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The Challenges of Learning and Design

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[Learning organizations are] organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together. (Senge, 1990/2006, 3)

Suppose, for a moment, that we were asked to design an organization that would enable adults and young people to develop and exercise their capabilities as learners— nothing more complicated than that. In other words, suppose we were asked to design a learning organization. Suppose also that this organization was an embodiment, at the collective level, of what a healthy, engaged learner would look like at the individual level. That is, it would be an organization in more or less constant engagement with its environment, capable of more or less continuous adaptation in concert with its surroundings, and more or less agile and flexible in its ability to adapt its internal structures and processes to what it learns through this engagement. In other words, this *learning organization* would look and behave like a highly evolved learning organism, constantly adapting and changing in response to its collective aspirations and its capabilities as a learner.

A major premise of this book is that the physical environments in which we learn should reflect our most powerful aspirations and our most promising ideas about learning. A corollary of this premise is that our most powerful ideas about how learning occurs are constantly changing in response to new knowledge and our experience adapting our learning practices to the practical demands of daily work. In an ideal world, schools and the systems in which they are embedded would model for the rest of society what learning should look like. In the real world, schools often model what learning used to look like in a world that no longer exists. What would it look like if schools, as intentional learning environments, actually became "learning organizations" in the sense defined above? They would not just be places where adults and children engaged in predictable patterns of activity grounded in past practice; they would be places where the very definition of what learning is, and how it is enacted, are themselves the result of constant learning— from research, from experience, from observation, from aspirations, and, possibly, from wondering. Wondering whether we are ambitious enough in our understanding of learning as a human activity.

In this chapter, I will ask my readers initially to consider five propositions about what it means to treat schools, and a number of other learning environments, as learning organizations. I will then offer a framework for analyzing a range of ways in which learning occurs, and the organizational structures and processes underlying those learning modalities. Finally, I will offer a set of preliminary design principles, drawn from current research on learning, that can inform the practices of building and sustaining learning organizations. I conclude with a set of challenges for the future design of learning environments.

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Five Propositions

To be clear, "learning" in the context of this chapter, is the ability of humans to consciously modify beliefs, understandings, and actions in the presence of evidence, experience, and reflection. A later section of this chapter expands on this definition. For the moment, it is sufficient to observe that, according to this definition, learning is an activity that humans pursue out of evolutionary, biological, and practical necessity. "Design" means the intentional use of cultural, behavioral, and physical norms and structures to achieve a desirable result, individually and collectively. Learning is central to the evolution and survival of the human species. Design is the means by which humans intentionally create various means and modes of learning.

Five Propositions About Learning and Design

(1) *Understand and appreciate how the existing design of schools reflects present and past theories of learning*.

The daily demands of work in schools are not necessarily conducive to reflection on organizational design. More likely, people learn to adapt to the structures and processes they are given; at most, making marginal adaptations to accommodate individual differences and preferences in practice. For most educators, the design of learning spaces is not the result of conscious action, but a "given," in the same sense that the water in an aquarium is for the fish that swim in it.

In fact, the existing design of schools is the accumulated residue of thousands of choices, deliberate or not, over decades of daily work. The cellular structure of classrooms, for example, embodies a theory that learning should occur in a physical setting in which an adult typically supervises a group of students for a particular period of time. The array of classrooms along hallways is a way of managing and controlling the movement of students in more or less predictable ways through the course of the day— embodying an explicit theory of custody and control in a physical environment. The presence, or absence, of dedicated workspace for adults, individually or collectively, embodies a theory of how adults interact, or not, with each other and around their work with students. The degree to which teachers "own" the space they teach in, and treat it as their personal preserve, represents a complex set of agreements over the private use of public space. The separation of administrative functions in dedicated spaces embodies a theory about the division of work between those who work directly with students and those who supervise that work— a division that separates learning work from administrative work, spatially and culturally. The physical arrangement of space within classrooms, and the variability among classrooms in how space is used, communicates how adults think about learning and how the organization as a whole treats individual and collective theories of learning. The fact that these theories underlying the design of schools may have receded into a fog of unconsciousness for people who work in schools does not mean that they aren't powerful determinants of how we define and enact learning.

The first step in understanding the relationship between learning and design is to treat familiar patterns of organization and practice as default theories of learning. They exist because they represented, at some point in time, a defensible theory of learning. There is no such thing as a "neutral" learning environment— a physical and cultural space that can accommodate any conceivable theory of learning. The fact that the environment is familiar does not make it functional as a learning environment. Not all theories of learning are adaptable to all physical environments, and vice versa. The structure of the environment constrains, shapes, and represents the definition of learning that occurs within it. [2]

(2) ***The deliberate design of learning environments requires a reversal of the traditional relationship between learning and schooling***.

The conventional way that educators have thought about the relationship between learning and schooling is to ask how our best ideas about learning can be made to fit within an existing cultural, physical and organizational model. "Innovation" in schooling is typically conceived as changing practices within an established, fixed form of organization, or at most making marginal adaptations within a fixed physical and organizational structure to accommodate incremental changes in learning. Deliberate design requires starting from a set of principles—a theory of learning— derived from research, reflection on practice, aspirations and action-forcing questions, then creating structures and processes that accommodate those principles. In conventional innovation, learning adapts to schooling; in deliberate design, learning precedes and informs structures and processes that enable learning. (See Elmore 2018 and Ellis, Goodyear and Marmot 2018a and b)

It is one thing to state this proposition, and quite another enact it. In advanced societies, education is a heavily institutionalized sector, which means that the structures and processes by which the sector is governed and administered carry with them a particular mindset that values predictability and stability. Furthermore, the physical and cultural constraints on learning represent heavily institutionalized interests, ranging from local governance structures to organized interest groups to commercial interests to powerful political interests. A shift to deliberate design requires a shift in mindset, from predictability and stability to informed choice and adaptation, from established patterns and procedures to flexibility and responsiveness, from established "truths" to inquiry and questions.

Deliberate design often involves, as we shall see, a painful reckoning with the difference between the espoused and enacted beliefs that characterize institutions. Specifically, schools may be idealized in institutional rhetorical as places where learning occurs when, in fact, their primary social function may be the allocation of privilege in society.

(3) ***Multiple modes of learning require multiple modes of practice and multiple modes of organization***.

As we shall see later, learning is a basic human activity that occurs naturally in many forms, individually and collectively, throughout society. (National Research Council 2000). Schooling, on the other hand, is a particular, institutionalized form of learning that occurs in an institutionally-defined sector, with its own structural and procedural imperatives. Human beings have come to embody, through evolution and practice, multiple modes of learning, some of which can be accommodated in formal institutions, some of which require modes of interaction that are much more fluid and loosely distributed.

The deliberate design of learning environments requires an understanding of the full range of modalities of learning, not just the familiar, established modalities. Powerful design is expansive rather than exclusive in its focus, accommodating the full range of ways in which humans engage in deliberate learning. Design is about expanding rather than containing learning, opening access rather than controlling access, adapting to differences in learning modalities and preferences, rather than restricting modalities and controlling preferences.

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[2]David Tyack analyzes the relationship between "reform" and what he characterizes as "the grammar" of schooling"— deeply embedded structures and norms—in Tyack 1997.

Again, this shift is as much, or more, a shift in mindset as it is a shift in technical or managerial practice. A design mindset carries with it a different, broader vocabulary of alternative forms for organizing learning, coupled with a deeper appreciation of the breadth of human capabilities for learning and for exporting opportunities to learn in a broader, more diverse human environment.

(4) O*ur knowledge of learning itself is changing as our ideas about how to organize learning are changing; different contexts require different solutions to common problems*.

Conventional ideas about "innovation" in schooling embody what might be called an "implementation" mindset. That is, a new idea about learning becomes embodied in a particular set of practices and those practices are implemented in schools and classrooms. The idea of implementation carries with it the requirement of fidelity to the original practice and the notion that "successful" innovations are ones that can be implemented "at scale." Good innovations are ones that can produce more or less identical replicates in multiple locations across different social and cultural contexts.

As our knowledge of learning increases, the implementation mindset becomes less and less useful. Despite our best efforts, our best ideas produce highly variable results in different contexts, depending on the capabilities, preferences, and conditions under which real people try to adapt them. At the same time, research on the neuroscience of learning, as we shall see, is leading away from the expectation that standardized responses to individual learning differences will produce robust results. We are living through a period in which the basic science of learning at the individual level is growing at a fast pace and our understandings of differences among individuals and between individuals and the context in which they learn are increasing. While the implementation mindset might be a convenient fiction for a highly institutionalized sector, like education, it is an increasingly limited mindset for thinking about learning. (See Honig, ed. 2006)

Robust designs for learning in this context are ones that deliberately design for change and uncertainty, for contingency and adaptability to specific individual and contextual differences, for questions rather than answers, for curiosity and wonder rather than settled assumptions and conventional wisdom. In other words, robust designs are design that enable deliberate learning over time in the face of changing knowledge, rather than implementing solutions to past problems.

(5) M*etaphors matter*.

We have known for decades, thanks to the work of cognitive psychologists and neuroscientists, that human beings rely heavily on metaphors to make sense of the difficult and tangled realities of daily life and problem solving. (Lakoff and Johnson 1980/2003) Metaphors have many functions, but among the most important is their ability to make deliberate, symbolic simplifications of complex problems, and to make those simplifications available as guides to understanding and action. Metaphorical thinking is deeply embedded in the language we use to make sense of our lives— "that music left me floating on air," "I left the meeting feeling like the rug had been pulled out from under me," "garbage in, garbage out," etc. Metaphors can be useful in helping to ease the transition from a stable, predictable environment to a more uncertain, less predictable environment in which opportunities for learning will abound, but safety and security are less available.

Let me propose one possible metaphor for the situation in which we currently find ourselves around the conceptualization and design of new learning environments. The metaphor derives from the physics of changes in the state of matter. In the physical world we experience solid things (the table on which my computer is sitting), liquid things (the coffee in the cup on the table), and gaseous things (the air that is circulating through the room) as distinctive states of matter. We are comfortable with these distinctions in everyday life because they behave predictably and we don't have to spend a lot of time worrying about whether they will change at random— the table will probably still be there tomorrow morning when I wake up.

For a physicist, however, this stable, predictable world is a boring illusion. What the physicist sees is a world that is constantly in flux, in which changes in the state of matter are occurring all the time in various forms in response to various changes in conditions. Highly elaborate crystalline structures turn into amorphous fluids that, in turn, transform into gases, all with the addition or subtraction of energy. The physical world is full of a massive number of these transformations, each one unique in the form and nature of the transformation, each one worthy of detailed description and study, each process leading to a a new set of questions about the subtleties and differences among different types of transformations. [3]

One could think about the transformation of learning in society in a similar way. As an advanced economy and society, we have come to associate learning with a stable, enduring crystalline institutional structure that is more or less comprehensible to those who inhabit it and that embeds a metaphor in our minds that (we think) helps make sense of how a certain part of the world works, and relieves us of the more complex task of understanding how learning actually works as an individual and social activity. But with a relatively modest shift in metaphors, from a stable crystalline structure to a continuum of states of matter from the stable, to the malleable, to atmospheric, we would see learning in an entirely different light. We would see it as a naturally-occurring human activity, driven by biological and evolutionary imperatives, that can— and will— take an infinite variety of forms, some of which we can deliberately shape to specific human ends, if we understand them. We can choose, first, not to be constrained by one particular state of matter, and second, to exercise human control and agency to shape new organizational forms that capitalize on the natural variation in states of learning.

In the following section, I will lay out a simple framework that accomplishes a couple of purposes. It helps describe the familiar, highly institutionalized forms of learning, but it does so in a way that, I hope, makes the familiar look and feel a bit strange. Making the familiar strange is an important step, I think, in "unfreezing" the crystalline structure of institutionalized learning and beginning to imagine more agile and fluid organizational forms. Another purpose of the framework is to begin (and here I stress *begin*) to capture other forms of learning that are abroad in society and to suggest how they might be incorporated in to our thinking about the design of learning environments for the future.

A Four-Fold Framework [4]

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[3] For a review of research on the relationship between organizational form and environment, see National Research Council 1997, especially Chapter 1, "Organizational Change and Redesign," 11-38.

[4] This framework was originally developed for the Harvard X online course, Leaders of Learning. Elmore 2015-present.

First the simplicity, then the complexity. The archetypal four-fold table is a way of incorporating a modest degree of complexity into a relatively simple model. To do so, however, requires some deliberate over-simplification, which we'll have to adjust for later.

The simple version goes as follows: You can think of the social organization of learning along two broad dimensions: (1) the degree to which learning is organized hierarchically or in a more distributed, lateral way; and (2) the degree to which we think of learning as a primarily individual activity versus a more collective, social activity. *Hierarchy*, in this model, has a couple of meanings: it captures that sense in which learning is considered to consist mainly of the transfer of knowledge from one who is assumed to have it to one who doesn't; it also captures a form of organization of learning in which there are differences in status and authority between those who have knowledge and those who don't (yet, at least). *Distributed*, in this model, captures the idea that knowledge is not contained in any one place or institutional structure. It is, instead, available in a variety of different forms from a variety of different sources, some requiring human interaction, some through various social artifacts. *Individual*, in this model, focuses on the motivations, actions, and choices of the individual as determinants of learning. *Collective* focuses on learning as an activity resulting from various forms of social interaction.

[Modes of Learning Graphic About Here]

Each quadrant can be characterized as an "ideal type," an example that characterizes its essential characteristics. The upper left quadrant can be thought of as the classic comprehensive middle or high school. It is hierarchically organized in the sense that it typically entails traditional administration-teacher, teacher-student relations. It is primarily individually competitive in the sense that students are judged individually according to their academic performance by traditional measures. The learning model here is essentially one of knowledge transfer: information organized around a structured curriculum is transferred from teachers to students, and becomes knowledge by assimilation (or not). Success in this model is judged by attainment— the accumulation of course credits, grades, and test scores. This accumulation is thought to embody society's definition of "merit." That is, people who accumulate more of the valued indexes are thought to be "better" and "more deserving" of status than those who don't.

The lower left quadrant is the more "progressive" version of the upper left. It still embodies the traditional adult-student, administration-teacher relationships, in the sense that the organization works primarily as a hierarchy of status and position and knowledge is assumed to flow from adult to students in a structured way. The distinctive difference between the upper and lower left quadrants is that the upper left is an individually competitive model, where the purpose of schooling is to make distinctions among students based on various measures of academic "merit," whereas the lower left quadrant emphasizes socialization to a set of collective social norms, based on adults' visions of a "good" society. Learning in this model is equally about meeting adult expectations for academic performance and assimilating demonstrating social values in students' behavior. The ideal type in this quadrant might be John Dewey's vision of schooling as preparation for democratic citizenship, or alternatively a school founded and run by a religious community.

The important distinction here is that the left-ward quadrants embody society's vision of what educational sociologists have called "real school"— organizations with hard physical boundaries in which adults and children engage in purposeful, structured activities, and learning is valued for its contribution to socially-approved academic, economic, social, and cultural norms. These values and norms are quite literally transferred from adults to students, by teachers who claim their authority by appealing to governmental bodies or other organized collectivities. Learning, in this domain, can only occur as a result of an activity called teaching, and teaching must involve authoritative judgments of students, based on the values of the organization. Those authoritative judgments are thought to embody society's definitions of merit.

The authority of schools in the left-ward quadrants stems from two important sources: (1) the power of the state to compel participation of children in schooling— what I will call "custody and control;" and (2) the power of educational institutions at multiple levels to determine what constitutes valuable learning, and the rewards that accrue to that learning— what I will call "attainment." These sources of authority run deep in the social order of advanced societies. It is, for example, difficult for most adults to imagine something called "learning" happening in any fruitful way outside the boundaries of something called a school, despite the fact that the vast majority of what people learn does not occur in school. It is difficult for society as a whole to imagine a world in which children are not under the custody and control of an institution called school for something in the neighborhood of 16,000 hours of their prime years of development, yet most of the developmental growth that children experience occurs before they enter school and outside school after they enter. The left-ward quadrants exercise enormous influence and control over society's understanding of learning.

Shifting from the left quadrants to the right quadrants means crossing a boundary that is unfamiliar in most discussions of organized learning but often quite familiar in terms of peoples' experience as learners. When I do clinical work with educators on learning I often ask them to identify the most powerful learning experience they have had in the last six months or a year and to describe it in detail. The first few times I did this I was shocked by the results, but I have now come to accept the dominant pattern. The overwhelming pattern of responses is that adults describe very powerful, often transformational, learning experiences that have nothing to do with any formal organizational structure, much less their own schools. They describe things like physical and cognitive transformations necessary to master a musical instrument in mid-life, the deep impacts of caring for an elderly parent or a disabled sibling on their identities and interpersonal skills, the shift in consciousness required to master an unfamiliar cuisine, the curious reorganization of the cognitive and somatic parts of the body involved in trying to do yoga, etc. When we debrief these discussions two important themes typically emerge: (1) these are "powerful" experiences because they require people to exercise agency and control over something in their lives that has meaning to them; and (2) the value of these experiences is deeply individual, involving choices and values that are often outside the familiar routines and relationships in their daily lives.

Shifting from the left-ward to the right-ward quadrants involves shifting from a view of learning in which the value of knowledge is not mediated by authoritative institutions to one in which value is determined by its utility and meaning, broadly-defined, to the learner. In this model, when we say that learning is "distributed," rather than hierarchical, we mean that agency and control over what is learned and how shifts in important ways from institutions to learners. The upper right quadrant is the most extreme form of distributed learning, in which the learner decides what learning has value in a highly individualized way and sets about acquiring knowledge through whatever modalities he or she chooses. The range of learning modalities is determined by a combination of opportunity and preference, all under the learner's control— books, articles, on-line text and video resources, lectures, individual tutorials, casual group discussions, peer-to-peer relations, etc. The actual modalities of learning in this quadrant are less important than the skills required to exercise agency, choice, and judgment in the purpose of learning and the evaluation of sources. It is tempting to think of the ideal type in this quadrant as the archetypal nerd in sweatpants and hoody sitting in front of a computer, oblivious to the world at large. In fact, the growth of learning in the digital space has accelerated the growth of individually-driven learning immensely. Driven by flexibility of format and rules of engagement, the demand for learning tailored to individual utility and preference has become the norm in the digital learning space. If you are struggling with factoring quadratic equations in your middle school algebra class, not only do you now have the option of learning the operations on-line, unconstrained by the time, personnel, and physical space of schools, but you can choose which of a number of platforms and modalities best adapt to your learning needs. Furthermore, there is no prescribed curriculum structure to tell you that it is "inappropriate" to drop into a lesson on differential calculus until you have successfully taken and "passed" a battery of pre-requisite courses. It you are interested in the mathematics of acceleration or how to compute the area under a curve, you can find somewhere to learn it in a couple of keystrokes.

The lower right quadrant takes us into the distributed/collective world of voluntary communities of learners, joined in various degrees of loose and tight networking around domains of knowledge in which individuals share a mutual interest. In the upper right quadrant networking as a form of organization is implicit in the technology. In the lower right quadrant networking is in the foreground as the dominant form of social interaction around knowledge. Working with schools and teachers in the dusty agricultural Central Valley of California, I discovered that the dominant form of organized learning for adolescents and college undergraduates was what I came to call the "Starbucks Circle." I would routinely walk into a local Starbucks in the early morning hours or the mid-afternoon and see groups of largely Latino students sitting in homework circles (yes, teachers, they actually do share their homework) and study groups loosely organized but deeply engaged in learning. It was clear from my conversations with them that they viewed this form of organization as a survival mechanism in a world they perceived as largely indifferent to their needs as learners. The variety of networked learning communities is infinite, largely due to the flexibility of networked structures in accommodating diverse interests and levels of engagement. The important contrast here with hierarchical forms of learning is that networks can accommodate vastly different levels of expertise in areas of common interest so that the flow of knowledge among participants is very fluid and efficient. People can find others in the network with a command of knowledge close enough to their individual zone of proximal development so that they can learn something of value without having to go to a single source.

The lower right quadrant is now the dominant form of learning and knowledge transmission in advanced research and development fields. Most university professors, professional practitioners, research and development experts, and entrepreneurs operate in highly-networked environments, where their success depends on their ability to build relationships of mutual benefit across domains of knowledge and levels of expertise. The kind of learning required to master these skills cannot be contained in conventional forms of organization. It can, however, be learned, through sustained engagement and practice, through the development and use of agency and choice, and through the cultivation of insight and creativity. One has only to look at the design of physical and digital space surrounding major research universities to see this model in action. Private companies' research labs are located cheek by jowl with university labs organized around transportation and communication hubs, all linked globally through high-speed digital environments working 24-7 on the transfer of information among nodes in complex networks.

As noted above, any schematic model compromises the true complexity of learning as an individual and social activity. But there are ways in which this schematic helps us understand important design decisions. One way it helps is to reinforce the idea that design decisions have real consequences for the development and growth of human beings as learners. By design decisions I mean choices about which modalities of learning are important to cultivate and nurture and which physical, organizational, social and cultural affordances go with which modalities of learning. My experience working with educators is that they tend to think that any modality of learning can be made to fit into any standard form of school organization, and the evidence is that this is clearly not true. Let me illustrate: "Blended learning" is now a popular adaptation of technology to conventional schooling. Advocates of blended learning think it is a major innovation. In most instances, what blended learning means is that students engage course material online before or after class time, typically in lecture form, so that class time can be used for less structured, more discussion oriented learning. In terms of the Modes of Learning framework, this version of blended learning is not really very innovative at all. First of all, the whole activity is embedded in a hierarchically determined structure of control and attainment, so that choice and agency on the part of the learner occurs, if at all, in a carefully scripted setting. Second, the technology is used to reinforce a hierarchical modality of learning (knowledge flows from the teacher to the student); the only thing that has changed is the means of transmission, from lecture to video clip. Third, the modality of learning actually increases adult control over student choices by requiring students to engage a larger share of their discretionary time in adult-controlled activity. These features may be regarded positively in a hierarchical learning environment, but they are hardly "innovative" in a broader framework that sees the individual learner as the central agent in learning and development. Design decisions have real consequences for learning, whether they reinforce existing modalities or disrupt them. Often we confuse any kind of change with changes in learning, when most "change" is designed to reinforce existing modalities of learning.

Another useful contribution of the framework is to provide a clearer way of differentiating learning, as an individual and social activity that occurs in society at large, from schooling which, at least in its existing form, is a highly institutionalized form of learning. The big design questions for the future will revolve around the relationship between schooling and the broader, more extensive, increasingly fluid and responsive learning sector. These will not be easy questions to answer, much less to translate into useful, functional, inspiring physical designs for learning environments. One way into these questions is to take a provisional look at the future of learning through the lens of current research on the neuroscience of learning.

<u>The Future of Learning</u>

Learning is the ability to consciously modify beliefs, understandings, and actions in the presence of evidence, experience, and reflection. [5]

We live in a world in which learning is largely defined by institutions and the organized interests these institutions represent. We are emerging into a world in which learning, as a human activity, is increasingly escaping the bounds of institutions, and in which the stakes for individuals and for society at large increasingly depend on our ability to understand the many forms and modalities of learning and to create access to those forms through the use of design. The future of learning for society as a whole depends on our ability to disentangle our understandings of learning from its institutional constraints and to imagine a future in which designs for learning follow and enhance the actual contours of human capabilities.

The definition of learning above collapses a vast welter theory and research, and, of necessity, leaves out much of the conflict and disagreement over the meaning of learning that has occurred historically. It does, however, reflect a view of learning that represents the current convergence of thought among behavioral psychologists and students of the neuroscience of learning.

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[5] This is essentially what experts in the field of learning would call a "functional" definition, meaning that it stresses learning as manifest in changes in behavior over time. For a development of this view and its alternatives, see De Houwer, Barnes-Holmes, and Moors 2013.

One way to understand the significance of this definition is to say what it does not include—that is, what learning is *not*. Primarily, and most controversially, in this definition learning is not memory, in the usual colloquial sense of that term. Memory is an important cognitive process by which knowledge and experience are encoded and stored for later use, but learning is not synonymous with the capacity to remember things. The reasons for this distinction run deep in theory and research, but the simplified version is that it turns out that memory— the ability to remember and repeat things experienced in the past—is a very unreliable proxy for actually knowing things. Memory, it turns out, is not just the storage and retrieval of facts and experience. Memory is a jumble of initial experience, combined with and corrupted by all subsequent recall, new information and experience related to the initial experience, continuously revised by all future experience. Memory plays a role in learning; memory is not, itself, a reliable proxy for learning. (Schacter 2001, Kandel 2006) Indeed, one whole line of empirical research on memory and learning involves the productive role that forgetting plays in the learning process, as it introduces pauses to revisit and reconcile earlier understandings and misconceptions, and results in “interleaving” of prior and subsequent learning with earlier memories. [6]

Nor is memory a unitary phenomenon. Long-term memory, the most unreliable form of memory, is quite distinct from working memory, which might be thought of as the just-in-time workhorse of active learning. Judy Willis, a clinical neurologist who also became a classroom teacher, gives the most lucid account of how memory works as an aid to learning. For Information to make its way through working memory into long-term memory, it needs to find a place in an existing neural network that, in effect, creates meaning for the learner. That is, it has to have some correspondence to some prior knowledge or experience (no matter how unreliable) in order to work its way into conscious learning. From there, in order to be useable in any longer-term sense, it has to be recreated and reinforced in relation to other new forms of information and experience through repeated practice. All of this has to be encoded and related to some positive sense of accomplishment and pleasure. Memorization, Willis argues, tends to stress recall rather than meaning, and recall tends to reside mainly in short-term memory, which has a very short half-life (around twenty minutes, she argues). (Willis 2006, 5ff) Teachers I have observed and interviewed often express frustration with how little of what they think they have taught is actually retained for any length of time by their students. It’s hardly a mystery why this happens when most of the tasks I have observed involve either assimilating and repeating information in relatively short cycles, or “practice” at reproducing information on worksheets. In these instances, what children are “learning” is not the actual content but the practice of engaging and disengaging their short-term memory in repeated cycles.

This distinction between memory and learning is very practical. When I code teacher-student interactions in American classrooms, it turns out that something like 60-70% of the tasks that students are asked to do are memory and recall tasks. They consist of teachers asking students to do things and then asking them to perform tasks that demonstrate whether they remember how to do them. There are important variations in this pattern among schools and classrooms as well as internationally, but in the U.S. the functional definition of learning in classrooms turns out to be remembering and repeating stuff that the teacher or the textbooks have told you.

Another important distinction that arises from this definition is that learning is a highly individualized activity, heavily influenced by experience and practice over time. The complexity of this process cannot be captured by simple schematic input-output, or stimulus-response

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[6] See, for example, Robert Bjork’s lecture, “Forgetting as a Friend of Learning: Implications for Teaching and Self-Regulated Learning,” October 13, 2013, Harvard Initiative for Learning and Teaching, https://hilt.harvard.edu/event/dr-robert-bjork-ucla .

models, where a standard experience produces a reliable response on the part of the learner. Again, this is important to understand because a very high proportion of teacher-student interactions in U.S. classrooms assume that every student will assimilate a body of information in a more or less standardized way in the same amount of time. We routinely make judgments about the competence of students as learners by how well they meet specific learning goals on a standard timeline according to a standard model of "age-appropriate" expectations. The research on learning as a developmental activity does not support this view, but the bureaucratic necessities of schooling require it.

Finally, it shouldn't need to be said, but this definition of learning excludes the idea that learning is the simple transmission of information from one person to another. Learners are active agents in the reception and processing of information, not passive storage units. Their capabilities as learners depend crucially on the active development of strategies for integrating new information and experiences into existing understandings and prior learning experience.

The definition also tells us something about what learning ***is*** as well as what it is not. Learning is a cumulative developmental process that occurs over a life course. Central to this process is the concept of *neuroplasticity*. [7] It turns out that accomplished learners continue to develop neurologically— literally increasing, pruning, connecting and elaborating networks of neurons into more efficient and powerful patterns— well into adulthood and old age. This process results in something neurologists elegantly call *arborization*, or the elaboration and integration of increasingly dense neural networks around highly specialized cognitive and affective functions. (My neurologist once complimented me, after an fMRI, for my "nice arborization." It made my day, whether true or not.) These processes look differently at difference life stages— brain mass actually decreases, by a process called "pruning"— from adolescence into adulthood as we become more efficient at processing various types of experience. The fundamental process of increasing neurological efficiency through practice and use is robust over a lifetime. In this sense, learning is a life practice, and humans make choices over a lifetime about the degree to which they engage in this practice. The cultivation of practice is central to the activity of learning. Practice is a lifetime project.

Learning is a biological and evolutionary necessity. Humans have evolved into learning organisms by engaging in activities that have caused increasingly complex forms of perception and cognition to develop. Humans have had to overcome enormous physical disadvantages, relative to other species, in order to survive and develop. They have done so largely by compensating for physical limits with cognitive and social skills. Most of this development has occurred as a result of direct experience through the deliberate activity of making and modifying our environment and the things in it. In this sense, learning is not something that occurs only in specific settings at a specific times. It is a more or less continuous process growing out of physical necessity that occurs whether we choose to engage it or not.

Humans are distinctive among other species in their capability to consciously modify the ways they engage and experience their environment, and, in this sense, they can channel and manage learning in deliberate ways for specific purposes.[8] Humans are also special in that they are capable to developing conscious perception and understanding of themselves, their

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[7] Kaas 2001 defines "neural plasticity" as the development and elaboration of connections among neighboring neurons in response to "events in the external environment," and as "essential for the normal development of the brain, creating the differences in those circuits that make us individuals."

[8] For a riveting account of how this human capacity for self-conscious growth and modification of cognitive and emotional capabilities has developed and evolved, see Damasio 2010.

identities, and their capabilities as human actors. The parts of brain that manage this process specialize what neuroscientists call *executive function*. Highly-developed executive function is a key marker of high capability as a learner. We have learned to use learning as a way of creating value, sustenance and pleasure, which means that deliberate, conscious pursuit of and control over learning can become self-reinforcing. We learn because it gives us pleasure, and the pleasure we experience from learning causes us to seek more learning. To the degree that we engage in activities that, intentionally or not, inhibit or discourage the pursuit of pleasurable learning, we are stalling and deflecting human evolution.

Learning is a somatic and tactile activity as well as a cognitive one. A major field of inquiry in the neuroscience of learning is *embodied cognition*,[9] which studies the relationship between the extended physiology of the body with the brain and its cognitive functions. A major finding of this research is that, in some as yet not fully understood way, we "think" not just with our brains but with our bodies in concert with our brains. In this sense, "experience" is not simply encoding and making sense of our perceptions in daily life, but also understanding how our ability to consciously engage and modify the environments we live in increases or inhibits our ability to learn and develop. Making and modifying things is a major way we "learn" through mind-body connections.

It should be clear by now that learning is a much broader activity, requiring and inviting a much broader definition of learning environments, than simply "doing school." One very useful metaphor that captures this idea is Alison Gopnik's wonderfully evocative distinction between the carpenter and the gardener. (Gopnik 2017) Gopnik is a neuroscientist who studies learning in children from birth to age five— that is, before learning becomes confounded with schooling. The findings of this body of research can only be described as amazing. She presents an inventory of the ways in which infants and pre-schoolers develop highly complex perceptual and cognitive capabilities that we have previously attributed only to adults. One astonishing finding, for example, is that children begin to develop something called a "theory of mind"— that is, the ability to distinguish between their own thoughts and the possible thoughts of others with whom they engage— as early as eighteen months of age, a faculty that had been previously identified with much later stages of development. We have failed to understand these important developmental patterns in large part because we have, in the past, relied heavily on research methods that require high levels of language development on the part of subjects. When you correct for this bias, it turns out that you find amazing neurological and cognitive complexity, including powerful capabilities for learning, in very young children that were previously attributed to adults.

Gopnik uses the metaphor of the carpenter and the gardener to frame the developmental project of human learning. Carpenters build to purpose and plan. Their materials are inert and must be combined and modified in order to produce a product. The results of their work are concrete and tangible objects that either function or not. If they don't function, they can be modified or built to a different plan. Gardeners, on the other hand, have to operate in partnership with nature in order to accomplish their goals. Their task is to understand, through study, observation and practice, how live organisms live, grow, and adapt to often quite specific variations in their environment. Their results vary from one plant to the next, from one season to the next, and from one year to the next, often depending on imperfectly understood and complex interactions between plant and environment. Gopnik uses this metaphor to explain how viewing learning and development of children is trivialized and stunted by build-to-plan models of parenting and schooling, and how understanding infants and children as resilient, competent, highly-evolved learning organisms operating in a variety of environments can teach us how build their capabilities as learners. This core idea of infants and children as

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[9] For an accessible discussion of the neuroscience of embodied cognition, see Claxton 2015.

learning organisms, of course, has a long history—Gopnik did not invent it. What is novel about Gopnik's approach is that it is backed by deep research on the actual neurological development that occurs as children evolve their capabilities as learners, and how consistent these patterns of development are with what we know about how human beings have evolved as a species.

Gopnik makes a particularly acerbic critique of "parenting" manuals that stress abstract models of child development and build-to-plan views of raising successful children. Her critique also extends to scripted instructional practices in schools and to highly-structured, attainment-based models learning. Gopnik's argument is a preview of a looming split between emerging research on the neuroscience of learning, on the one hand, and the existing conventional wisdom about standards, rigor, and relevance in American educational reform. Americans have never been particularly adept at incorporating serious scientific inquiry into the design of schools, and the growth of knowledge in the neuroscience of learning poses little or no short-term threat to schooling in the U.S., because neuroscientists are too busy doing research to develop models of clinical practice that threaten standard educational practice. Sooner or later, however, there will have to be some reckoning with or rejection of the emerging findings of the neuroscience of learning.

Here are a few principles that might begin to guide experiments in the design of future learning environments:

<u>Human beings are learning organisms</u>.

Millenia of human evolution have biologically programmed human beings to learn. In some basic sense, humans do not need to be "taught" how to learn. They are equipped to learn from birth. By age five or six they have already mastered the two or three of the most complex cognitive and emotional developmental tasks humans confront— the development of language, the ability to differentiate themselves from others, and the ability to manipulate their human and material environment for purposeful ends. The job of adults, care-givers, and society at large is to engage with, to encourage, to support, and to develop this innate biological drive with sufficient curiosity and humility so as not suppress and disable it. For better or for worse, the real developmental work of learning— the complex project of learning how to become a competent and powerful learner in the world— must be done by the learner herself. We can construct environments that enable and support this work, we can populate these environments with people who have the competence and humility to model what powerful learning might look like, and we can exercise restraint in our own urges for custody, control, and judgment, but the work of turning curiosity into competence lies with the learner.

A major lesson we have learned from attainment-driven models of schooling is that it is possible to disable human beings as learners by convincing them that they do not have the capability to manage their own learning. Attainment models require failure as a condition for success; models in which everyone is assumed to be competent in different ways at the same critical task called learning are considered to be flabby and to lack sufficient rigor, merit, and legitimacy. They are suspect because they challenge the existing distribution of privilege. The social costs of this model are horrendous. The question is whether those costs matter enough to open up the design of learning environments to more divergent thinking. The knowledge base is growing, the creativity exists, the future is uncertain. [10]

<u>Individual variability is the rule, standardization is the exception</u>.

Accepting the reality that humans are learning organisms carries a formidable cost in terms of our existing models of learning and education. We have chosen to organize institutionalized learning around 19th century models of human development and capability. Organizational structures are deeply entrenched in age-grade theories of human development; assessment and clinical treatment models are based largely on psychometric techniques that assume a normal distribution, despite the existence of alternative modes of assessment and practice; policies dictate attendance and compliance measures that require participation in age-grade structures regardless of the value they add; physical structures mimic the architecture of custodial institutions. These structures and processes are so heavily institutionalized that they will not be transformed on any time scale that is consistent with the development of new knowledge about learning.

The solutions to this predicament, in the foreseeable future, lie in the development of existence proofs of learning organizations that switch the order of standardization and variability. Initial designs will have to take their point of departure from the assumption that individuals—children and adults—come to the learning project from different points of origin developmentally and experientially. It is possible to create a common culture of learning as building on individual differences in a common culture of commitment to learning, but that requires treating each learner as a project in human development, rather than treat children as if they were representatives of predictable age-grade groups.

<u>Knowledge equals information plus affect plus cognition plus fluency</u>.

The late Albert Shanker, a powerful spokesperson for teachers over his lifetime, was fond of saying: “I taught the content, but the students didn’t learn it. Define the meaning of ‘teach’ in that sentence.” Shanker’s observation captures one of the fundamental problems with attainment-driven learning. Attainment-driven incentive structures reward the accumulation of credit and memory-based performance, rather than the more complex neurological skills of self-organization, curiosity, executive function, and fluency through practice. The teachers I have worked with routinely use the term ”information” as if it were the object of teaching, as in “I have only so much time to get the information across before I have to move on to the next topic.” This largely unconscious trope suggests that learning is a process of absorbing discrete bits of information; students are like sponges with varying capacities for absorption; the “best” students are those who are quickest at absorbing and repeating on command the information that teachers impart.

In fact, fluent and powerful learners tend to be highly variable in their absorptive capacity, depending on how interested they are in the knowledge they confront, how the knowledge domain matches their previous experience as learners, and how well they can use the skills of their previous learning to solve the puzzles of acquiring new knowledge. A common complaint of undergraduate college and university faculty (and, I can attest, graduate faculty as well) is that their students seem not to have mastered the pre-requisite content that is represented on

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[10] A remarkable demonstration of the costs of the attainment model and of the remarkable resilience of human beings who have “failed” in that model is Mark Katz’s study of children who fail in school and succeed in adult life. (Katz 2016) Katz, a clinical psychologist, documents the range of strategies that his clients have developed to overcome the stigma of failure in school and develop their capacities as learners and as active agents in their own lives.

their high school (and college) transcripts. Between three quarters and one quarter of the students who have completed the demanding “A through G” high school curriculum requirements for enrollment in California higher education institutions are required to take non-credit remedial courses to correct for the pre-requisite knowledge they are supposed to have already mastered in high school. [11] (California Legislative Analyst March 2017) Faculty at elite universities have begun to require students who have achieved high scores on Advanced Placement tests— which are supposed to carry college credit— to take entrance exams for basic course content in their disciplines before they will accept their scores. Clearly, there is a difference between ticking boxes on a prescribed curriculum and knowing stuff at even a modest level of fluency. Clearly, the expectation embedded in the attainment model that “good” students are equally knowledgeable across a broad collection of domains doesn’t seem to hold for a substantial proportion of young people.

The obsessive focus on curriculum content and the transmission of information in the attainment model runs against the grain of what we increasingly know about how fluent and accomplished learners operate. They tend to follow their interests, often obsessively, in ways that educators find a bit scary. They are good at following cues that lead through successive layers of complexity in a given knowledge domain. They develop heuristics for deciding what is relevant, interesting, and useful information, based on schematic models of the knowledge domain they are working in. They cultivate the capacity to relate new information to their fund of existing knowledge. Most importantly, they are passionate about what they are learning. In other words, information becomes knowledge when it is captured by a learner who is affectively engaged and deliberate in the acquisition of fluency in a given domain. No one becomes a fluent learner in a field they find repellent. No one becomes a fluent learner following a script they had no role in creating.

There is a version of this model that can be described as brain chemistry— certain hormones and neurotransmitters are stimulated by engagement in certain kinds of activity, which lead to the engagement of cognitive capacity and the development of increasing complexity of neurons dedicated to the acquisition and processing of information in a given domain. (See Damasio 2010, 67-94) You don’t need to know the brain chemistry to know that highly-motivated, fluent learners tend to be people who exercise deliberate control of their immediate learning environment, and for whom the pleasure of finding the next thing is the main source of their motivation.

Depth and continuity over coverage.

A wise psychotherapist, Deborah Britzman, has described the experience of schooling as “an avalanche of certainties,” a tsunami of answers to long-forgotten questions. (Brtizman 2009) I recall sitting in a high school chemistry class being lectured on Boyle’s Law— that the pressure and volume of a gas are inverse to each other at a constant temperature— and thinking to myself, “how in the world did Boyle figure this out,” while other more disciplined students dutifully reproduced the formula and the teacher’s explanation in their notebooks. The riveting story of an amateur scientist in the 17th century puzzling over a question few people had thought to ask would have been considered an unfortunate distraction for a beleaguered science teacher who was already a week behind the syllabus for the year. Most school-based science had, for me, this quality of “stuff to be memorized” with little or no reference to how the science came about or what scientists actually do. I did reasonably well in “advanced” science courses as a student, but I was unmotivated by answers to which there seemed to be

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[11] The proportions are: three quarters of community college entrants, about 40 percent of state college entrants, and about one-quarter of entrants to the elite University of California campuses.

no prior questions, or, more specifically, no human beings asking questions. I have since spent on the order of 150 hours or so observing, recording, and analyzing middle- and high school math and science classrooms and what I observed accords with my own experience in school. More importantly it accords with aggregate data on American classrooms and with the observations of the practitioners I have worked with. There are, to be sure, exceptions— some of them spectacular examples of learning how scientists actually work and what mathematicians actually do. The exceptions are a tiny proportion of the total, and they prove the rule. Fine-grained observational studies across broad samples of classrooms confirm wide variability in levels of cognitive challenge from one setting to another, skewed significantly toward the less-challenging end of the distribution. (Hill, Blazar, and Lynch 2015)

My own experience learning mathematics is instructive. Math was not my favorite subject, to say the least. Every math course I took after my freshman undergraduate year was always going to be the last math course I would ever take. But I was an uber attainment junky, which meant that I continued to take math courses through college into graduate school because to do so made me part of a privileged class of people thought to be deserving of higher status. One day, when I was 27 years old, in graduate school at Harvard, I walked out of an econometrics lecture on some hopelessly obscure topic I can't recall, and I approached one of those incredibly complicated traffic intersections near Harvard Square. It suddenly occurred me with an electric jolt, as I observed the drivers orchestrating their behavior through the intersection, that "math is everywhere!" I realized that I could actually build a model using the language of mathematics that would describe what I was seeing. Some years later another insight hit me with equal force: why did I have to wait until I was 27 years old, doing time in one increasingly obscure and terminally boring math class after another, to discover that math is a language can be used to discover and describe the world? Virtually all the math I studied, because I had to, has receded into an obscure fog. What remains, for me, is a more or less fearless disposition to see the world through a series of frames, one of which is the language of mathematics. I could have learned that disposition in the early years of elementary school, in a decidedly different learning environment. Math, in my student world, was less a language for exploring and understanding the world than it was a way of culling the herd.

Our confounding of learning with course-taking, transcript-building, test-taking, and status-marking has led us away from a central insight of neuroscience, which is that human beings develop and build their capabilities to sense and understand the world through the acquisition of multiple "codes" or symbolic languages. We do this through exposure and practice, but, as my own example attests, simply being exposed to a broad range of languages doesn't mean that we learn how to use them to understand the world. In this sense the brutal emphasis on content coverage inherent in the attainment model undercuts the more fundamental task of building capability and fluency in *any* useful domain. We have a lifetime to learn. The disposition to see the world in particular and useful ways is something that can only be learned through depth and practice, not by racing through a syllabus. I would have become a much more engaged and competent mathematician if, at the age of five or six, I had been given a clip board, a pencil, and sheet of paper and asked to go out and count something in the world that mattered to me and to explain what I saw and why it mattered. Not fancy enough for this hyper-institutionalized world in which the Common Core specifies something like twenty discrete math competencies that children should have mastered by age nine. [12]

Learning and Design: Hard Questions, Provisional Answers

[12] see: http://www.corestandards.org/Math/Content/3/introduction/

Ambitious ventures in uncertain times begin with hard questions rather than clear answers. We are entering a period when, for better or worse, the meaning and practice of learning in society will be transformed. The problematical democratization of access to information through digital culture will not be domesticated through established institutions. That genie is out of the bottle. The monopolization of access to learning by established institutions cannot be sustained for long in a world where individuals will have access to the world's experts in any given domain of knowledge with a few keystrokes. The hard boundaries of credentialing embedded in the traditional attainment structure will not survive a world where learning is a life-time project in which failures at one phase of life can stimulate transformations at later stages, and in which the knowledge and skill requirements for a productive life will change many times over the course of a generation. These dramatic changes remind one of the apocryphal Chinese curse, "May you live in interesting times." Interesting, indeed. But also exciting and promising.

Through the lens of learning, then, here are some hard questions that might shape our future discussions and projects around the design of learning environments:

How will humans adapt to transformations the practice of learning?

If learning is the active creation, pruning, elaboration, and consolidation of neural networks what will the practice of learning look like in the future? If "memory" of facts and information, algorithms and models, is a few key strokes away in the digital cloud, how will the practice of learning change? If the cultivation of the practice of learning becomes the object of learning, rather than the accumulation of information and algorithms, what will formal learning look like at various life stages?

One clear implication of these questions is that the physical and cultural design of learning environments should accommodate more or less continuous adaptations to emerging knowledge and insights around the practice of learning. To reiterate an earlier theme, the project of designers and practitioners of learning is to make the familiar strange, to question how established structures and practices of learning influence, predetermine, and constrain what human beings think is possible, and how designs can encourage a disposition for surprise at what human beings are capable of doing: Physical space as site for thoughtful observation of learners at work, for reflection on the dispositions and competencies of individual learners, for learners to operate at different levels and trajectories in their development of the practice of learning, for learners to tutor and coach each other in their practice.

How will the practice of learning and the design of learning environments adapt to the democratization of expertise?

However one might feel about, the debate about the survival and ubiquity of *Wikipedia* is over; the arguments now revolve around how to sustain, monitor, and improve the medium as a self-organizing learning environment. *Wikipedia* is only one among thousands of examples of the emerging importance of self-organizing learning networks. If you are the parent of a middle-schooler struggling with how to factor a quadratic equation, at last count, you have a choice of several dozen different on-line teachers to correct for the limitations of your child's math teacher. The problem is no longer whether there are alternatives to institutionalized learning, but how to navigate and make use of them and how to correct for the inevitable social inequalities in access to them. Sometime in the next decade society will begin to question whether putting a group of children in an enclosed space with single adult who is the sole arbiter of what constitutes learning in a subject domain is a viable way to develop the learning competencies of *their* individual child.

As noted earlier, the movement of learning environments from hard, crystalline structures, based on narrow attainment-driven models of learning, through more fluid and flexible structures better adapted to individual differences, toward networked relationships that follow the contours of where expertise actually resides in society will be the central design challenge of the next decade or so. At the very least, learning environments will require more flexible and permeable physical and cultural boundaries, accommodating the movement of information and people.

How will society orchestrate its duty of care and responsibility for socialization of children and adolescents with the unfreezing of institutionalized learning?

Currently, society's answer to the role of schooling in duty of care and socialization is relatively straightforward: We legally require children and adolescents to spend something like 16,000 hours (more like 17-18,000 hours, counting homework and exam preparation) housed in a single physical setting under the (imperfect) custody and control of designated, credentialed adults. Underlying this arrangement is the imperfectly realized assumption that this enormous command of children's time and lives nurtures their cognitive and emotional development. This effective monopoly of custody and control is confounded with and legitimized by an authoritative attainment structure that is nominally charged with allocating privilege and merit in the larger society. It is possible that as learning begins to escape the bounds of this structure its social authority will begin to erode. Because this structure is so deeply embedded in advanced capitalist society, it is far from clear that society has a Plan B for how it will adapt to the erosion of its authoritative.

A question that is central to the future design of learning environments and worth a great deal of thought and creativity is how to preserve the important elements of human connection and relationships that are central to the development of competent and accomplished learners. One painfully obvious response to this question is that learning environments have to places where young people want to be— attractive, responsive, adaptive, comfortable spaces populated by people whose warmth and curiosity align with the dispositions of their clients. We know a great deal about how to design these environments; we obviously know a great deal less about how to move the enormous capital stock of institutionalized learning in the direction of creating such spaces. As learning begins to migrate out of institutions into the broader world, the challenge— and the promise— will increasingly be the creation of physical environments where young people want to be, rather than where they are required to be.

How will learning environments adapt to the challenges of individualization?

The neuroscience of learning and the social democratization of learning both point in the same direction: increasing adaptation of the form, content, and practices of learning to the individual differences of learners. In the theory, the hallmark of institutionalized learning has been equality, defined as universal access to prescribed content through an attainment structure based on objective measures of merit. The struggles to make this structure responsive to individual differences have been persistent and well-intentioned, as well as predictably ineffective. The more we know about learning, the less this structure makes sense in terms of both the individual's growth and development in the practice of learning and society's stakes in the creation of a broad-based vital and creative society and economy. It is less and less plausible that we will solve society's problems with a structure founded on the guaranteed failure and subordination of a large proportion of its young people.

The practical and physical design challenges of building learning environments that incorporate the full range of human talents that learners bring are formidable, and they are not susceptible to simple prescriptions. The will, however, require the creation of a culture of deep curiosity and inquiry about the capabilities of human beings as learning organisms, a culture characterized by its willingness to be surprised at the richness, variety, and resourcefulness of the human organism as a learning being, a culture less invested in making distinctions among more and less worthy individuals and more invested in the cultivation of individual interests and competencies, a culture of gardeners rather than carpenters. The physical settings for learning will have to adapt, for example, to what happens when learners outgrow the knowledge and competencies of their nominal teachers and tutors, what happens when a learner discovers a deep interest in a domain for which they have little prior preparation, what happens when learning jumps the boundaries of conventional content domains and challenges conventional curricula, what happens when a learning with serious physical limits in one neurological domain is discovered to have unusual competencies in another, and (heaven forbid) what happens when an otherwise competent and highly motivated learner becomes a listless and seemingly unmotivated learner. Just listing these few possibilities in a more or less limitless range of learning challenges helps us understand the appeal of highly institutionalized definitions of learning— they make the work much simpler. Frederick Engels is alleged to have said, "the problem with socialism is that it spoils too many good evenings at home." One could say the same about the problem of neuroscience and learning— energizing, but far from comfortable.

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