Q: Why do I have to keep teaching the same things over and over?

Jeff had a plan. He would teach his eighth-graders to write a paragraph in two weeks. He spent the first week reading and discussing paragraphs, presenting models from books of essays and from his file of successful student writing. He talked about topic sentences, supporting evidence, sentences that tied evidence to the topic idea, and summary sentences. In the second week, he led the class through the creation of a couple of group paragraphs, which he wrote on the white board as the students shouted out suggestions. They really seemed to get it. On Thursday, he assigned each student to write a paragraph to share with the class on Friday.

Following Friday's class, Jeff walked into the English department office and threw the papers on his desk. "You'd think they'd never seen a paragraph before," he shouted, his voice crackling with anger, defeat, and despair.

Jeff's voice is part of a choir of frustration heard in many faculty rooms and classrooms. "I keep having to teach the same thing over and over again." "We studied all that last semester. Why can't you remember it?" "They had that yesterday, and all but two failed the test today." "People, this should all be review. I haven't got time to teach it to you again."

These voices reveal some basic, usually tacit assumptions about learning, assumptions that have been passed on from generation to generation of teachers. They form the basis of how teachers have been taught to teach. For example, learning is the result of teaching. I taught paragraph writing—or addition or the Civil War or the preterit—last semester; therefore, my students have learned it or should have learned it. Frequently, teaching and telling are used as synonyms. Many teachers talk about entering the profession motivated by the generous desire to "share their knowledge" with students; they want to tell students what they know so that students will know those things. And, often, everyone (teachers, parents, even students) substitutes some form of the verb "have" for "learn" or "know" or "understand." Bill "had" it yesterday, as though a skill or concept is an object that is fixed and can be held or possessed like a pencil or a book. These voices also suggest that if students could perform some skill they "had" yesterday, like writing a paragraph or solving an equation, then they ought to be able to perform the same skill just as well or better today.

All of these assumptions suggest that learning means knowing stuff and doing stuff and that we can judge the knowing and doing using various tools (tests for concepts, or exhibitions for skills like writing).

Traditionally, schools treat this stuff as isolated bits that can be retrieved from memory, rather like pulling
an apple from a bag. Once it's in the bag, it is accessible. Those who fail to access it are lazy; those who fail to put it in the bag in the first place are stupid (usually couched in a more acceptable euphemism—challenged, working below grade level, less able, differently abled). Despite the progress of advocates for constructivist approaches to the classroom and for differentiated instruction, the persistence of the language that dominates the lamentations of teachers like Jeff, who struggle endlessly to design effective lessons, reflects the persistence of traditional assumptions about learning. "They had this stuff last week. They can't remember anything, and I can't teach it again."
UNIT 5: BUILDING NEW NEURAL NETWORKS

Section 2: Neural paths to understanding

Q: What is the difference between teaching and learning?

Based on research that reveals the connection between emotion and learning, we know that real, durable, meaningful learning is much more complicated. Although the process and experience of learning suggest the impossibility of separating emotion from thinking, it can be useful to explore and discuss cognition separately. Many scientists have done so for several decades, such as Kurt Fischer and his colleagues in the Mind, Brain, and Education Program at Harvard University.

These scientists theorize that learning anything requires that the learner build a new neural network. Understanding the Civil War, for example, requires building new neural networks for the Civil War, not just opening a conduit from the teacher's mouth to the student's memory bag and filling it with facts about the Civil War. This idea that learning skills and concepts involves the same process of building neural networks is essential to understand. Teachers have tended to distinguish between skills like writing an essay or solving for x and concepts like the causes of the Civil War—concepts that have traditionally been presented as "facts." Researchers suggest that conceptual understanding is a skill, rather than a thing. We may be able to memorize that osmosis is the passage of water through a semi-permeable membrane or that emotion is the rudder for thinking; but to develop a meaningful understanding of these concepts, an understanding that enables us to use the concepts creatively and in new contexts, requires that we build and rebuild the concepts, as well as build and rebuild understanding.

To develop meaningful, internalized skills, learners must actively build neural networks, a time-consuming process that results from the effort required for repeated trips over the same ground—to lay out the routes, mark them, clear them, create foundations, pave them, roll them several times, connect them, and add the signs, lines, and railings that will guide us when we revisit them. Each time we cover this ground, each time we rethink our way through the Civil War or try to write a paragraph, the network becomes...
more defined. Sometimes, progress is slowed by obstacles—a new idea or an old idea we thought we understood but didn't, or an inability to focus—but, over time, our understanding or skill deepens and improves. And because we are building these neural paths, these abilities, in our own brain, we must be active and persevere. No one can think or act for us (which further suggests the need for the goal to matter to us—to be emotionally relevant). Being told is not a substitute for learning.
Q: How do they understand it in class and fail the test?

Although this process of building new neural networks takes time and requires individual effort, it is also heavily dependent on the context in which the individual works—especially, the social and emotional supports in the environment. In schools, surprisingly, teachers often look at performance alone, independent of context. Jeff's frustration over his students' inability to write a decent essay at home after seeming to understand the process in class illustrates this tendency to judge performance separately from context. Jeff lost sight of the supportive context that he had created to enable his students to perform the skill in the classroom, so he didn't appreciate the debt their skill level owed to the conditions he had set up.

Jeff supplied critical help to ratchet his students' understanding and skill to a level they couldn't sustain without his support. He provided examples of good paragraphs and identified the elements that made them good: the topic sentence, the evidence, and the way all the sentences worked together. He gave them other examples and provided a structure and guidance to help them identify the elements that made these paragraphs effective. He is an energetic, entertaining teacher who cracked jokes and had selected paragraphs that were provocative or amusing, so the students were having fun. Then he prompted them through the creation of a group paragraph that he wrote on the board. In short, he raised them to a level of performance built on the scaffold of several elements: his presence, his doing much of the actual intellectual work involved in creating a paragraph, his priming key ideas and components of the paragraph, the collaboration of the other students, and a classroom atmosphere conducive to doing intellectual work.

(Opened ScienceTalk Sidebar)

Zone of Proximal Development

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Dr. Joanna A. Christodoulou works at the intersection of education and neuroscience with roles as a scientist (Department of Brain and Cognitive Sciences at Massachusetts Institute of Technology), clinician (Children's Hospital, Boston), instructor/professor (Harvard University: Department of Communication Sciences and Disorders at MGH Institute of Health Professions), and practitioner.

Imagine that you are in the company of a skilled teacher who makes concepts seem incredibly accessible and apparent. You leave a session with this teacher, attempt to explain what you learned to
Then quite suddenly, he pulled the scaffold away by sending each student home to write a paragraph alone. Writing a paragraph is a complex skill composed of many smaller skills: the ability to conceive of a topic, to organize an argument, to write sentences, to keep ideas in mind, to connect ideas, to recognize and use evidence, and many more. As teachers, we need to know what skills are embedded in our goals, what skills students bring to the task (likely somewhat different for each student), what skills they can reasonably be expected to do on their own, and what skills we are actually doing for them in the classroom. Could Jeff's students write a paragraph?

(End of first column online)

Well, yes and no. In the scaffolded context of the classroom, the students as a group, relying heavily on the teacher's support, could write a paragraph. But alone at home, they could not.
Most adults know, at least intuitively, that performance depends on context. For example, perhaps we have attended a lucid lecture about a complex topic, like the connection between emotion and learning. A good lecture provides an intellectual scaffold that enables us to begin to understand a new concept. It's as though we are hoisted onto someone's shoulders so that we can see beyond the usual crowd of familiar ideas and glimpse a new vista; we see it with exciting clarity—but only for as long as we stand on those shoulders. As soon as the lecture ends, as soon as we are put down again into the crowd, the vision begins to dissipate. In the excitement of the afterglow, we rush back to our school and attempt to explain to a colleague what we have seen, and it all falls apart. "It's so great. Emotion is so important to how we learn. It's like the rudder for thinking, so you really have to get the kids to be more emotional. But, no, I'm not really sure how it works with learning math."

The lecture allowed us just barely to begin to build the new neural network; it led us to the path and showed us its shape. But we must return to it again and again, building and rebuilding the concept a bit more facilely each time. We have to reread our notes, listen to the lecture again, read articles on the subject, discuss it with more knowledgeable people, try again to communicate to others our growing understanding, use the ideas to invent lessons, see what worked and what didn't, reread the articles, and go over our notes. Eventually, we may develop a decent neural network for this concept, but each time we need to use it, we must re-create it—reactivate it, rethink it. Although we become increasingly skilled, complex concepts must always be reconstructed. Building knowledge is a dynamic process, not a collection of static things that we store in a memory box.

And each time we reconstruct a skill, we do so in some sort of context that offers varying degrees of support for its reconstruction and various opportunities for reinterpretation (understanding it in new ways). If we are relaxed and talking with a colleague who is exploring the same idea, our reconstruction might result in new discoveries and a more substantial understanding. If we are being attacked by a parent who belittles the notion of any connection between emotion and reason, if we are late for a meeting, or if we just had a fight with our spouse, any weaknesses in our basic understanding will tend to loom larger and may undermine our attempts to reconstruct the pathway.

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### Glossary

**neural networks**
A term describing a conceptualization of how brain systems operate, which can refer to either biological systems of neurons or computational models of how biological systems operate.

**scaffold**
A term describing support offered by a learning partner (mentor, teacher, more experienced peer, or parent), which structures the context and environment in a way that facilitates learning for the student.
Q: How can I get students to do their best?

A lot of what happens in school involves measuring student understanding or performance, and most people view performance as a simple linear progression, a straight line that should rise steadily each time we perform. But it is important to consider the variability introduced by changes in context: Performance will vary as conditions change, so what does performance actually look like when elicited in a context? Kurt Fischer offers some useful models for understanding context-dependent skill fluctuation. The first captures the variability in performance over a relatively short period of time, whether 20 minutes, a week, or a few months.

When the context supports performance, our skill level increases. The context includes external factors (like the environment, the materials we have to work with, the amount and quality of help available) and internal factors (like motivation, mental and physical readiness). As these factors fluctuate, so does performance. In a context offering high support (either scaffolding that actually does some of the work for us or the optimal conditions for performing a particular skill), we will perform at high skill levels. At the scaffolded level (like Jeff’s classroom), the amount of sustained support leads to intermittent, unsustainable breakthroughs in the level of skill performance. At the optimal level (providing the most supportive conditions for a given task), the amount of support results in a high level of fairly sustainable but effortful and varying performance. In contexts of low support (the conditions of normal daily life with all its distractions and imperfections), we perform at a level that reflects the degree to which a particular skill has become stable and automatic—our functional level, the level that most resembles a linear progression.
knowing what's around us and the traffic laws—become largely automatic and stable. Over time, we become increasingly skilled, so our change in ability level, from a long-range view, resembles a steady linear improvement. However, if conditions change sufficiently—a blizzard, a fight with someone sitting next to us—our driving can suffer, and we will have to concentrate more to compensate for the change in conditions and to maintain our skill level. When conditions change dramatically, for example, if we are asked to drive a backhoe (to transfer the skill from the car domain to the backhoe domain), the new condition may prove so challenging that our ability to drive virtually disappears and must be rebuilt, with great effort, in the new context.

The optimal level reflects our best performance, the best we can do, because the conditions are the most supportive. Consider Joan, who is just learning to drive. At her functional level, she is able to start the car, put it in gear, and slowly drive from her garage 100 straight feet to the point at which her driveway meets the street, where cars whiz by in both directions. So, she stops, shifts the car into park, and lets her father take over. When her father creates the most favorable driving conditions by taking her to a clear, fairly straight, dry, well-lit, empty road and adjusts the seat and mirror to her needs, Joan can drive more skillfully—a bit faster, able to steer gradual turns and to vary her speed accordingly. It is these experiences of practicing the skill in the most supportive conditions that most improve her performance when she returns to the functional level.

(End of first column online)

At the scaffolded level, we are really just beginning to learn a skill or understand a concept that is beyond our current ability. Joan might have started to learn to drive as a young child by sitting on her father's lap and turning the key while he worked the gas pedal. She might have shifted into drive while he braked and then placed her hands over his as he steered. "Wow, look at you driving," her father might have said, but her functional level at that point was to sit in the car with the engine off and turn the steering wheel from side to side while making engine noises with her lips.

So, performance is always dependent on the context in which learners perform. The better the conditions, the better the performance—whether the performance is driving a car, regulating our emotions, writing an essay, or understanding a concept. In school, teachers constantly work to improve student performance; so, they tend to create conditions that result in optimal or scaffolded performance in the classroom in order to improve functional performance in the world. However, it's essential that teachers understand the differences in these performance-context relationships, and it is helpful for students to understand them, as well. Much of the frustration experienced by both teachers and learners results from failing to distinguish between what can reasonably be expected in each situation.

It takes time for a learner to build a new skill or understanding and become able to move from requiring scaffolding to performing skillfully without scaffolding. Teachers see this variability between optimal and functional frequently in the classroom. The teacher comes close to the student, gives a hint or two, and
the student's performance rises to optimal level. Then the teacher moves away, the hint-effect dissipates, and the student's performance drops to a lower level. Understanding the process by which skills gain stability—understanding why students appear more able when teachers provide support and expecting regression when they withdraw the support—can greatly reduce frustration.

In scaffolded conditions, the teacher is actually doing some of the work for the learner—whether it's steering the car, writing the paragraph on the white board, or providing the reasoning that produces an understanding of a concept like emotional thinking. The scaffolded skill level is barely sustainable even when the scaffold is in place, falling and rising wildly and sharply, and it collapses completely once the scaffold is removed. Skilled teachers remove the scaffold slowly both by transferring more and more of the actual work to the learner and by providing practice in multiple contexts. In essence, these teachers transform scaffolded performance into optimal performance.

For example, Jeff might have continued having his students write paragraphs in class, weaning them from dependence on him. After the white-board exercise, he might have asked them to work in small groups or pairs to create a paragraph. Then they might have worked alone, though still in the optimal conditions of the classroom, where they could ask a question and where others around them were engaged in the same sort of work. During this weaning process, their homework might have been simply to write topic sentences or to write a simple idea and illustrate it ("My brother is mean. Yesterday, for example, he tripped me when I..."), something they could successfully achieve at their functional level. In short, Jeff's students might have been more successful had they transitioned more gradually from scaffolding at school to soloing at home.

When performing at the optimal level, the learner is doing all the work, but the conditions are the best they can be to support that work. That is, the key components of a complex performance are supported or primed. During a 50-minute class, the students' performance will fluctuate because the skill hasn't become stable; the students are still learning; and as the priming varies over the 50 minutes, so will the performance—though, unless all support disappears, the performance is unlikely to drop down to the functional level. When the class is over and the support conditions are missing (say, at home that night), the students fall back to their functional level.

Over several classes in conditions supporting optimal performance, the students' skill becomes more stable; so each time they drop back to the functional level of performance, that functional level shows improvement. They become more skillful. The result is that, to those seeing these students performing over time, without any special support, the skill level appears to be improving gradually in what seems to be a linear fashion. Eventually, their functional performance becomes as skilled as their optimal performance used to be, but now they don't need those earlier supports. It's important to understand that this steady line of modest functional improvement over time results from more skillful practice at the scaffolded and optimal levels.
UNIT 5: BUILDING NEW NEURAL NETWORKS

Section 5:
Putting away the ladder: real development involves multiple strands and pathways

Q: Why is the ladder a poor metaphor for learning?

Whether it's the expectation that skill development is a linear progression or the idea that skills are separately built "up," the ladder has long served as a metaphor for learning and development. For example, traditionally, writing an essay is presented as a simple ladder of hierarchical skill development: sentence → brainstorming a topic → finding evidence → topic sentence → paragraph → five-paragraph essay → research paper. Despite knowing that writing is an infinitely messier process, many teachers continue to create syllabi that assume the learner must climb this ladder. Dynamic skill theory suggests a more useful metaphor: the web, which more accurately captures what happens in skill development. Each strand in the web is meant to represent a particular skill that develops and changes over time and in relation to other skills.

Imagine that the web above represents Sarah, a high school junior who has become a good writer, and that this web provides a picture of the interrelated skills for her development as an essayist. At the top, perhaps in early adolescence, three separate skills are developing: writing, interacting with friends, and playing board games. What happens is that these skills, though perhaps starting to develop separately, branch out and intersect, helping to inform, develop, and support each other (and produce other skills unrelated to writing—for example, persuading her parents to give her more social freedom). Sarah writes pretty good grammatical sentences, and she develops a real knack for helping her friends, who tend to bring their social problems to her. She helps them solve interpersonal difficulties, such as what to say to parents who won't let them do what they want. It is this social skill, Sarah's ability to persuade, that comes to inform her understanding of how to use specific evidence to develop a paragraph topic and, thus, improve her writing skill. Meanwhile, her developing skill as a chess player begins to inform her ability to think strategically both in social situations and as a writer.
The ladder as metaphor fails in two main ways. It misses the variability involved in developing a skill like writing by presenting it as a single ability when, in fact, it is the result of the interaction of several developing strands of skills, some of which we might (erroneously) not even consider relevant to writing. The ladder also fails because it suggests that there is some universal, standard ("normal") way that a skill develops—one syllabus for all. In fact, although there may be many similarities in developing a particular skill, the differences are important.

Let's look at a typical situation. A history teacher assigns a research paper to her juniors. "Write a paper on Andrew Jackson and the significance of his policies when he was president." One student, Judy, has real analytical strengths. She has a knack for getting to the heart of arguments, and she is good at Latin and geometry. As a child, she enjoyed sitting with her parents and working on the household budget, an interest that led her to board games and an understanding of rules and procedures. Now, she enjoys reading about economics and has a growing understanding of people's spending habits. As a result of this web of skills, she writes a strong analysis of Jackson's economic policies and their significance for the country.

Bob, another student, has very strong social skills. Not only is he a leader in school government, but he also shows real promise as an actor in school plays and is good at English, where his teacher praises him for his insights into character. As a child, he developed strong skills for taking the emotional perspectives of others and for understanding why people make the decisions they make. He enjoyed keeping an introspective journal and loved to play with words, eventually learning that people's words often reveal their motivation. His essay explores Jackson's personal life and the significance of his policies as a reflection of his character.

Both Judy and Bob used their strengths, their interests, and their way of seeing the world to solve the problem presented by the teacher's rather open-ended assignment. The result was two very different, legitimate essays. Had the teacher restricted the assignment—for example, to Jackson's military strategy—the challenge might have resulted in less success. Judy, especially, might have struggled, though perhaps she could have found a new entry point in her affection for and knowledge of board-game strategy. Bob might still have been able to see Jackson's character reflected in his military decisions.
Skill Web for Bob

In this second hypothetical diagram of skill interactions, Bob displays an alternative approach to an essay assignment on the impact of Andrew Jackson’s policies. Unlike Judy, this student...

View larger image

Glossary

Dynamic skill theory
A theory put forth by Kurt Fischer and colleagues describing concepts (and methods) for understanding how cognition and emotion impact development and learning based on assumptions of individual variability and interactions with context and environment. In the context of learning, dynamic skill theory posits levels of development and dependence of performance on context.
UNIT 5: BUILDING NEW NEURAL NETWORKS

Section 6:
Skill development

Q: How do we build new skills and understandings?

Not only is a skill such as writing the result of an interaction of a web of skills that inform and support each other, but is also the result of a building process that resembles the classic children's construction game involving knobs joined by inserting sticks into holes to create various two- and three-dimensional structures.

Skill theory suggests that cognitive development involves building connections between skills and ideas, a process of coordinating skills into more complex mental units. For example, consider a baby learning to fill a cylinder with blocks.

Building a Skill System: Knobs and Sticks

As suggested by skill theory, cognitive development involves forming connections between units of skills to develop increasingly complex skills. The construction of a cube in the classic...

View larger image

Johanna and Her Mother

At less than a year old, Johanna demonstrates how simple skills are combined to build more complex skills and how our ability to perform skillfully depends on context. Watch this video twice, first...

View video

The process begins at the most basic level with simple independent reflexes like grasping, looking, moving, or vocalizing (making a noise that signals some sort of need). Then two reflexes are coordinated so that the baby grasps a block in order to look at it, or stops vocalizing in order to move the
 developed a system of coordinated activities, goal-directed actions that allow her to fill a cylinder and to get help from her mother for the steps she cannot complete alone. This system is represented by the cube in the picture above.

This process of building skills (abilities or conceptual understanding) becomes increasingly complex as we mature, moving from reflexes that are coordinated into actions (infancy), actions that are coordinated into mental representations (childhood into early adolescence), and representations that are coordinated into abstractions (early adolescence into early adulthood). Finally, in domains in which adults have significant expertise, abstractions can be coordinated into principles.

At each level, the process of building the system (the metaphorical cube) of coordinated skills is repeated so that at the start of each new tier, the cube from the previous tier becomes the single skill unit for the next tier. That is, simpler skills become absorbed or nested within more complex ones.

This model is intended to suggest that building new neural networks of skills and concepts depends on making connections between simpler elements in order to build more complex abilities and understanding. We move from perceiving and acting in the physical world, putting together several actions, to creating mental representations of the world that we can manipulate in our mind, and then move on to abstract concepts or principles that explain domains like algebra or the biology of learning. We move from actually adding blocks to a cylinder to being able to imagine putting blocks into the cylinder, at which point we understand the concept of blocks in a cylinder and can use language to refer to this concept. We move from counting the blocks as we put them into the cylinder to
mentally adding 2 + 2, to understanding the difference between adding and subtracting, to making sense of the relationship between the addition-multiplication concept and the subtraction-division concept, and then it's on to solving for x.

On the surface, this process may sound, again, like a simple ladder, but it's really more like a set of Russian nesting dolls—simpler skills nested within more complex skills. From the perspective of teaching, the key is to understand how more complex concepts and skills emerge from the connections between the simpler pieces that comprise them. In order to become a good writer, what skills have to work together along the way? In order to write an essay about the significance of the policies of Andrew Jackson, what teams of abilities and understandings do my students need to have yoked together? For example, have my students understood Andrew Jackson's actions and their impact on different groups of people in the short term and over time? Have they, in fact, developed a meaningful and useful sense of what "significance" even means?

Of course, as we have seen, students' ability to write this essay also depends on two other critical variables: the web of skills each brings to the task and the level of support of the context in which each works. Judy and Bob created very different essays based on their particular skills and ways of looking at the world that resulted from their experiences. These are part of the contexts responsible for the quality of their essays. There were other factors, as well. Perhaps Bob worked in supportive conditions—in a quiet library—while Judy worked in the less supportive conditions of home—in the kitchen with her three little brothers running around and the television blasting from the living room. Given all these factors, it's not difficult to understand the inadequacy of the ladder as an image for learning.
Q: What is failure?

People hate failure. In school, failure is a major source of fear and frustration for students and teachers alike. Our attitude toward failure may well be the result of the ladder metaphor's implication that good learning and, therefore, good teaching, are marked by steady forward progress toward mastery. "They learned this last week, and today it was as though they had never seen it before." Yet, regression, or performance that is typically misinterpreted as failure, is both inevitable and necessary for learning.

Once we understand the connection between performance and context, the inevitability of regression becomes obvious, especially in school, where teachers work to create conditions that support scaffolded and optimal performance. If conditions change, for example when the support of the teacher is no longer available or motivation wanes, performance falls back to the functional level. Moreover, conditions constantly change. Sometimes, they change within us, when we don't get sufficient sleep or become upset or bored. Even our most basic skills, like our ability to walk, can regress under the pressure of traumatic conditions. Some parents, for example, at the funeral of their young child have fallen to the ground and crawled because they quite literally lost the ability to walk for that moment, reminding us that in extreme conditions even seemingly simple automatic skills degrade into their underlying basic skills.

Sometimes, conditions change because the domain in which we are asked to perform changes: driving a backhoe is not the same as driving a car. Although a skilled adult driver may more quickly learn to operate a backhoe, at first he may look like a child—exploring the various levers, lurching forward, and stalling the engine. Furthermore, writing a science lab report is not the same as writing a history paper or when trying to compose a letter explaining personal feelings to her father.

Even when teachers sustain or successfully re-create highly supportive conditions within the same domain, their students' performance will fluctuate, showing signs of improvement and regression—two steps forward, one step back. That's the rhythm of learning, the rhythm of constructing new neural networks. It's a process of building and rebuilding that allows us to continue to improve, each time advancing a bit further from a more solid base. Integrating skills into increasingly complex systems of representations and then abstractions is difficult work, involving considerable trial, success, and error.
Each success brings us closer to the limit of our ability or understanding until we stumble, go back a bit, and start again—learning from both our progress and regression and slowly building stable neural networks.
UNIT 5: BUILDING NEW NEURAL NETWORKS

Section 8:
Implications for schools

Q: What is a teacher's job?

Principles to consider:

- Teachers cannot transmit knowledge to learners.
- Learning is a dynamic process of building and rebuilding new neural networks.
- Performance depends on context.
- Students need to learn to create contexts to support their own learning.
- Skills tend not to be isolated abilities learned in a linear fashion but webs of interrelated abilities.
- Learning new skills and concepts depends on coordinating more basic skills to form increasingly complex skills.
- Regression is essential to learning.

Teachers cannot transmit knowledge to learners. Knowledge isn't an object that can be passed on or held. The idea that concepts are skills that need to be built and rebuilt is fundamentally different from the idea that concepts are static things that can be placed in our memory for future use. Although memorization may sometimes be useful, it cannot substitute for building the neural pathways that create understanding. So, the student's job is the building, or the learning. The teacher's job is to create the conditions that support learning. If we think of schools as contexts for learning instead of places for teaching, we might effectively imagine new approaches not only to the classroom, but also to all aspects of schools—the physical and social, the policies and practices, the attitudes and metaphors. We need to replace the language of teaching with the language of learning.

Whether we can do something depends on the context in which we do it; whether we know something depends on the context in which we think it. In a world preoccupied with assessment—a world in which grades are the coin of the realm, traded for access to colleges and the jewels of capitalism—teachers need to consider carefully exactly what they assess and what factors have produced the test, lab, or essay in front of them. Let's look back at the essays on Andrew Jackson written by Judy and Bob.

Each essay emerged from a different web of skills that resulted in different approaches to the problem of making sense of Jackson's policies, an assignment that the teacher left typically vague—"Write a paper on Andrew Jackson and discuss the significance of his policies when he was president." Judy's essay was quite analytical and looked at economic policies and their effect on subsequent events. Bob was more interested in the man himself. Bob discovered significance in Jackson's policies as a reflection of character. It would be nice to believe that the teacher could see the merit in both approaches,
but the teacher, too, brings a web of skills and a way of looking at the world (too often unexamined) and probably had an ideal essay in mind. The grades of the two students will likely reflect the interaction of the teacher's web and the students' webs, and Bob might not fare as well as Judy.

Other factors will also affect the quality of the two essays and the perception of the quality. How developmentally ready are Bob and Judy to write an essay of this complexity? What level of performance is each capable of under supportive conditions in each of the skills required to produce such an essay? Has the teacher consciously identified those skills and helped Bob and Judy identify them? How developed is each student in terms of making conceptual links between and among the more basic skills embedded in the larger skill of writing a research paper in history? Has the teacher aligned his expectations with the contexts in which Judy and Bob worked and helped those students learn to build supportive contexts for themselves?

(End of the first column online)

Another critical job for teachers is to help students learn to create for themselves the conditions that support their own learning. For example, Laura Moore, an English teacher in Massachusetts, has worked for years helping students to become "attuned to their own writing process, to become increasingly aware of it, and to become adept at manipulating it, an effect which is achieved through daily self-assessment, introspection, and reflection. I tell them to pay attention to how, when and where they do their work; what kind of work they do in those conditions; and the successes and failures of that use of time. Some students find they write best in the early mornings or in the afternoons, in the back of the library, or late at night at Barnes & Noble." See article, "Student-as-Text: A Sustainable Philosophy for the 21st Century English Curriculum: Timeless Lessons in the Fully-Examined Life."

Frequently, students with some sort of diagnosed learning difficulty have been taught to ask a teacher for certain "accommodations" that will enable them to perform successfully. They understand their own brain, understand their need for more time, a quiet place to work, or a certain structure that will help them complete a long, complex assignment. Many adults eventually learn what conditions support their best work. In fact, some adults have learned to create scaffolds for themselves: They let spell-check recognize errors that they are unable to see for themselves; they let the computer voice read documents to them; or they design organizational templates to use whenever they tackle a large project. Schools might profitably spend more time helping all students explore, discover, and create the conditions that enable them to do their best work.

Perhaps the largest ethical issue is the challenge of how to grade regression. Although this cycle of moving forward and backward and forward is the natural rhythm of learning, many teachers perceive regression as failure and a source of personal frustration. For the most part, grading systems reflect the traditional models of education, which do not take into account productive regression. If assessment is continuous rather than just an end-point to mark that learning has occurred, regression becomes natural and expected, and a learner's skills can be assessed in a more process-oriented way.

The new models of cognitive development—the web, the connection between performance and context, the tiers of development from reflexes to abstractions, the more basic skills connected and nested within more complex skills, and the necessity of regression—are rich in implications for schools, but fundamentally they suggest that learning is slow and hard. It takes time. The old linear models—the ladder, the isolated skills, knowledge as objects stacked in memory boxes, performance as a steady rise
regardless of context, and teachers talking—imply that learning can move along pretty quickly and that everyone can move at pretty much the same rate. The clash between these models presents exciting opportunities for rethinking how schools manage and use time.

Finally, it's essential to remember that, although we are looking at cognitive aspects of learning in this unit, emotion remains an equally critical factor. Research into the processes of learning suggests that learners must do the work of learning, the hard work of building neural networks. At the same time, we know that people tend to work hard only when the work matters to them, a trait that reminds us that cognitive development must always be considered in the context of the emotional goals it serves.
UNIT 5: BUILDING NEW NEURAL NETWORKS

Section 9: Resources


