio, H., & Damasio, A. (2009). Neural correlates of admiration and compassion. *PNAS*, 106(19), 8021–8026.

emotionally empathizing with people’s situations in the “here-and-now”—the better their relationships (such as with diverse peers and teachers).

Broader Reflection

Building abstract narratives—bringing to bear broader

interpretations and values and invoking systems-level explanations—was associated with increased activation in key regions in the brain’s *Default Mode Network* (DMN), especially if the teens also reported feeling strongly emotional about the story or issue. The DMN is activated when reflecting, imagining

hypothetical or possible future scenarios, remembering the past, and processing morally relevant information. It is important for conceptual understanding, reading comprehension, creativity, nonlinear and “out-of-the-box” thinking, for constructing a sense of self, and for feeling inspired (Immordino-Yang, 2016).

The most compelling results in Mary Helen’s research involved the changing “cross-talk” among the networks, and only revealed themselves over time. The more adolescents built abstract narratives and deliberated in emotionally motivated ways about the issues and stories we discussed with them (facilitated by the SN), the more growth they showed two years later in the *connectivity between the ECN and the DMN*. Even when teens just rested and daydreamed in the brain scanner two years later, the network that supports self-directed and regulated behavior and emotion, and the network that supports reflective, big-idea thinking, were better coordinated in teens whose narratives had been not just concrete, but also abstract. This coordination between ECN and DMN, in turn, predicted better personal and scholarly outcomes in young adulthood.

In short, though more research is needed and many questions remain, the findings suggest that adolescents grow the power of their brains (and selves) by thinking with and through complexity, cycling between concrete and abstract thought—and that this process both drives and is driven by their emotions.² Teens’ tendencies to engage empathically in the here-and-now helps them to manage, regulate, and maintain good relationships. But it is their growing dispositions to also transcend the here-and-now,

Effective education supports students toggling between the concrete and the abstract, the here-and-now skills (“fractions”) and the big ideas (“infinity”).

to build narratives that connect their skills to big ideas that reflect systems, histories, and values, that enables more fully their brain development and fulfillment in young adulthood. The implication is that educators must create cultures and learning experiences that enable this developmental process. Consistent with a century of progressive educational thinking, it seems to be that the *way kids think*, more than *what they know*, grows their brains over time.

Relevance Redefined

The transcripts and findings from Mary Helen’s research resonate with Doug’s experiences working in schools, including those associated with the New York Performance Standards Consortium, that empower adolescents to build strong relationships with peers, staff, and the content they are exploring together in-depth. These schools engage their students in choosing and pursuing open-ended, project-based coursework, and then leverage student interest to broaden exposure to new knowledge, concepts, skills, and questions. Ultimately, these schools expect and support their students to make sense of all that they are discovering through writing, problem solving, dialogue, and reflection, culminating in presentations and defenses of extended performance-based assessments in front of panels of teachers, external evaluators, and other students.

This kind of approach—rather than a predominant focus on testing—creates the conditions for adolescents to connect their emotional selves to their burgeoning intellect. Concrete and abstract narrative construction occurs in demanding yet pro-social schoolwide and class-specific cultures. This approach is specifically designed to help students affectively recognize the importance of academic issues and problems (think: Saliency Network). It then helps students leverage this affective momentum to iteratively cycle between effortful focus on building-block skills and information (think: Executive Control Network) and effortful (and empowering and often inspiring) abstract reflections that connect the work to big ideas relevant to systems and processes in the world (think: coordinated connectivity between the ECN and the Default Mode Network).

Consider the following student’s explanation of a performance-based math task about Zeno’s Paradox that he completed for graduation:³

I want to be the first person in my family to graduate from college . . . [but] I never even imagined I could reach that level of math. . . . Math at [my school] has helped me learn mathematically, learn how to think outside the box, in different strategies. When I was given a problem, I had to think in a new way, research ideas I don’t [sic] know before. I have spent two months working on a problem called “walking to the door.” . . . It led me to think about limits and the idea of asymptotes. I had to study fractions to

be able to think about the problem I had. Through doing the problem I got fascinated by finite and infinite. I was able to connect it to my life.

This student's narrative cycles in self-directed ways between concrete meaning-making ("I had to study fractions") and abstract meaning-making ("I got fascinated by finite and infinite"). Through exploring a big problem, but with support for specific skills as needed, this student felt compelled (rather than forced) to learn the necessary math skills, felt empowered (rather than threatened) to make choices, and felt as though the work "connect[ed] to my life." He had redefined math as relevant, exciting, and worth spending effort on.

Teaching to Transcend the Here-and-Now

Today, there is a renewed focus on whole-learner approaches in schools, districts, and philanthropy, though now with explicit commitments to cultural responsiveness, trauma-informed practices, and restorative justice. Our findings reinforce the importance of these efforts, which focus on pedagogies that support youth in reworking the kinds of abstract narratives they create to affirm their lives, experiences, identities, values, decisions, and possible futures. By situating daily happenings in systems-level contexts with bigger, personal meaning, these pedagogies support youth learning to engage with, but also transcend and eventually reinvent, the here-and-now. In the spirit of bolstering and broadening the current equity reform agenda, and of reimagining developmentally empowering education for all adolescents, here we outline three processes that educators can use to extend narrative building

The way individuals make meaning is cognitive and emotional at once—like a good story.

more deeply into academic content, and help adolescents shape their dispositions of mind.

The best education for adolescents:

① *Facilitates students building, sharing, debating, and defending strong, self-generated, and abstract narratives, while integrating core, challenging concrete content and skills.*

Effective education supports students toggling between the concrete and the abstract, the here-and-now skills ("different strategies," "fractions") and the big ideas ("infinity"). Note that this cannot be done in a culture of weak intellectual autonomy or tight social control, or with a focus on memorization/recall and test preparation. In those contexts, knowledge and skills are fragile, nontransferable, and uninspiring because they are overly concrete.

② *Enables students to expand the range of topics, skills, and ideas that they are capable of recruiting in the service of enriching and continually re-envisioning these narratives.*

A classroom and school culture of sharing and debating narratives about big ideas provides educators the chance to stretch students, and for students to stretch themselves and each other, as they explore less familiar terrain ("I had to . . . research ideas I don't [sic] know before"; "the problem . . . led me . . ."). The more students can tie big questions and abstract thoughts to the concrete content, procedures, and skills of academic work, the more likely

they will be to: (a) see the concrete content as salient and important (and therefore to work hard); (b) think about learning as a process, akin to a story, that takes time ("I have spent two months . . ."); and (c) begin shifting their dispositions of mind to see the allure and personal relevance of academic knowledge.

③ *Provides targeted, situated, differentiated support and instruction for acquiring the building-block skills necessary for accessing information, solving problems, and communicating with others.*

As adolescents deliberate on big ideas, they come to recognize the salience of concrete problems and tasks that help flesh out these ideas. As this happens, students' concrete tasks take on a new urgency. Because students are invested in understanding the big idea or problem, they return to the concrete tasks with a new determination ("I had to study fractions to be able to think about the problem I had . . ."). The teacher's role then is to provide the students the specific supports and resources they need to advance those skills, according to their individual skill levels and profiles. No small part of the teacher's task here is getting to know each student, and their interests and needs, well.

Reinventing Schools for Meaning-Making

New research on the connections between adolescents' narrative building and brain development aligns closely with old lessons from progressive practices. Adolescent learners thrive when provided an environment conducive to building strong, personal narratives that leverage the emotional power of big ideas and abstract meaning-making in the service of motivated work on

concrete tasks and skills. Presently, our public school system undercuts much of the approach we outline here, typically focusing on the here-and-now, the what-can-you-recall. Though student-driven approaches are often employed well in extra-curricular activities and nonacademic spaces like the arts and afterschool clubs (Mehta & Fine, 2019), success in academics overwhelmingly relies on fast and rote activities. Students build narratives anyway, of course—but these, sadly, do not usually point kids in enlivening and healthy directions.

Especially in an era when equity, academic achievement, and adolescents' mental health are of serious concern, it is crucial to understand that teenagers' narratives are the means they use to make meaning of their experiences, to invent themselves and their possible futures, and to learn. Although the process will be difficult, impacting all aspects of educational policy and professional training and supports (Forman, Knecht, & Fray-Oliver, 2020), it is time to enact holistic systemic approaches that make schooling meaningful. **EL**

¹The findings presented rely on the dissertation research of Rodrigo Riveros, Rebecca Gotlieb, and Christina Krone, and the work of Xiao-Fei Yang.

²These ideas build on the work of Kurt Fischer, of Harvard Graduate School of Education, Mary Helen's first mentor in the field. This article is dedicated in his memory (1943–2020).

³To see this and other students' presentations, go to <https://tinyurl.com/ubtz5x>.

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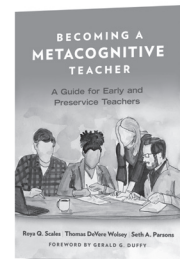
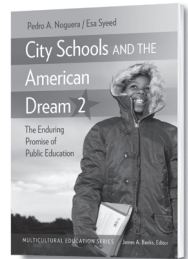
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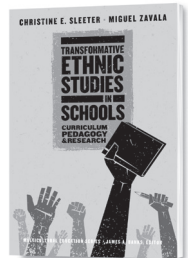
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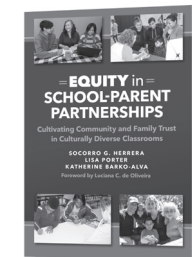
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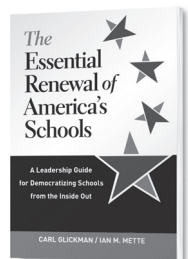
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