



## Learning in the 21st Century: Concepts and Tools

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*“Tell me and I forget, teach me and I may remember, involve me and I learn.”*

—Benjamin Franklin

The value of learning through education has been recognized for millennia. However, in Egypt’s Middle Kingdom, for example, only the offspring of the royalty and the wealthy were afforded such an opportunity. Aristotle’s Peripatetic Lyceum and Plato’s Platonic Academy were the first type of formal schools in the Western world. During the Roman Republic and later the Roman Empire, the tier-based schools, like those in modern time, were created and made somewhat accessible to commoners.

Surprisingly, the delivery of information by educators has remained almost unchanged since the Middle Ages, despite the great changes from the industrial revolution and the advancement in technology. Teaching in schools and universities remains to this day a passive delivery of materials that assumes all students receive, handle, absorb, and process information similarly. Even in the medical discipline for which continuing education is expected, such a requirement can be fulfilled by attending lectures and conferences. No evidence of learning, in this case, must be provided. Therefore, competency assessment and meeting regulatory continuing education requirements have often been reduced to achieving compliance rather than actual learning. Furthermore, with information now abundantly accessible, simple and passive transmission of information is no longer considered adequate. Various approaches in delivering knowledge and assessing competency and learning are now being explored and used. For example, AACC (the publisher of *Clinical Chemistry*), in collaboration with the New England Journal of Medicine Group (the publisher of the *New England Journal of Medicine*), and Area9 Lyceum (a global leader in education technology) launched a cloud-based

educational program for laboratory medicine professionals that is based on the concept of adaptive learning, the method closest to personalized education. Adaptive learning uses a sophisticated computer algorithm to customize the interaction between the learner and the educational materials; it identifies the areas in which the learner is deficient and provides the needed targeted information to remedy the situation. In this article, we explore some of the new educational concepts and tools and address some of the larger societal and professional issues related to learning with four educators and education experts.

***How can new concepts and tools be used in the democratization of the education needed in the 21st century?***



**Ulrik Juul Christensen:**

In healthcare, 21st century skills are nothing new—just a new name for something we have known for decades. The challenge is that it has been hard to create learning environments that provide fertile grounds for the development of such skills. For example, when the current

wave of simulation-based learning started, we were all critically aware that the cost of developing and using simulation would inhibit its democratization. Still today—almost three decades later—access to simulation is limited, although orders of magnitude larger than before. The primary impact of the modern tools in education, such as personalized adaptive learning, will be to increase the value of the time that learners have in the impactful situations (i.e., use of simulators or human

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coaching in the clinical setting). Through democratizing access to advanced technologies, learners get basic learning “out of the way” much more efficiently, which then enables them to concentrate on advanced learning in the more impactful environments—which are often diluted by technical or knowledge-based discussions.



**Todd Rose:** There are at least two related issues that must be addressed: access and credentialing. Access is the most obvious of the two because without it nothing else matters. Getting access right requires addressing a wide range of obstacles that are already recognized, including ensuring high-

speed Internet for every individual and prioritizing adoption of platform-agnostic environments over “walled gardens” (to name just two). At the same time, for access to matter, the learning that takes place must count for something. Thus, credentialing matters. In education, a shockingly small number of gatekeepers determine what counts, and allowing these bottlenecks to remain will hold back the full promise of advances in access. Therefore, expanding and diversifying sources and mechanisms for credentialing will also be an important part of efforts to democratize education.



**Graham T. McMahon:** In an information age, the currency of education is not information. Because we can look up guidelines more quickly than someone can tell them to us, the currency of education for clinicians now includes problem-solving, skill development, wisdom, and insight. Creating these types

of activities is more work for the educator and more work for the learner. Only effortful activities are effective at helping clinicians unlearn and replace established practices with new approaches. One-and-done types of educational approaches that have historically been information exchanges must be replaced by programs and activities that stimulate curiosity, create engagement, drive meaningful learning, and then—critically—support the behavior and practice change using repetition and reinforcement over time, effectively incorporating deliberate practice with feedback.



**Bror Saxberg:** A key is to recognize that minds vary widely in what they take away from any context. This comes from the work in cognitive psychology and motivation research. One student seeing “ $ax^2 + bx + c$ ” written on a whiteboard reacts by thinking, “Oh, no, a quadratic equation—I hate those

things—I know she’s going to make me factor it!” Another student reacts by thinking, “Why are there numbers and letters in the same sentence?” Completely different cognitive, motivational, and even emotional experiences from the same sensory experience.

This means if we really wish to make increasing mastery accessible to more students at all ages, we are going to have to consider what their minds already have on board, including domain-specific masteries, motivation, issues of identity, social and emotional mastery, cognitive functioning, and more. These are matters of brain functioning, not choice—to ignore these and wish learning were simpler is to move back toward failing large numbers of learners.

#### *Is testing the best way to assess learning?*

**Ulrik Juul Christensen:** It depends on which kind of testing. The construct behind summative testing when you sample parts of the knowledge that learners should have learned is that by not telling the learner what is being tested, one hopes that the learner will do her best to learn all. However, there are significant weaknesses with this approach. The first is that all imperfections in the questions get amplified, as each answer is used to infer what people know about other things; we now know that it does not work that way. It is difficult to ask 20 questions and get a reasonably precise picture of what people know about, e.g., the 1000 underlying learning objectives in a course. This gets even worse when testing is used to separate top from average performers on the “fringe” performance when an “average” performer is scoring 15 questions correctly while the top performer knows 19 or 20. It is our experience that often you will find at least 5 weak assessment items out of 20, which severely jeopardizes the applicability of this approach to assess what learning has really happened and to compare performance. Pass/fail testing addresses some of these shortcomings and can be used as a cheap alternative for accreditation. An even worse situation occurs when summative testing is used to guide learning or to assess professional competency. In that case, another kind of testing is much more applicable: formative, short cycle testing when learning and

competence are continuously assessed and in a very granular way. This can then be used to guide personalized learning, instruction, and coaching.

**Todd Rose:** All effective learning environments depend on having accurate ways to measure *individual* performance and progress. Although tests are not necessarily the best way to accomplish this, under the right circumstances if we use the *right test*, they can be effective. For example, if we need to assess learning to provide an individual with feedback to support his progress, then quality formative tests can be useful. Similarly, if we need to assess the outcome of learning to determine if that individual has mastered relevant material, then quality performance-based tests can also be useful. In stark contrast, norm-referenced tests—the tests that dominate our education landscape—are almost never useful at informing us about individual learning: They are too restrictive in how and what they measure, and they are based on assumptions that are too pessimistic (and inaccurate) about the nature and distribution of human performance to be useful.

**Graham T. McMahon:** Assessment is necessary for clinicians because—like all humans—we suffer from overconfidence, particularly in areas where we are least capable. This Dunning–Kruger effect has been demonstrated repeatedly among our community. Misplaced confidence consistently leads to errors that the learner may not be aware of; further, if those errors result in suboptimal outcomes for patients, those same learners are apt to blame system issues and patient variability/complexity before they recognize their contribution to the outcome. Fundamentally, clinicians are prone to the same cognitive errors as all other professionals, but we often lack the humility and self-awareness to identify our gaps.

**Bror Saxberg:** This is a bit of a trick question. It turns out there is substantial evidence that “testing” (asking a mind to produce an outcome grounded in what they are trying to learn) enhances learning (the so-called “testing effect”), so it’s actually a good thing to do. However, it doesn’t have to look like “a test,” for example, those timed bubble sheets completed with number 2 pencils under hushed quiet solo experiences—it needs to push a mind to produce and decide, no question, but there are many ways to do this.

The question here, though, is about how to “assess learning.” Here, psychometricians have moved to talk about “evidence-centered design.” The idea is that there are many sources of evidence of whether a mind has changed in the way intended. Definitely, some production tasks (even bubble sheets!) can provide some evidence, but so can success on later tasks that require mastery of the earlier task, or observing the kind of process a

learner goes through in executing tasks—how “expert-like” is their process? A good one-on-one human tutor can glean a lot of information about how a student is doing simply by watching her try to solve a problem: How much time does he spend looking off in space, following dead ends, looking for hints, etc. all play into an evaluation of mastery, not merely “s/he picked answer D, the correct choice.”

We need, especially with technology-enhanced learning environments, a much richer approach to gathering and interpreting evidence of mastery, including affective reactions, identity views, confidence, the solution process, and more. This can create the important triangulation of evidence to either support or deny a claim that a mind has, indeed, changed in the way intended.

***What are the biggest obstacles in moving from teacher-led education to personalized learning?***

**Graham T. McMahon:** The biggest obstacle currently is engagement. Clinicians are burdened by administrative requirements, productivity expectations, patient or research complexity, patient expectations, and trying to balance home and professional lives.

Many are burned out and increasingly cynical—particularly because compliance education has unsurprisingly eroded clinicians’ trust in “education,” continuing medical education and maintenance of certification in many cases. High work burden, time pressures, cynicism, and poor self-awareness are not ingredients for engagement in professional development programs, no matter how well designed they are.

**Ulrik Juul Christensen:** Lack of access to advanced learning environments that can be widely distributed. The current model is the equilibrium that has been reached based on what is possible with classrooms and books (including e-books)—as well as the lack of appreciation for postgraduate education. The time allocated for continuous professional education in many countries is minimal, and often not paid for in many professions.

**Todd Rose:** An accurate and actionable understanding of individuality. The structure and function of standardized education systems are primarily informed by average-based insights about learning derived from the study of groups, not individuals. From this approach, we arrive at common practices such as fixed-pace instruction, age-based cohorts, norm-referenced assessments, and lockstep learning progressions. Whatever the merits of this approach, it is now understood (see ergodic theorem) that average-based insights often fail to describe and predict individual patterns of performance, learning, and development. As the promise of personalization rests on the ability to be responsive to individuality, the biggest

obstacle is getting beyond average-based insights to understand, explain, and support individuality. There is a growing body of knowledge being generated from scientists who have moved beyond average to study patterns of individuality, and although this “science of individuality” has led to breakthroughs in many fields (including medicine), such methods and insights remain the exception in education, where averages still dominate research and practice.

**Bror Saxberg:** I’m not sure this is quite the right way to put it. A highly trained one-on-one human tutor is a terrific learning environment, and the experience is highly “teacher-led,” so it’s not right to characterize “teacher-led” as something to be unvaryingly “moved from.”

What we’d like to do is move from any kind of learner-invariant learning environment (with teachers engaged or without) to personalized learning environments (most likely with teachers involved with the right interactions). “Personalized learning” here does not necessarily refer to technology-enhanced learning (that one-on-one human tutoring example again) but rather refers to a learning environment that changes based on the learner’s own state: her motivation, his preexisting masteries, her identity, his social and emotional skills, her cognitive capacities, etc. (Even physical and mental health matter—a very hungry student is unlikely to start, persist, or put in mental effort no matter how gloriously designed a learning experience he’s put in. Getting students access to a healthy breakfast is potentially a great personalization of the learning environment!)

***Will access to the new educational tools contribute to increasing the gap between those who have and those who have not?***

**Graham T. McMahon:** Digital learning readily allows for the dissemination of programs and activities. However, it’s clear that knowing something, building cognitive skill in that area, and then sustaining necessary change is a complex process that needs local support—either from the clinician-learner or from mentors or continuing medical education providers. Those who “have not” may lack access to the technology and people they need to support longitudinal change.

**Bror Saxberg:** This entirely depends on how communities and societies allocate evidence-based approaches to learning. It is also one of the reasons well-designed technology-enhanced experiences linked with teachers can be so helpful—they may well be able to increase the reliability, affordability, and accessibility of well-designed personalized environments for students, if communities/societies choose to invest in widely distributing

these among the most challenged communities, and if they are designed to work with the affordances and interests of those communities.

There are many issues to address beyond what happens in a classroom, or an individual learning environment, to help: Learners who are subject to ongoing “toxic stress” in their lives experience biological chemical changes to their learning systems that reduce their capacity to learn. (Literally, genetic and cellular level responses to extended exposure to the stress hormone cortisol—not a moral issue, or a social issue, but a biological impediment.) If we truly want to help those in challenged communities become their best, we need to think broadly about what affects their learning. And, at least, their learning environments need to consider a full range of characteristics and capacities—academic, of course, but also identity issues, social and emotional capacities, cognitive capacities, and mental and physical issues that can impede or enhance learning and motivation.

**Ulrik Juul Christensen:** No—access will narrow the gap. Medical students who go to Harvard Medical School, for example, have access to world-class teachers and mentors who can personalize what the individual student is challenged with. New platforms can massively democratize those high value learning opportunities through intelligently helping and coaching learners to focus their efforts.

**Todd Rose:** It depends on our approach to adoption and diffusion. On the one hand, it will assuredly exacerbate inequality if we rely on the “early adopter” model that works so well in most consumer-facing sectors: Wealthy individuals gain access to the innovation earlier, albeit at a higher price point, and the masses gain access to it later through economies of scale. This model is problematic because personalized learning environments, at their best, hold the potential to amplify individual potential and, therefore, create massive asymmetries in ability and achievement that could have generational consequences. On the other hand, given the incredible (and incredibly expensive) R&D effort that will be needed to develop and scale personalized learning, it is unrealistic to assume that it will happen without a strong market contribution. Therefore, what is needed is a hybrid model of adoption that makes a distinction between public utility aspects of the system (e.g., universal access to underlying infrastructure, data, and other relevant systems) and aspects of the system where we want and expect market-based innovations to flourish. Without a new adoption model, we risk either profound and lasting inequality or the inability to get the innovation off the ground in the first place.

***What is the ideal continuing education program?***

**Ulrik Juul Christensen:** Continuous. Smaller amounts of learning happening every week. And no failures. There should only be “thumbs up” and “noncomplete – yet.” Make nonpunitive environments where learners can evolve, and as long as they do not give up, it is totally fine not to be perfect yet.

**Todd Rose:** It would be platform agnostic and accessible anytime and anywhere; it would be designed for learning in small doses and on a regular basis, rather than large, infrequent doses; it would be adaptive to individuality in terms of content, pace, and sequence of learning; it would have a mastery-learning focus, with an emphasis on timely, relevant, and actionable feedback; it would measure performance against an industry-aligned standard, not relative to other people; it would measure content accuracy and individual awareness of competence; and it would have a context-relevant performance orientation that prioritized demonstrating knowledge and skills in ways that are similar to what is required on the job rather than through proxy metrics that abstract away from real life.

**Graham T. McMahon:** One that is based on individual gaps and needs, builds on prior knowledge, is relevant to the clinician, is appropriately designed to create curiosity, engagement, learning, and change, and that is connected longitudinally to the learner to support and reinforce both learning and change over time, optimally as part of an educational home.

**Bror Saxberg:** One that works for a wide array of targeted learners over an extended period to change their real-world behavior in the way intended.

To get this, it requires a declaration of those outcomes and the expected characteristics of the learners coming in: exactly what do we assume of the array of learners intended to be changed (e.g., preexisting skills, identity, social and emotional capacities, cognitive capacities)? And what, exactly, are the decisions and tasks we want these learners to be able to do by the end of that experience? (Ideally, ensuring those decisions and tasks match what top performers decide and do vs mythologies within the profession about “what we experienced that made us what we are,” which often messes up getting ready for modern work.)

Once you have such a definition, then an ideal continuing education program should be grounded in learning science about how those kinds of outcomes can be achieved from those kinds of starting points: what kinds of practice and feedback have evidence they work for the types of outcomes and suboutcomes needed for the types of learners we plan to have. Such an environment would

have good evidence-gathering methods (not merely “quizzes” but rather evidence gathered and interpreted at the point of learning and later, when mastery is supposed to be used in other circumstances). There should be ample opportunities to practice the actual decision or task to be mastered, with feedback on both the process and the outcome that must be incorporated in another round of practice. Ideally, too, developers should have continuing flows of evidence about which parts of the learning environment are working as designed (usability, learner process development, and outcomes) and which are not.

***Have we gone too far in our reliance on standardized tests?***

**Ulrik Juul Christensen:** One hundred percent, yes! Google’s clear message that they no longer look at diplomas and degrees during the hiring process confirms our company’s strategy for years: We base employment entirely on the candidate’s ability to integrate technical skills with 21st century skills like collaboration, critical thinking, and advanced character skills like resilience and leadership.

**Todd Rose:** Yes, in the sense that we are expecting them to do things that they are not designed to do. Standardized tests may or may not be good metrics for school-level accountability models, but they simply fail when asked to serve as proxies for individual learning and progress because they lack the specificity needed to inform an understanding of any particular individual, they offer next to nothing in terms of feedback for improving over time, and to the extent they say anything at all about individuals is usually comparative in nature, taking the form of a relative rank against other people, on average.

**Graham T. McMahon:** Tests can have terrific value when they help clinicians identify gaps and compare themselves to a peer community. Test results can be a powerful remedy to overconfidence and poor self-awareness. Tests can also be instructional if/when formative feedback is provided. However, tests can be discouraging to some and can induce the type of binge-and-purge cramming behavior that is antithetical to the types of effective learning programs that facilitate unlearning and support new practice patterns and change.

**Bror Saxberg:** As mentioned previously, the concepts of evidence-centered design from modern psychometric theory are helpful here: Use multiple lines of evidence to test a hypothesis that a mind has been changed in the way you intend. Standardized tests certainly provide a form of bulk evidence for something related to mastery. However, the activities in a standardized test are far from most real-world working environments (how many bubble

tests have YOU completed in the past year at work?), so there is a real risk that too deep a focus on preparing for standardized tests misses the full preparation required for applying decisions and masteries in the real world.

What's needed is to develop more efficient ways to give both formative and summative feedback that is as close to real-world performance as possible. Simulations and performance recording (potentially with automated feedback and scoring) seem like highly promising directions here.

In principle, with rich technology-enhanced click-stream data collection, a fully functioning simulation-based practice-and-feedback environment just by itself might provide enough evidence of mastery that there is no need for some stand-alone, artificial "testing" activity that is far from embedded work practice: The evidence about the process of decision-making, the timing, the write-up and description of reasoning, and how that evolves through practice is likely to be enough to conclude, "this learner is expert enough now."

***What is the most interesting concept in education that is being used currently?***

**Graham T. McMahon:** Reestablishment of human mentorship in professional practice is most interesting to me. Helping capable clinicians support their peers in informal and workplace environments appears to be surprisingly important for the development of high-quality professional practice.

**Ulrik Juul Christensen:** The emergence of the concept of precision education. It manifests itself in multiple ways, but continuous maintenance of certification based on personalized and adaptive learning has massive potential to change professional education—among many others.

**Todd Rose:** Mastery learning, which implies that a learner must achieve a certain level of mastery of determined information before proceeding to learn subsequent information. Although the concept is decades old, our ability to embed it in learning environments at scale is relatively new. Mastery learning is interesting to me because of the implications it has for advancing new practices and mindsets needed to allow personalized learning to flourish at scale. For instance, although mastery is agnostic about individual vs group instruction, it has a clear focus on individualized feedback and correctives to advance learning—something that is not common in standardized education. In addition, because the focus is on measuring mastery against a standard, it calls into question the value of norm-referenced tests that cannot measure individual learning and progress. It may be that the shift to mastery in practice will do more to unseat the

outsized influence of standardized tests in education than anything else. Finally, mastery rests on an optimistic view of human potential: In our current system, we assume a fixed number of students can do well (this is true with grades in general, and in the historical practice of curving grades in particular). In contrast, mastery learning does not impose an arbitrary, predetermined cap on excellence—in principle, all students can attain the highest levels of achievement. This view of potential, put into practice, may be harder for selection, but it is most certainly better for individuals.

**Bror Saxberg:** It is not being used enough yet, but the incorporation of actual science around how human learning and motivation work has intriguing potential. There is a rich trove of research about working memory, long-term memory, executive function, and motivation that is only rarely being deployed in specific learning environments. A notion of "learning engineering"—applying learning science at scale to solve real-world constrained problems and iterate with good measures to continuously improve learning—could be a promising direction to pursue in many training areas.

***What are ways that the science of learning and development could be incorporated into learning throughout life compared with what is happening now?***

**Bror Saxberg:** Thinking multidimensionally about human development, grounded in the growing evidence about the science of learning and development, has enormous potential across people's life spans to change our definitions of "success" and "expertise."

Even the definition of expertise must be expanded to consider results from cognitive science research. Seventy percent or more of what top expert minds decide and do has become nonconscious, or tacit, through repeated practice and feedback—it's "obvious" what to do, what the situation is, yet not to a novice. This means, if we follow the learning science, we must do some serious work to unpack exactly what top experts are deciding and doing to accomplish their goals in ways that are measurably dramatically more valuable than median performers—and, with information-rich appliances continually changing the nature of work, this must be updated repeatedly.

Even with a solid evidence-grounded definition of expertise, humans are more than cognitive processors: We cannot separate their skills and domain-specific decisions from notions of identity, social and emotional capacities, cognitive capacities, and even physical and mental health affordances.

All of us have accepted that being an "expert" is no longer a static state—it includes "expertise in continuous learning" as well. We need continuous practice and feed-

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back environments built around the latest evaluation of what top performers are deciding and doing, and, perhaps, credentials that regularly sunset unless they are refreshed with these kinds of learnings accompanied by valid and reliable demonstrations.

All of this alters what learners need to experience to expand their expertise to pursue their dreams and capacities—and continue to be, in the words of Dana Gioia, a former head of the National Endowment of the Humanities, “productive citizens for a free society.”

**Todd Rose:** Perhaps the most straightforward way, because of the changing nature of work, would be to introduce the insights into workplace training and continuing education environments. As individuals are faced with the ongoing need to refine and develop skills to stay relevant in their jobs, and companies are faced with the reality that they are in the business of talent *development*, having workplace learning environments reflect the state-of-the-art insights from the science of learning and development would not only make those specific efforts more effective, but also it would likely help generate a broader understanding and demand for similar changes throughout public education.

**Ulrik Juul Christensen:** It requires that we depart from the current approach to summative assessments in which learners are sufficiently afraid of the consequences of not learning to an approach that demonstrates the benefit

of continuous learning. With modern precision approaches to personalized learning based on high resolution, formative assessment methods (adaptive learning), it will be possible to transform how we develop and refine learning.

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