KEYNOTE • 4 MARCH 2024

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ATP GLOBAL Innovations in Testing 2024

BETTER TOGETHER

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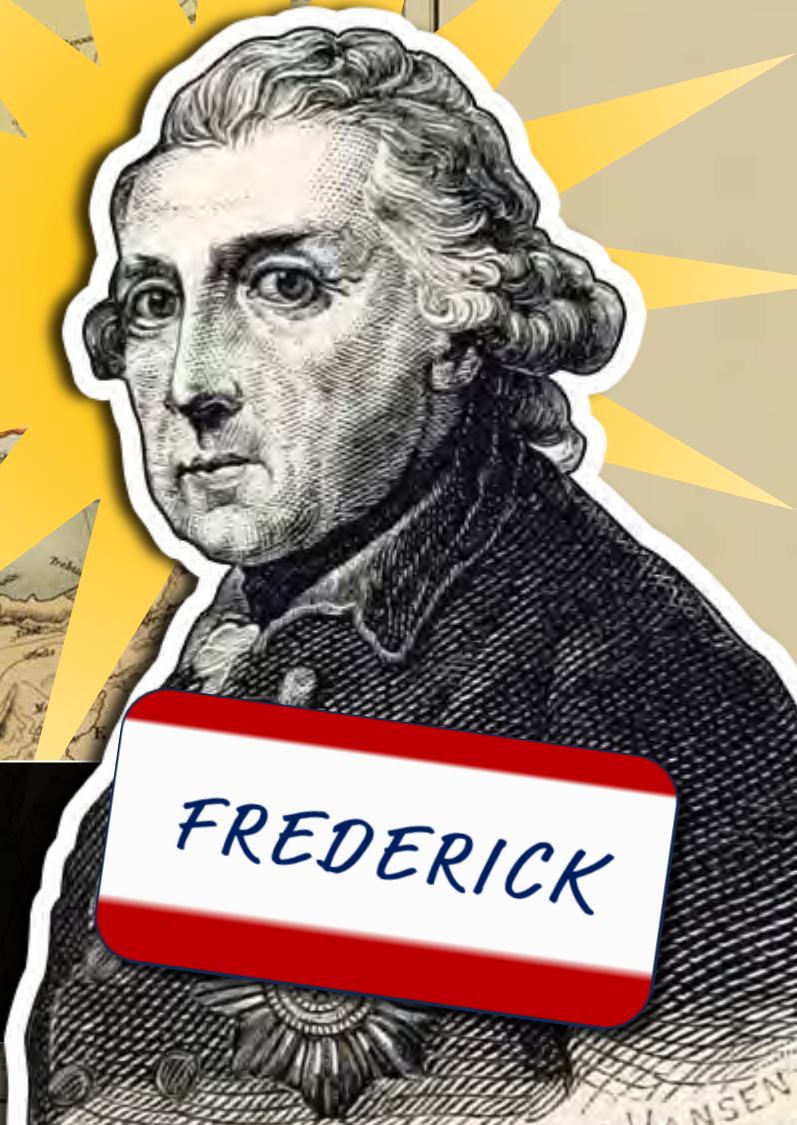
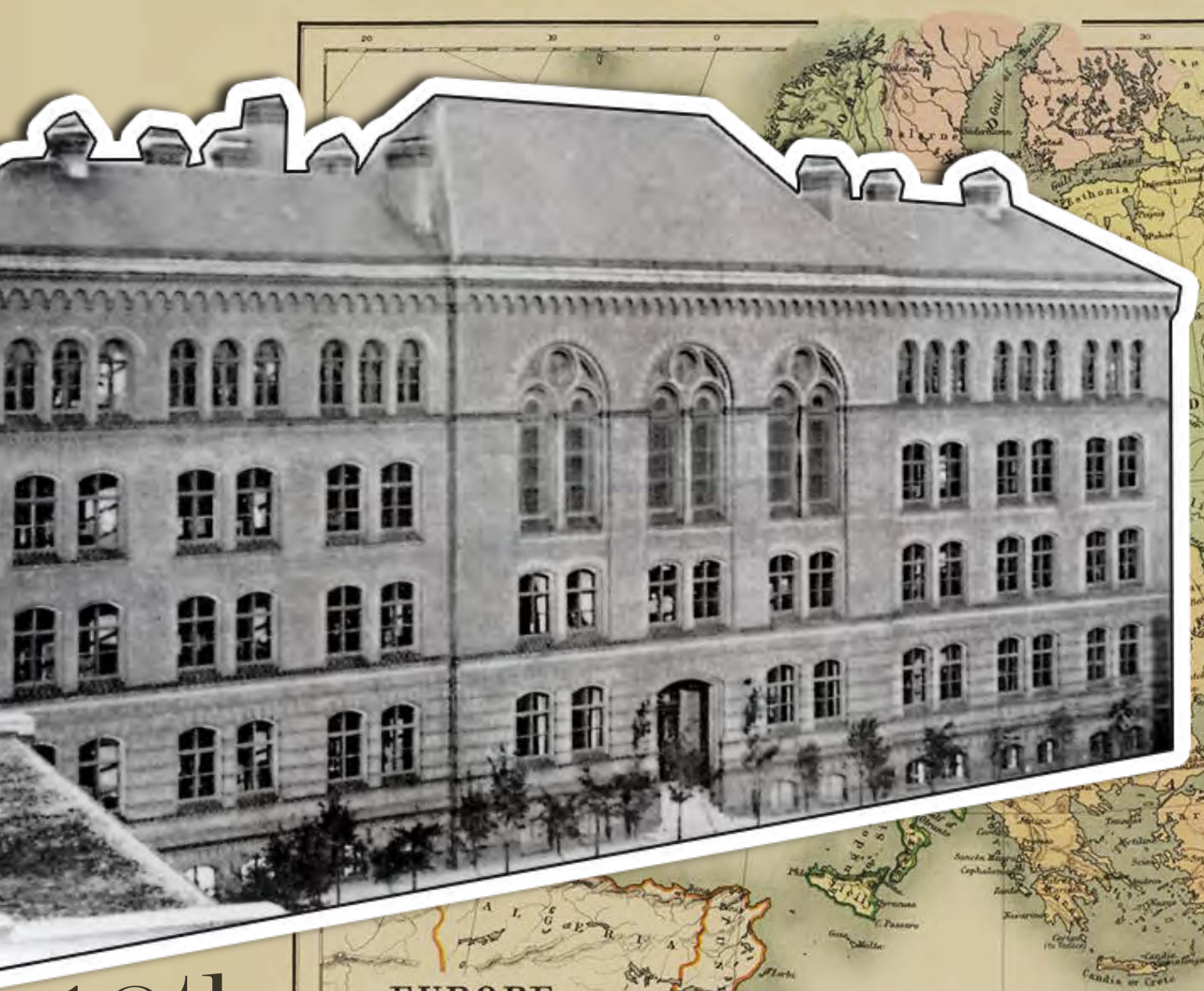
Much of what we envision as “formal education” can be traced back to the old Prussian schools of the 18th century.

PRUSSIA



Frederick the Great decreed that everyone, girls and boys from around 5 to 14 years old, had to be educated in these compulsory public schools.

18th CENTURY



EUROPE
IN 1740

18th CENTURY

The government subsidized primary, secondary, and normal schools. The system mandated specific training for teachers, national testing for all students, and a prescribed curriculum for each grade.

In 1810, Prussia introduced state certification requirements for teachers, and by 1812, there was also a final exam for students, called the *Abitur*. It was implemented in all Prussian secondary schools, and passing it was a prerequisite to entering the learned professions and higher echelons of the civil service.

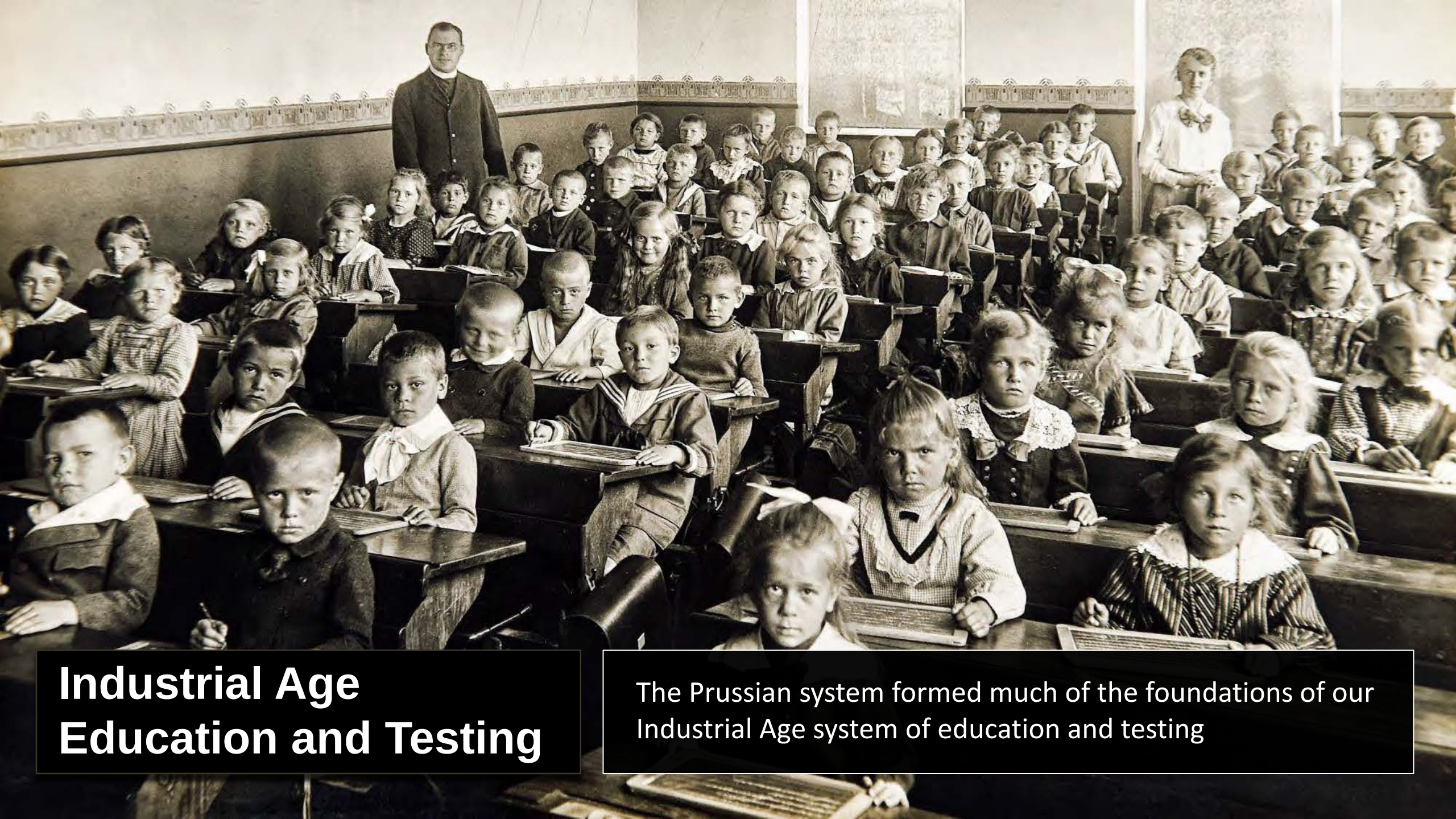
SCALE

STANDARDS

TESTING

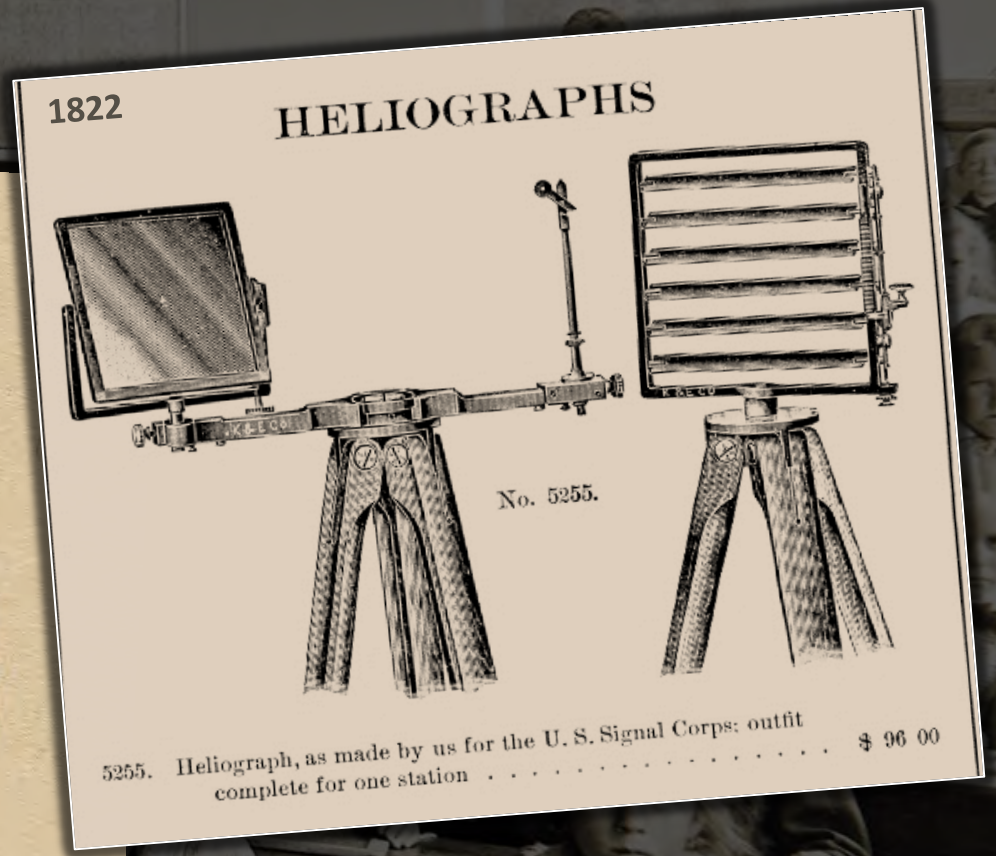
CERTIFICATION

So, by the 1830s, we had a scalable education system, built on education and testing standards, including standardized curricula and standardized summative testing, and professional certifications.



Industrial Age Education and Testing

The Prussian system formed much of the foundations of our Industrial Age system of education and testing

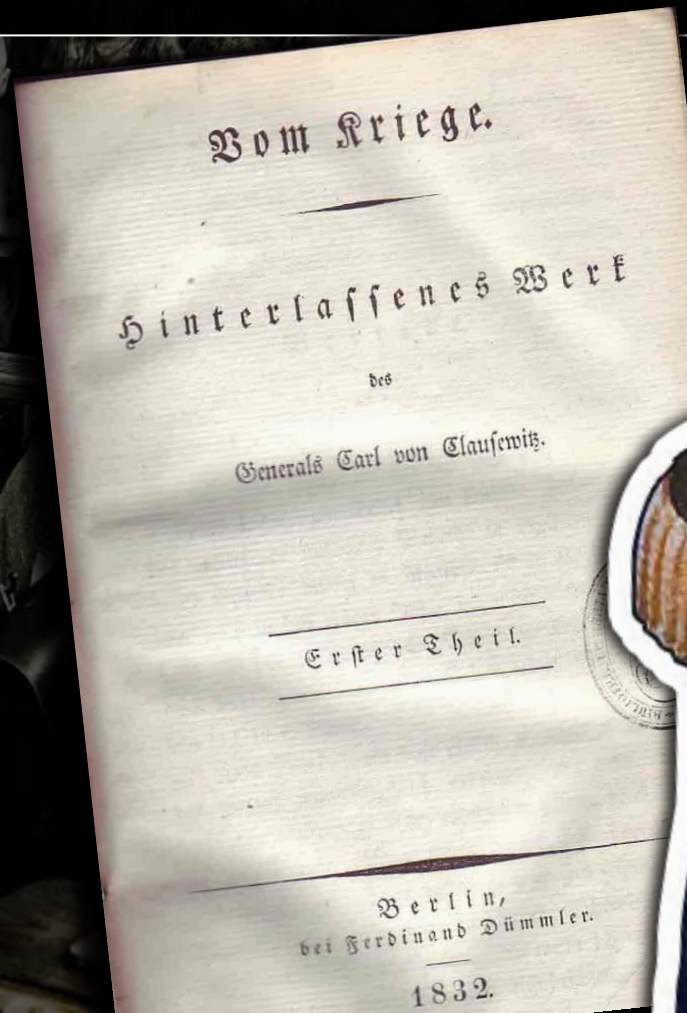


Consider some of the other inventions from around this time—the chronological peers to our Industrial Age education and testing system. The first steamboat in 1783, the first dandy horse (early precursor to the bicycle) in 1817, and the invention of Heliography, the first photographic process, in 1822.

For those with military experience, you're probably familiar with the famous book by Carl von Clausewitz, called *On War.* It was also a chronological peer to the invention of Industrial Age education and testing. Clausewitz was also engaged with the Prussian education system and spent over a decade as head of the Military Academy at Berlin.

In *On War,* Clausewitz coins the phrase "Fog of War" to describe a leader's state of uncertainty due to a lack of information.

Fog of War


Vom Kriege.

Hinterlassenes Werk

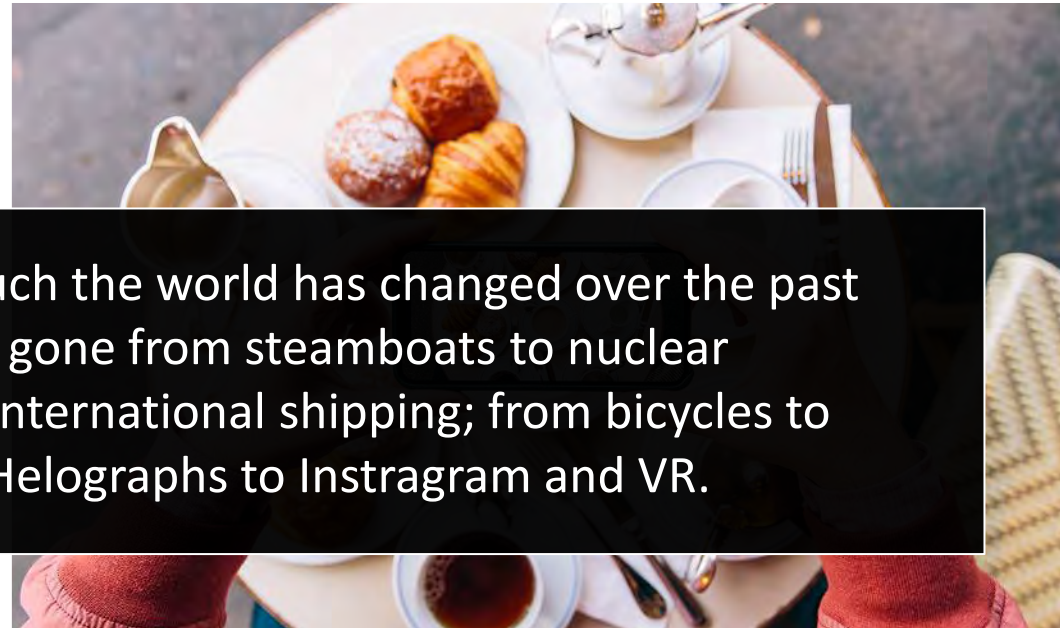
des

Generals Carl von Clausewitz.

Erster Theil.

Berlin,
bei Ferdinand Dümmler.

1832.



Consider how much the world has changed over the past 200 years. We've gone from steamboats to nuclear submarines and international shipping; from bicycles to spaceships; and Helographs to Instragram and VR.

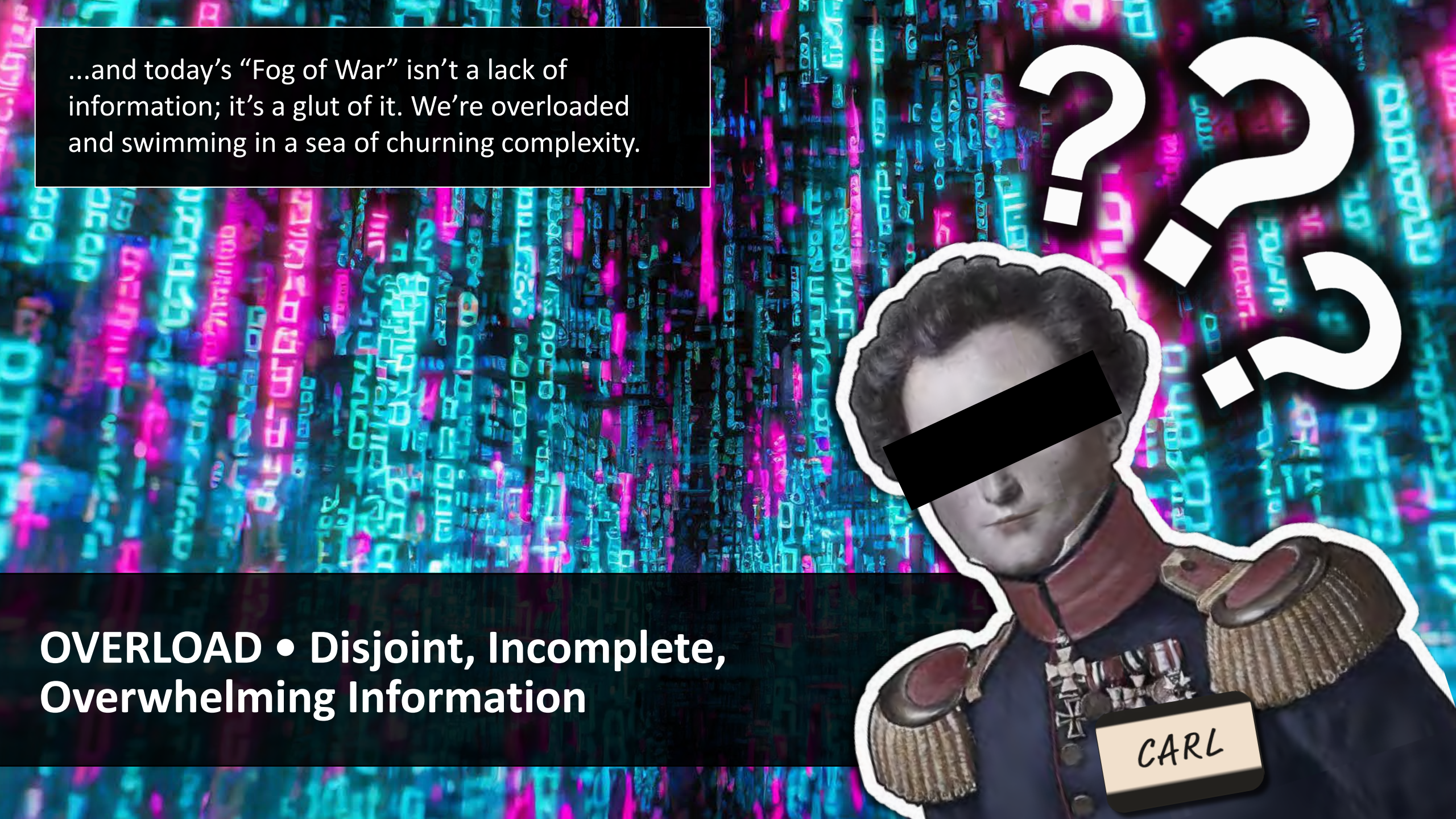
Information Age

We’re always connected, potentially always working and always learning. There’s a constant rush of new technologies, changing conditions, changing global dynamics… We’re in the Information Age—and beyond!

To remain competitive in the world, individuals need to engage in lifelong learning, a “60-Year Curriculum.” Individuals also require an increasingly diverse set of knowledge and skills (e.g., subject-matter expertise as well as digital and data literacy, cross-cultural competencies, empathy, and metacognition). And we need to navigate an increasingly complex, interconnected world.

People are expected to do more, with rapid adaptability, and under incredibly complicated conditions.

...and today's "Fog of War" isn't a lack of information; it's a glut of it. We're overloaded and swimming in a sea of churning complexity.

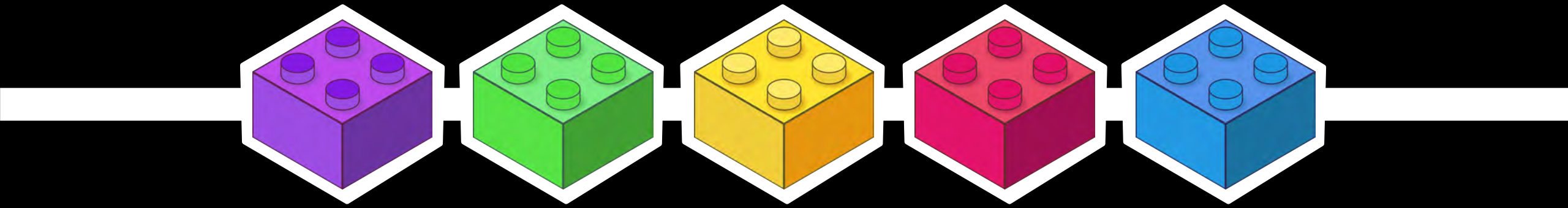


OVERLOAD • Disjoint, Incomplete, Overwhelming Information

So, what does the Information Age model of learning, development, testing, and assessment look like? Let's consider six trends that will help us shape and navigate the future.

LEARNING ECOSYSTEMS

First, consider the Industrial Age model…

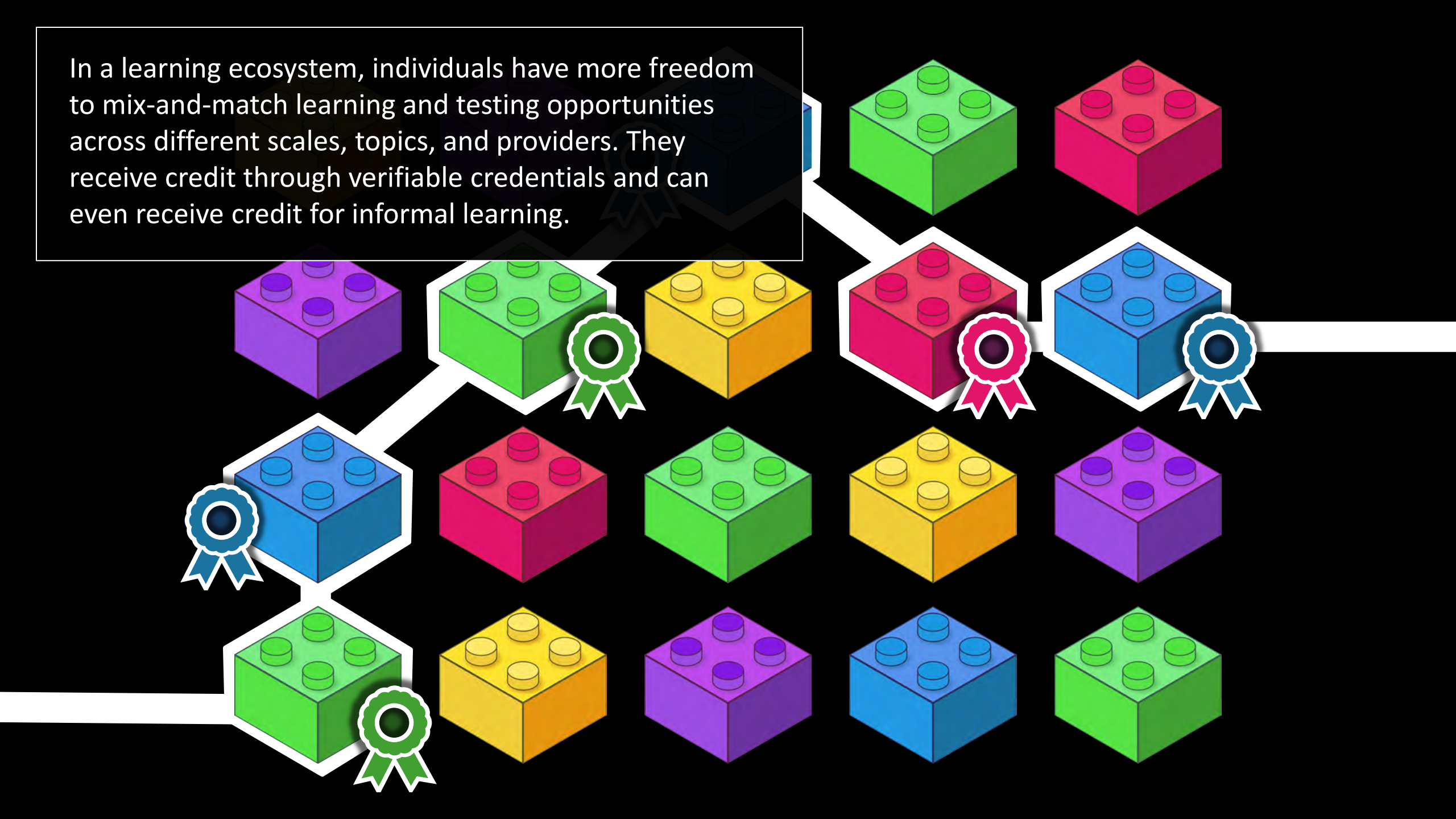


In the Industrial Age model of education and testing, someone's path is relatively linear and prescribed, with a heavy reliance on formal education and vocational training. Informal learning, such as apprenticeships, reading, and social learning, have always occurred, but they're relatively hidden to the "system."

Formal learning and testing organizations help guide people through established programs and authenticate their completions with credentials, such as diplomas.

Formal education and training are generally delivered in large chunks and frequently using a one-size-fits-all approach—that trusted, scalable, and standardized Prussian model.

In a learning ecosystem, individuals have more freedom to mix-and-match learning and testing opportunities across different scales, topics, and providers. They receive credit through verifiable credentials and can even receive credit for informal learning.

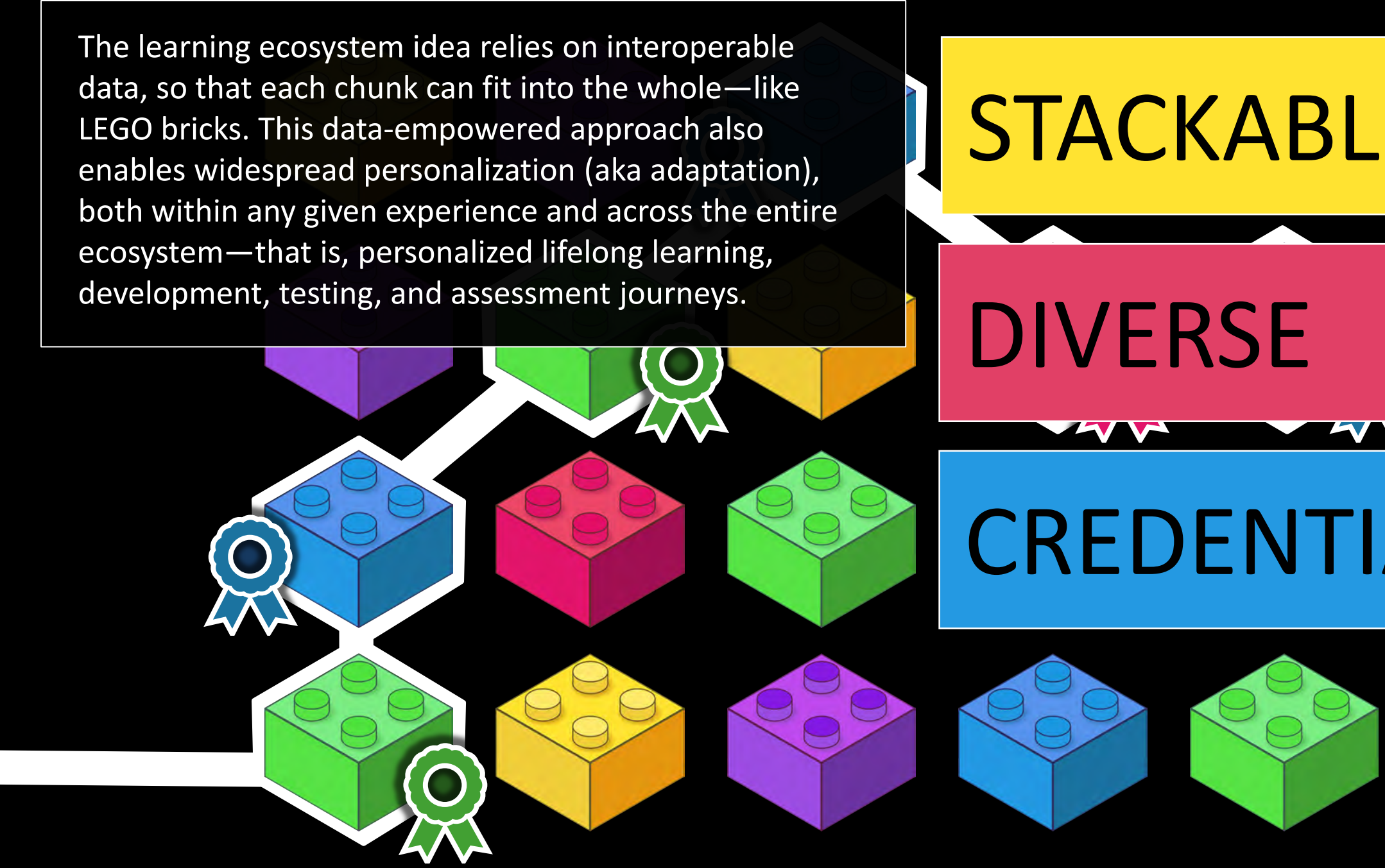


The learning ecosystem idea relies on interoperable data, so that each chunk can fit into the whole—like LEGO bricks. This data-empowered approach also enables widespread personalization (aka adaptation), both within any given experience and across the entire ecosystem—that is, personalized lifelong learning, development, testing, and assessment journeys.

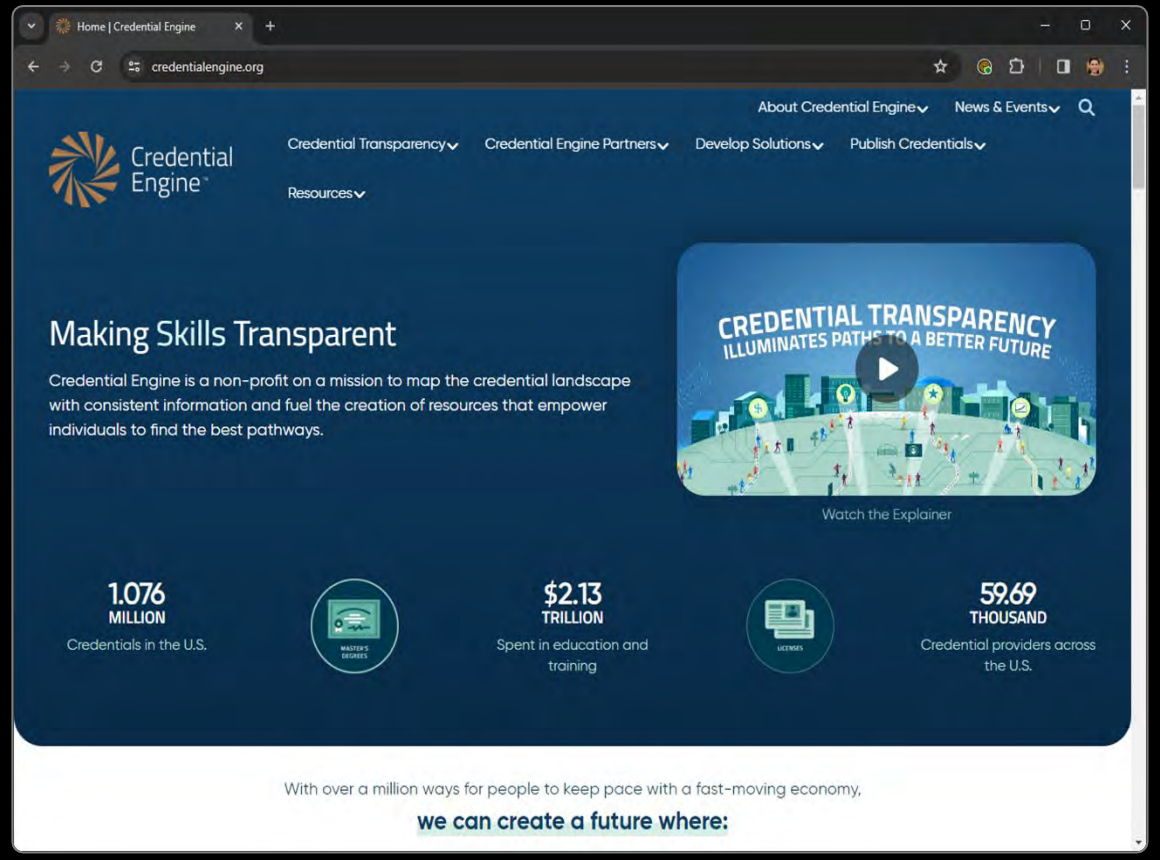
STACKABLE

DIVERSE

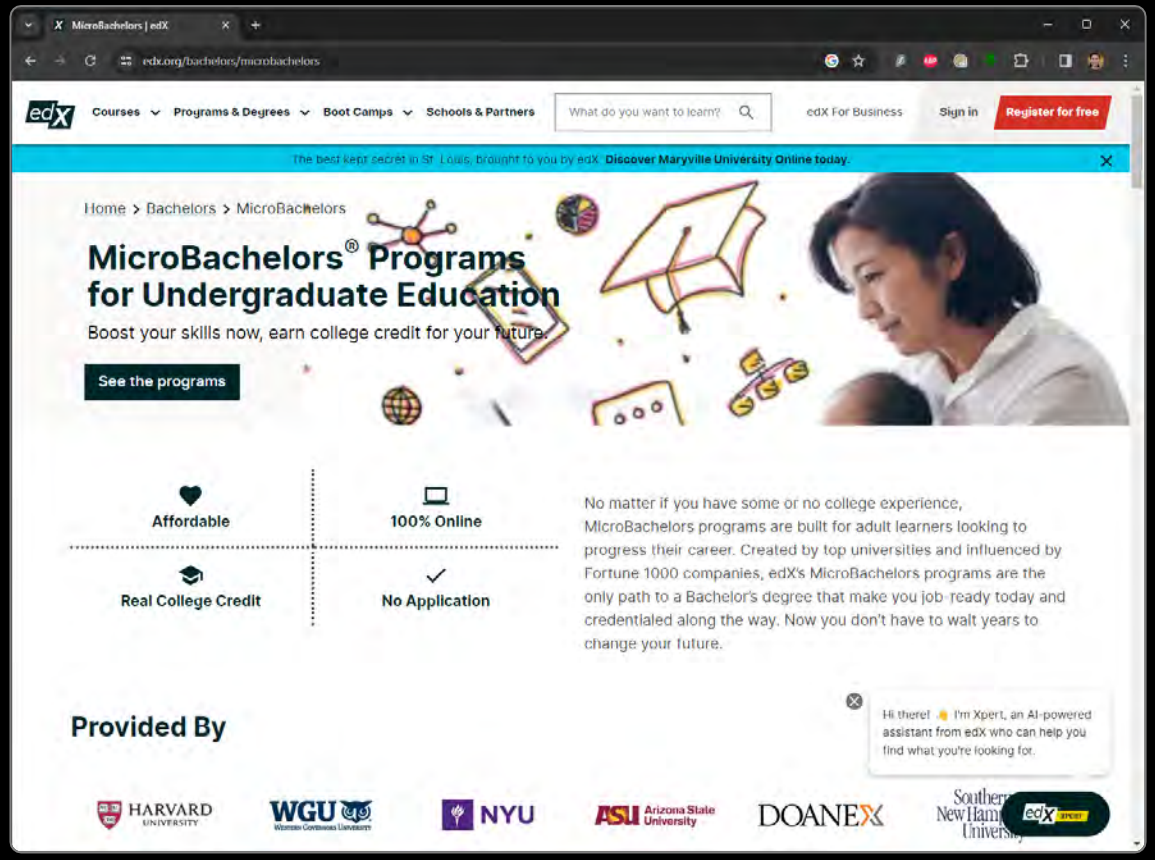
CREDENTIALED



Examples of learning/testing in chunks and interoperable credentials can already be found.

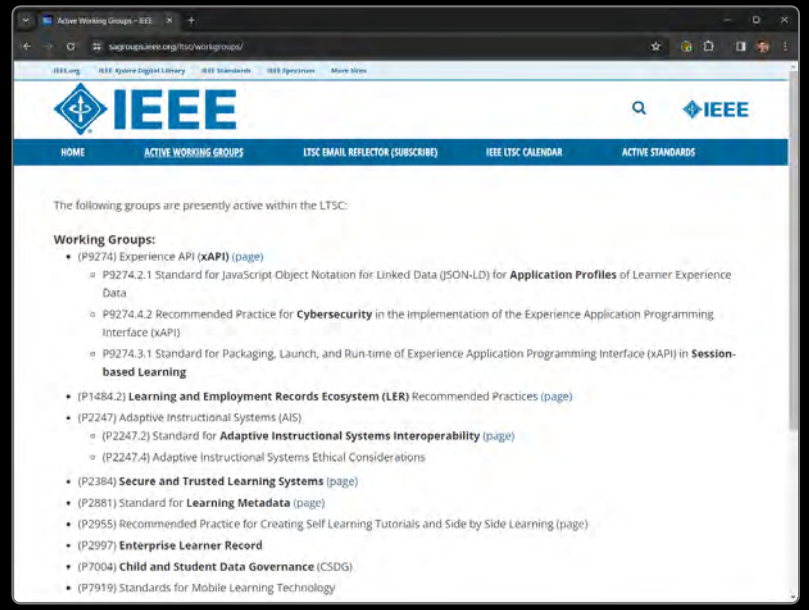


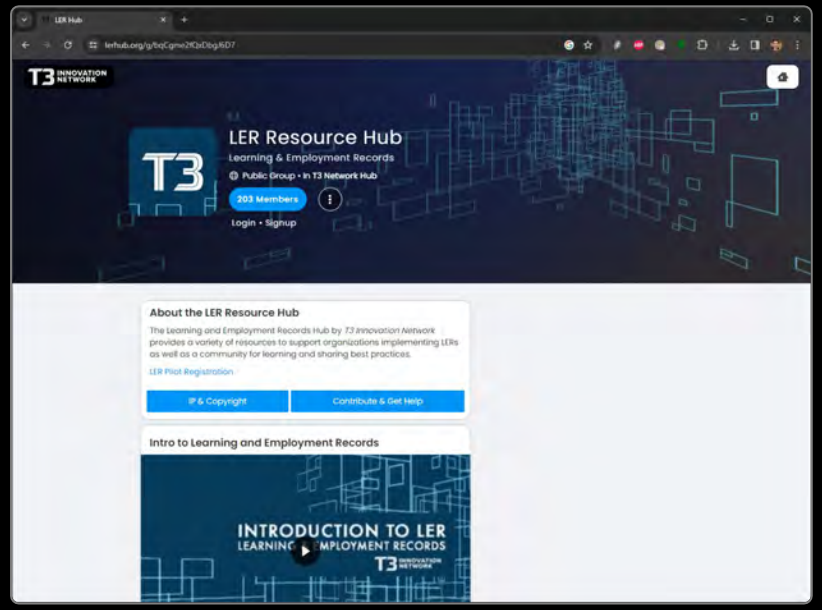
Credential Engine providing a credential marketplace • https://credentialengine.org

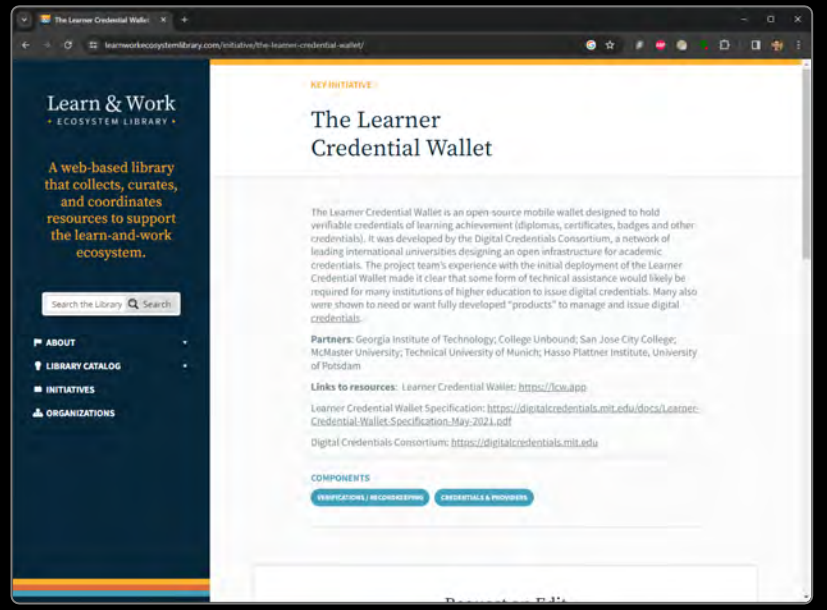


edX offering stackable MicroBachelors degrees • https://www.edx.org

The technology for enabling LEGO-brick style interoperability across diverse systems is also rolling out.



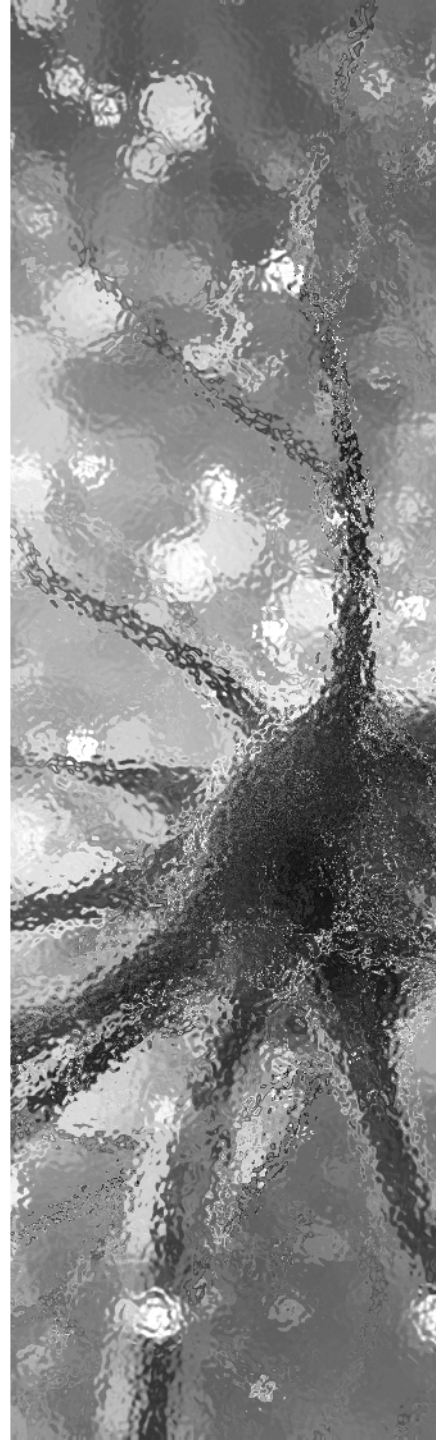




The IEEE Learning Technology Standards Committee (LTSC) develops and maintains specifications and standards for learning technologies • https://sagroups.ieee.org/ltsc

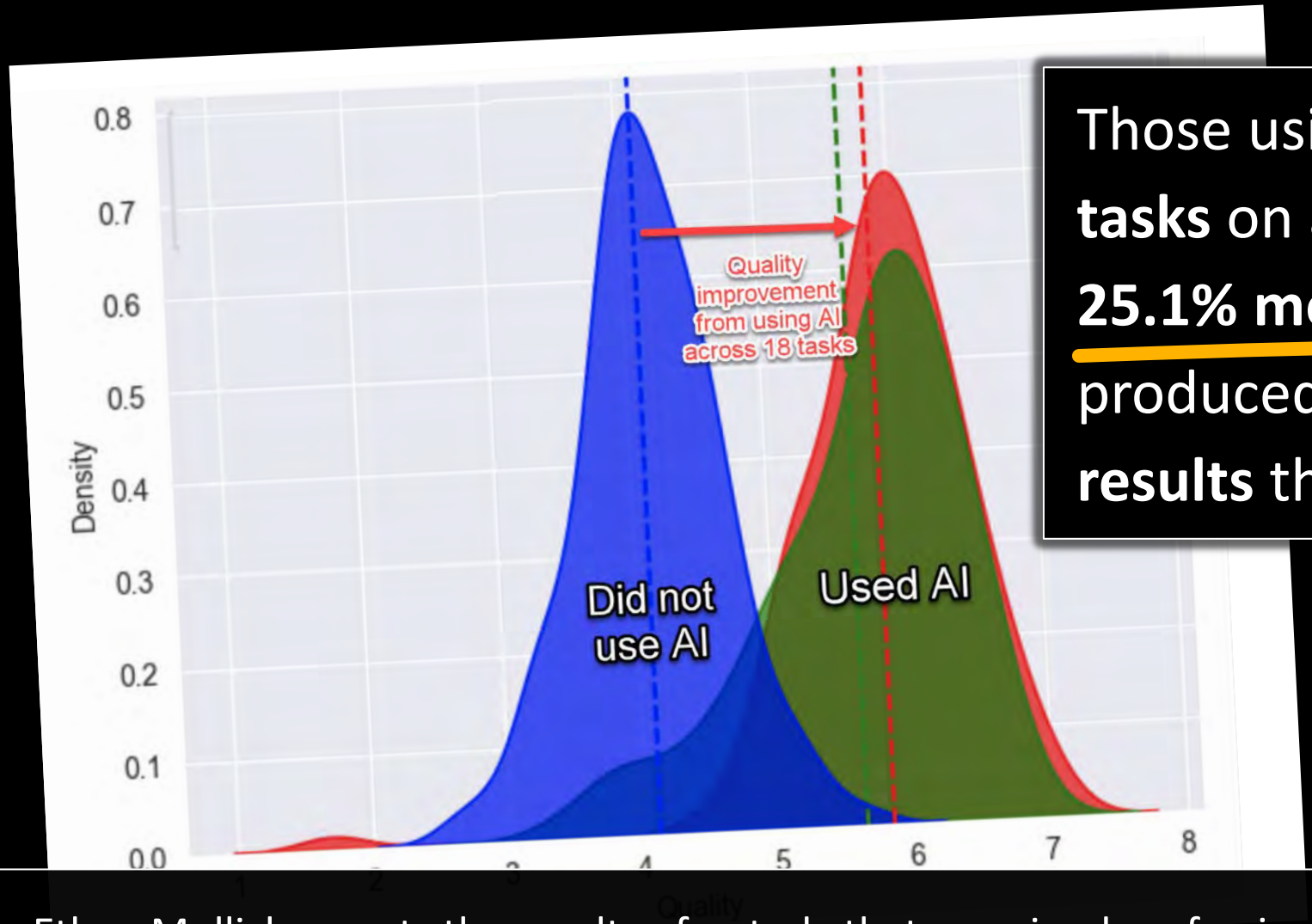
The Chamber's T3 Innovation Network is also working on Learning Employment Records for lifelong learning—to enable the learning ecosystem • https://lerhub.org

Learner Credential Wallets are already publicly available and notable groups, such as MIT and the W3C are working on these technologies • https://opportunityatwork.org



LEARNING ECOSYSTEMS

GEN AI CONTENT

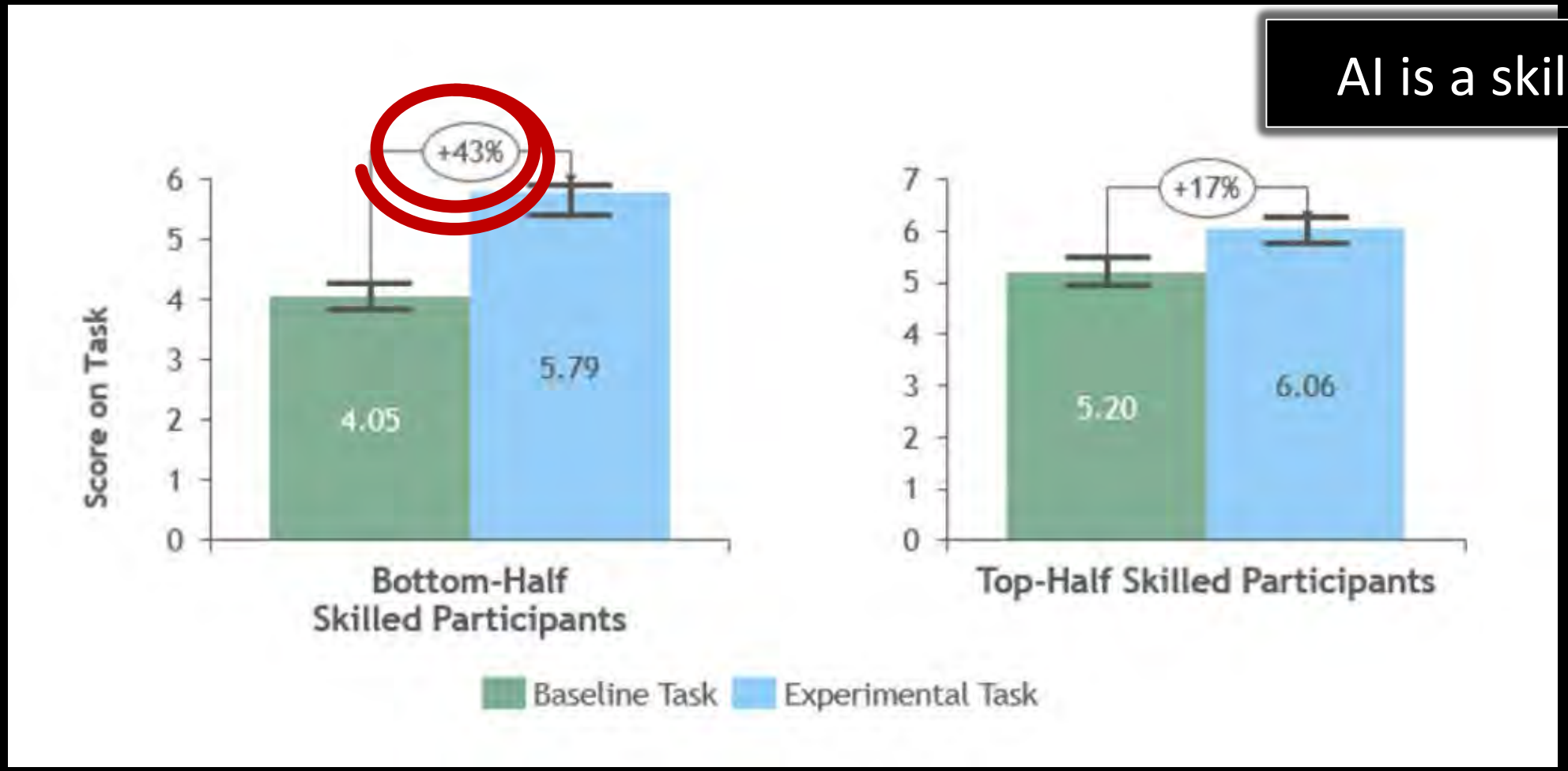


Those using AI **finished 12.2% more tasks** on average, **completed tasks 25.1% more quickly**, and produced **40% higher quality results** than those without

Mollick, E. (2023, Sept. 16). "Centaurs and Cyborgs on the Jagged Frontier." Research reports from the Boston Consulting Group. https://www.oneusefulthing.org/p/centaurs-and-cyborgs-on-the-jagged

Ethan Mollick reports the results of a study that examined professional workers at an elite consulting company using (or not using) ChatGPT-4 assistance across 18 different tasks. Consultants using Generative AI outperformed those who did not—by a lot and on every dimension measured.

AI is a skill equalizer

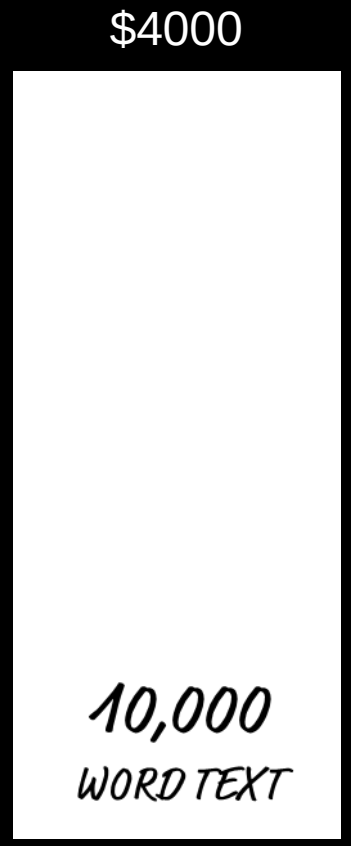


Mollick, E. (2023, Sept. 16). "Centaurs and Cyborgs on the Jagged Frontier." Research reports from the Boston Consulting Group. https://www.oneusefulthing.org/p/centaurs-and-cyborgs-on-the-jagged

The benefit of using AI assistance was especially pronounced in the less-skilled half of participants.

Philip Stelter examined the cost of Generative AI compared to equivalent human creators. ChatGPT and other popular large language models, such as Claude2, score in the 90th percentile on the Graduate Record Examinations (GRE) for writing.

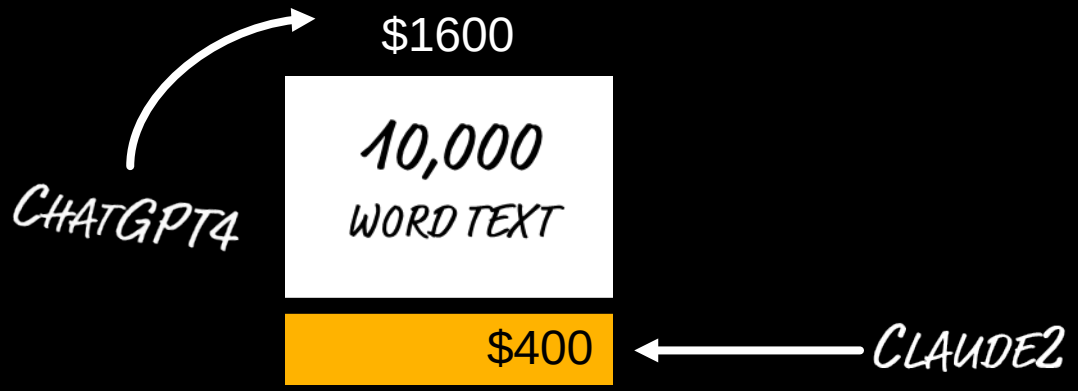
A similarly skilled human writer charges around $0.40 per word, while large language models cost around $0.16–0.04 per word—potentially a huge cost-savings.



Skilled Professional Writer

Scores 90th Percentile on GRE
Costs around $0.40 per word

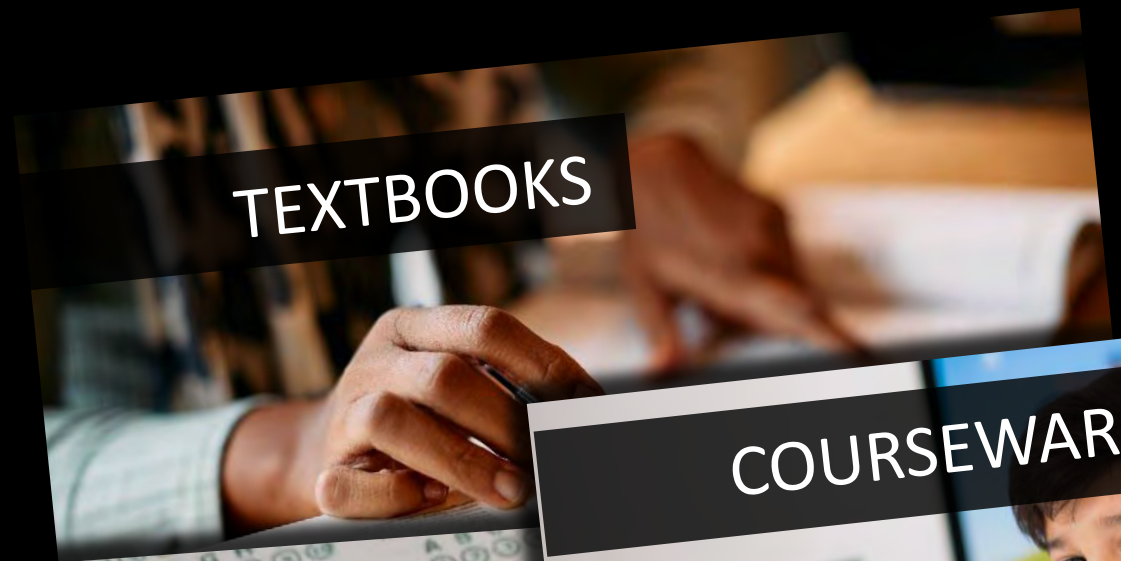
25% to 90% price disruption??

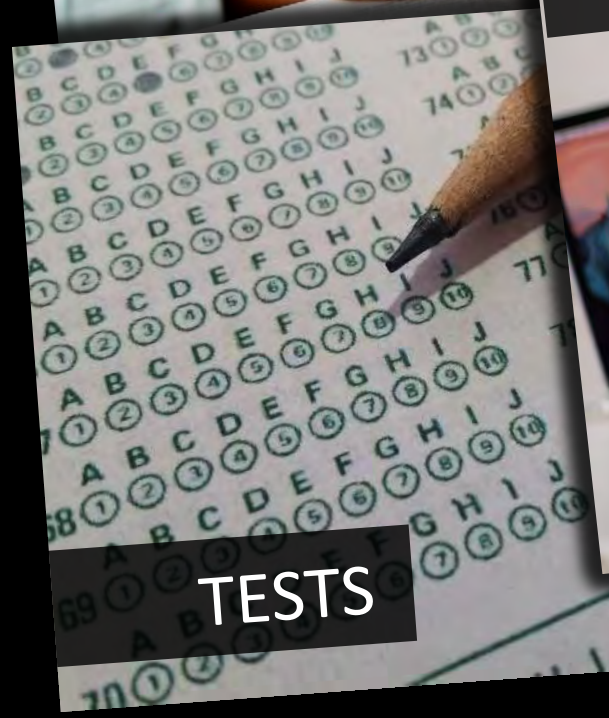


Generative AI

Scores 90th Percentile on GRE
Costs around $0.16–0.04 per word

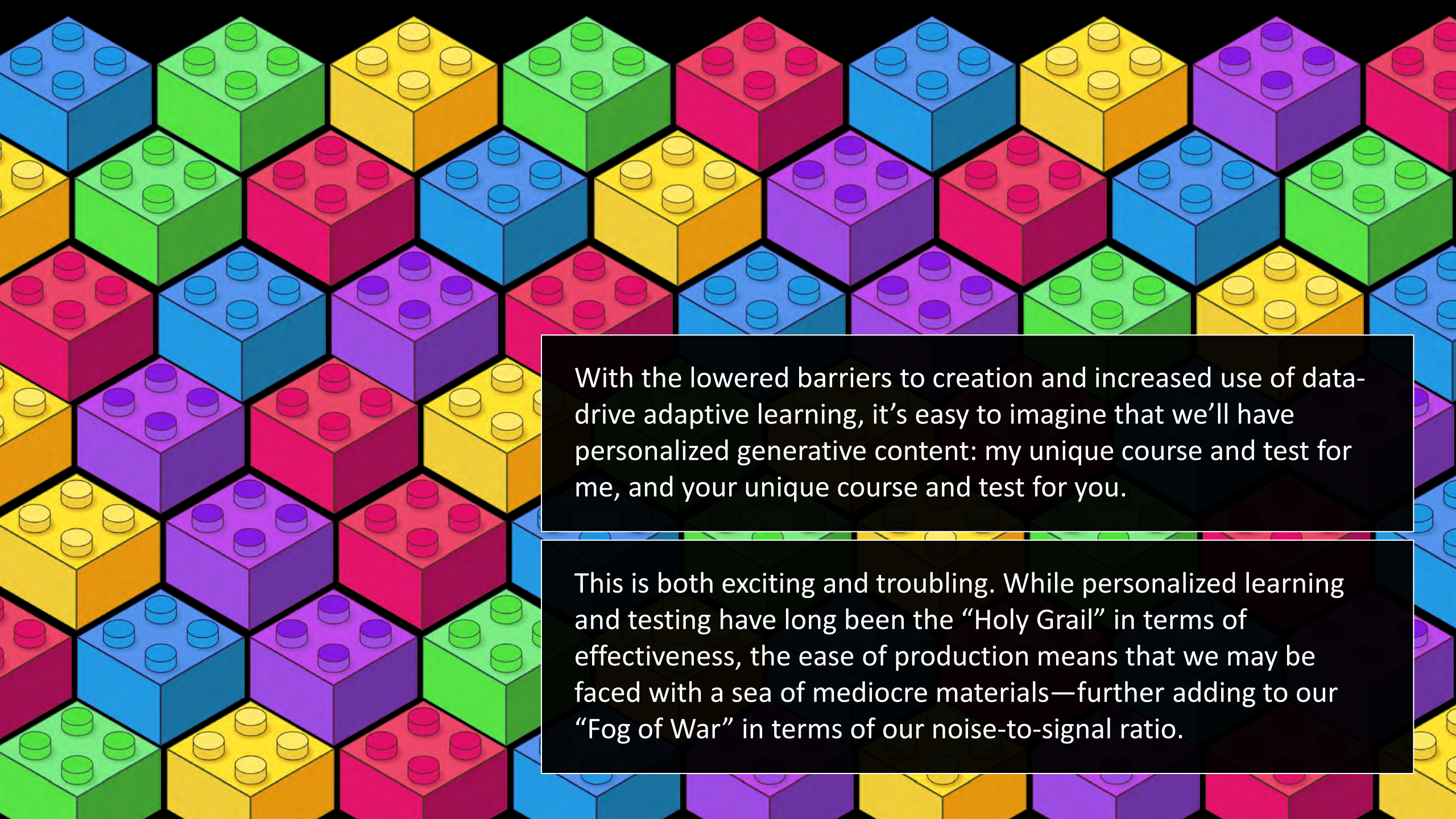
Stelter, C. (2023, July 26). "Fast, Cheap and Good: How much more productive can generative AI make writing?" https://www.linkedin.com/pulse/fast-cheap-good-how-much-more-productive-can-ai-make-writing-stelter





25% to 90% price disruption??

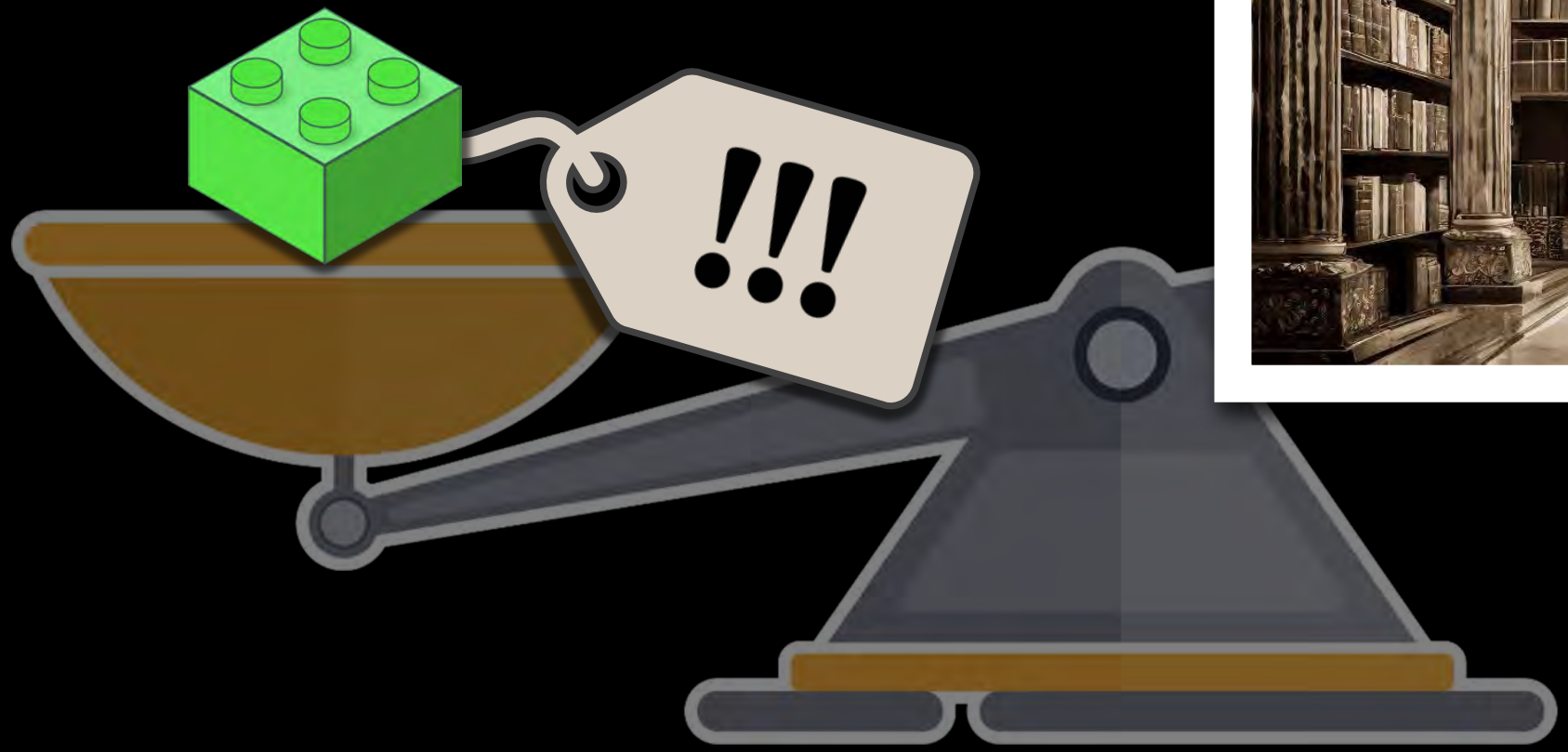
Generative AI technologies promise to create massive efficiencies—and business disruptions—across learning, development, testing, and assessment markets. What are the implications of a 90% reduction in the cost and time required to create courseware or textbooks?



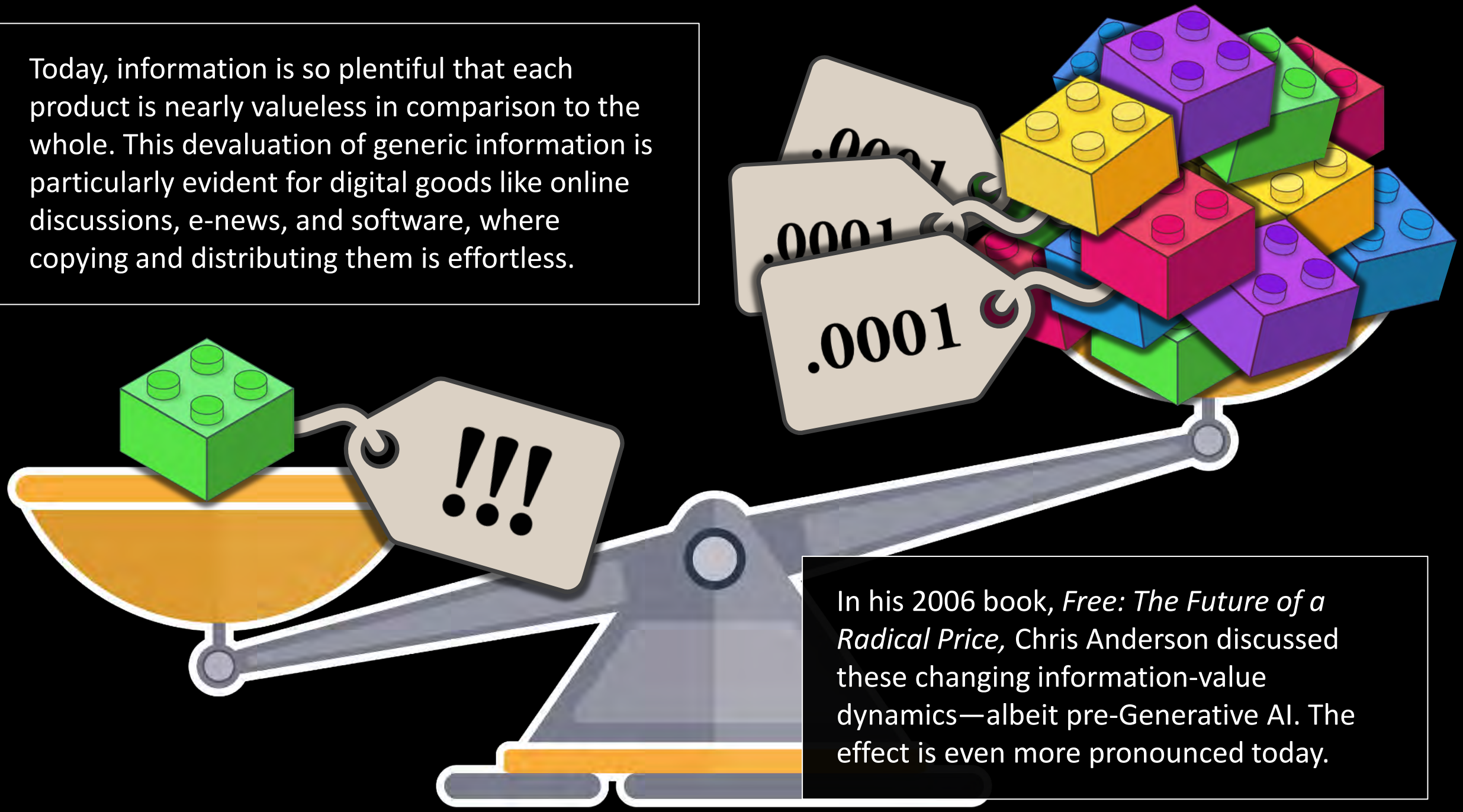
With the lowered barriers to creation and increased use of data-drive adaptive learning, it’s easy to imagine that we’ll have personalized generative content: my unique course and test for me, and your unique course and test for you.

This is both exciting and troubling. While personalized learning and testing have long been the “Holy Grail” in terms of effectiveness, the ease of production means that we may be faced with a sea of mediocre materials—further adding to our “Fog of War” in terms of our noise-to-signal ratio.

And as we rapidly build all these new products, the relative value of each is diminished. Once upon a time, information was scarce, and as a result, each scroll of ancient knowledge was prized—protected behind massive doors and only accessible by the societal elite. Information as treasure.

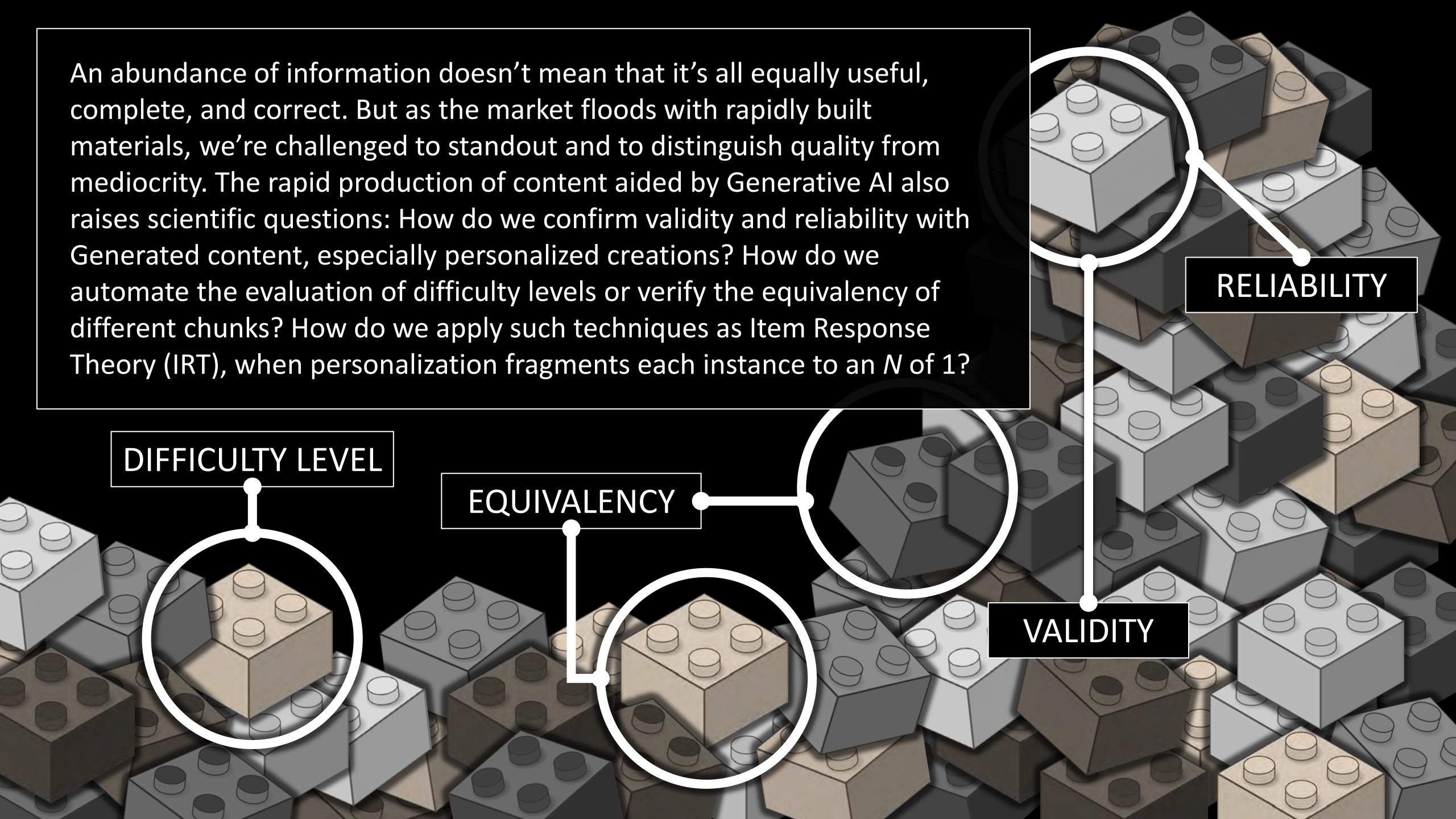


Today, information is so plentiful that each product is nearly valueless in comparison to the whole. This devaluation of generic information is particularly evident for digital goods like online discussions, e-news, and software, where copying and distributing them is effortless.



In his 2006 book, *Free: The Future of a Radical Price,* Chris Anderson discussed these changing information-value dynamics—albeit pre-Generative AI. The effect is even more pronounced today.

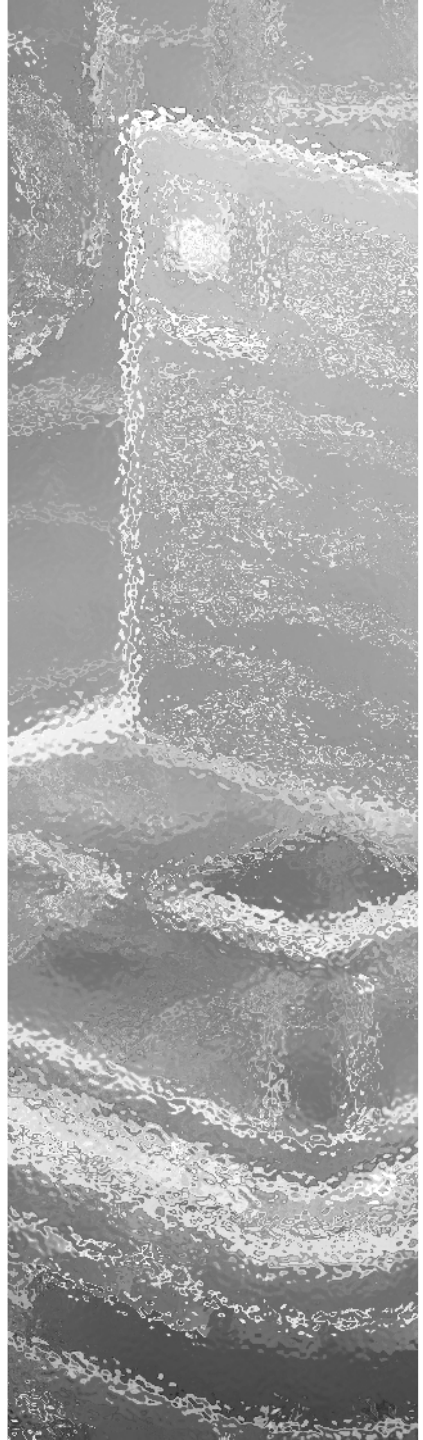
An abundance of information doesn't mean that it's all equally useful, complete, and correct. But as the market floods with rapidly built materials, we're challenged to standout and to distinguish quality from mediocrity. The rapid production of content aided by Generative AI also raises scientific questions: How do we confirm validity and reliability with Generated content, especially personalized creations? How do we automate the evaluation of difficulty levels or verify the equivalency of different chunks? How do we apply such techniques as Item Response Theory (IRT), when personalization fragments each instance to an *N* of 1?

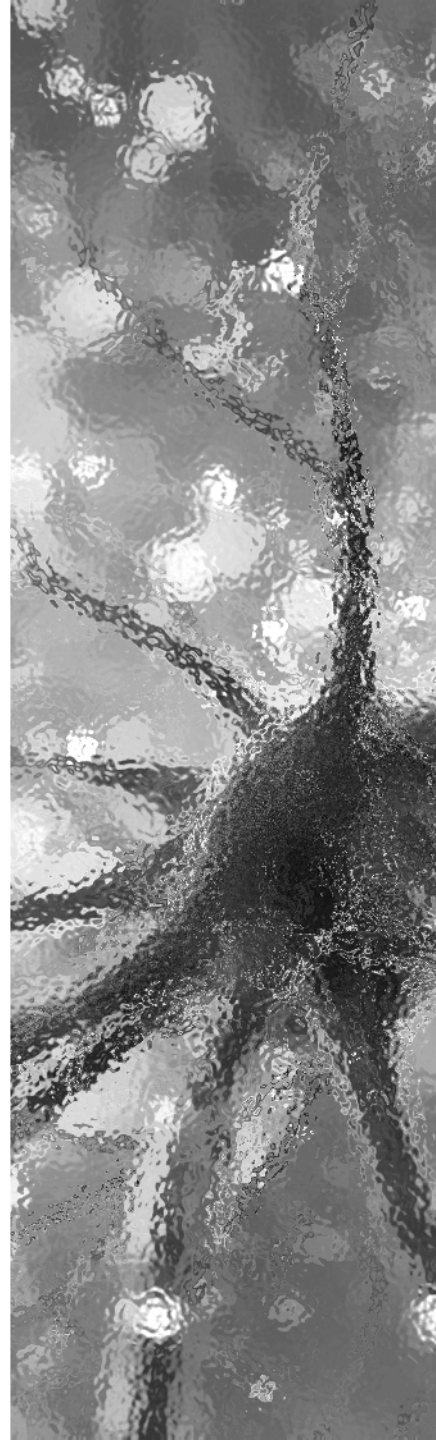


LEARNING ECOSYSTEMS

GEN AI CONTENT

LIFELONG LEARNING



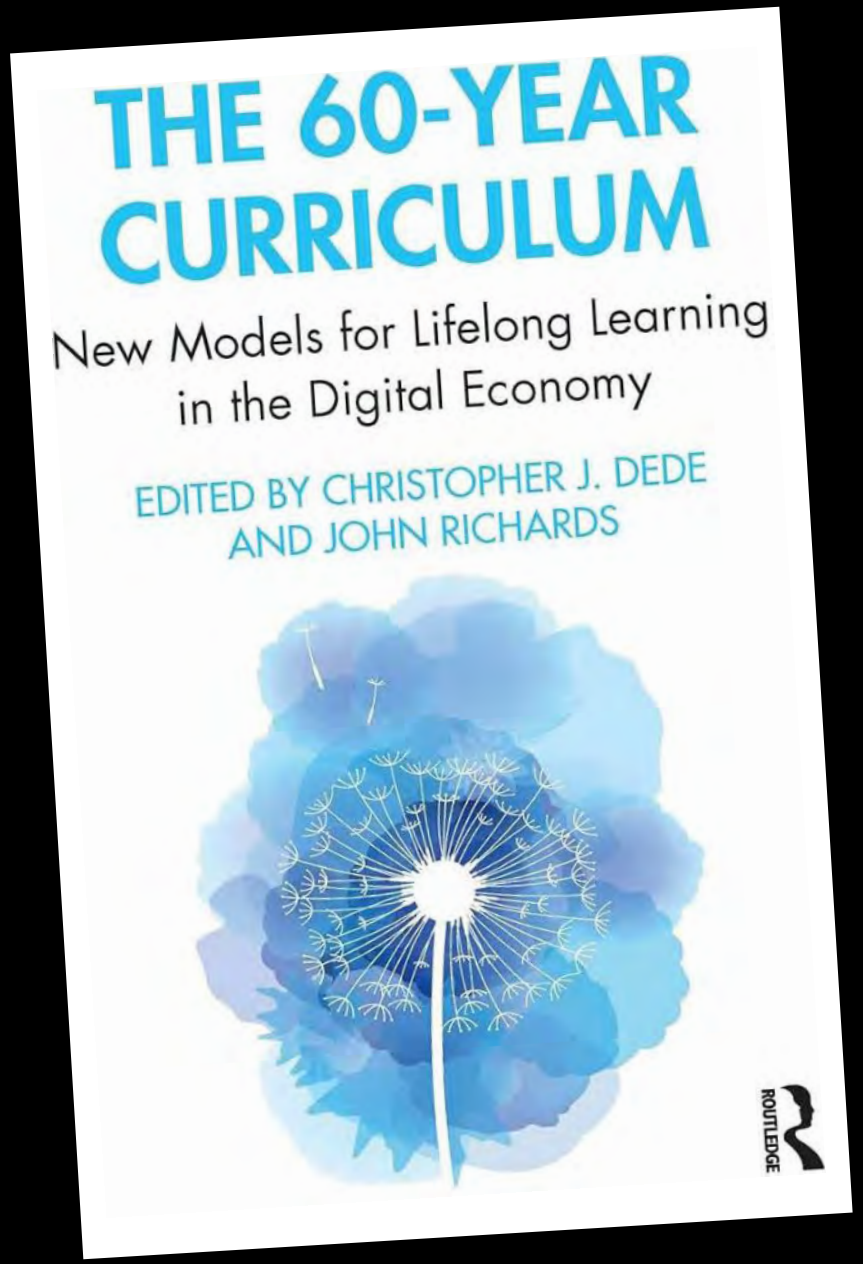


44%
of workers' core skills will change

60%
of workers will require training

…by 2027 (in the next 5 years)

World Economic Forum. (2023, May). *The Future of Jobs Report 2023.* https://www.weforum.org/publications/the-future-of-jobs-report-2023

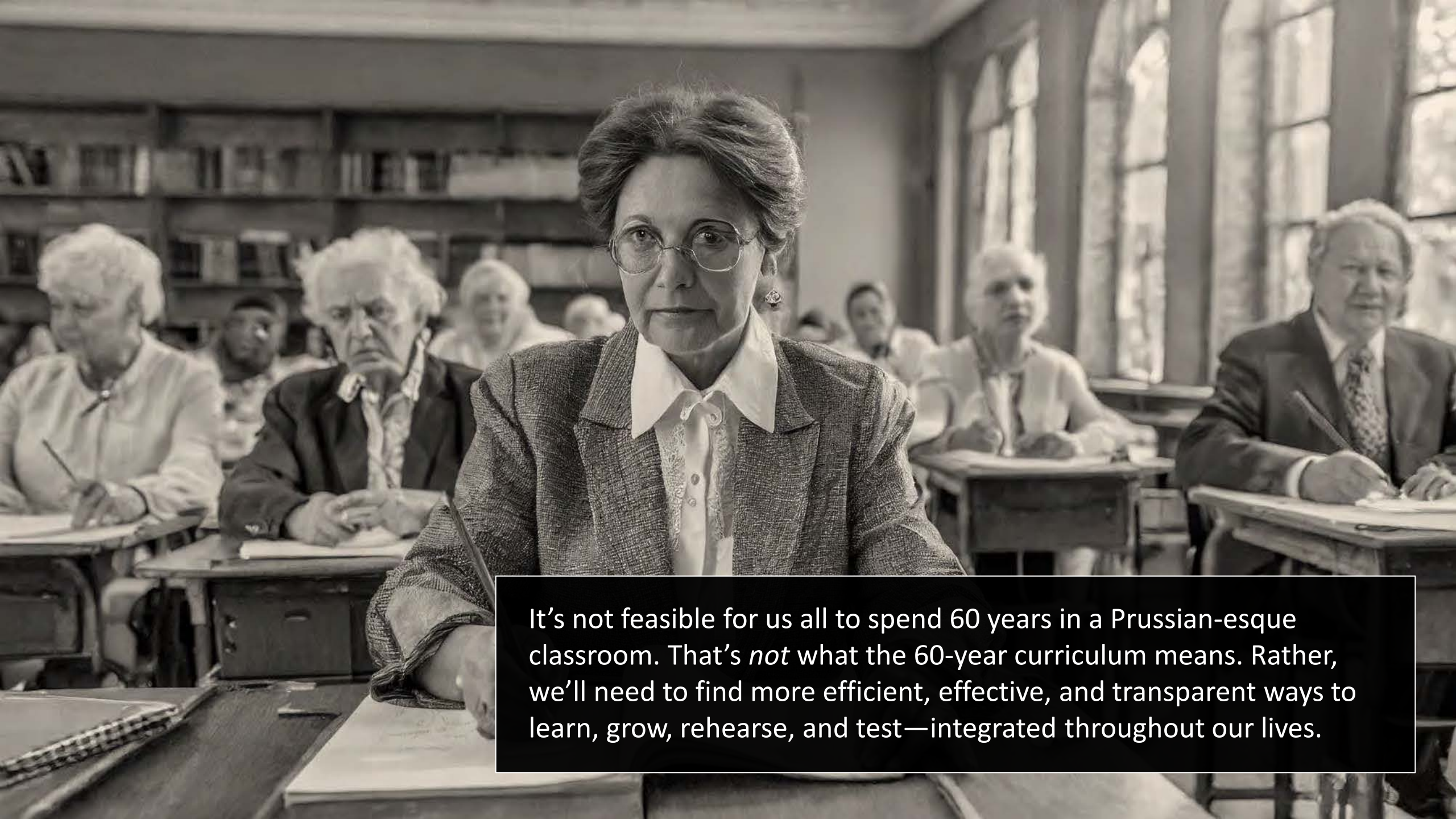


There's growing recognition that the pace of change in business and technology will require individuals to learn, upskill, and develop across their entire (working) lives.

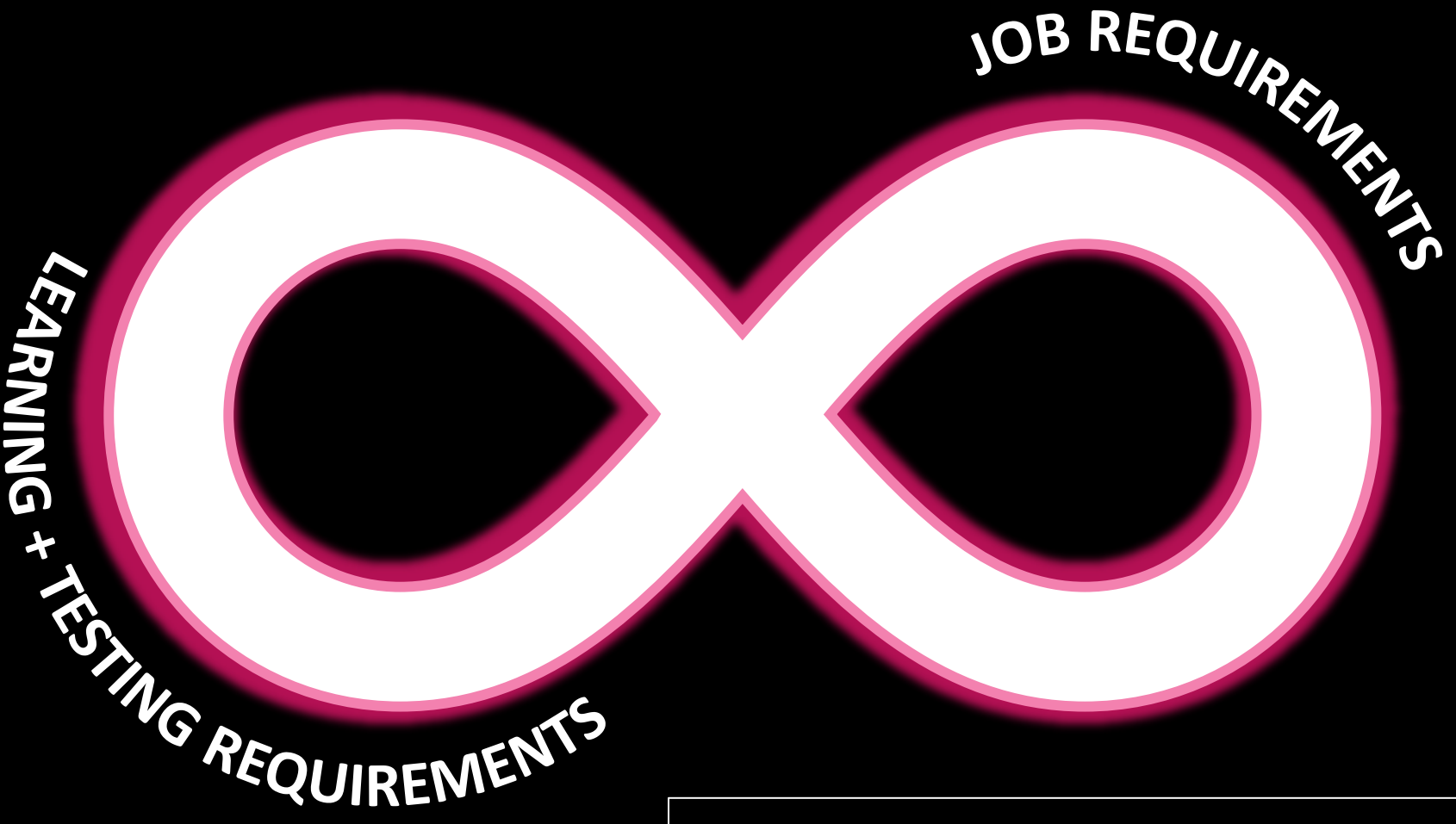
In *The 60-Year Curriculum*, Chris Dede and John Richards make the case for lifelong learning. The term "60-Year Curriculum" was coined by Gary Matlin, from the University of California, Irvine. It refers to a new perspective on lifelong (or at least career-long) learning, driven by the rapidly evolving context jobs, technologies, and market dynamics.

Dede, C. & Richards, J. (2020). *The 60-Year Curriculum: New Models for Lifelong Learning in the Digital Economy.* United Kingdom: Taylor & Francis.

For an online summary, see: Richards, J. & Dede, C. (2020, October). The 60-Year Curriculum: A Strategic Response to a Crisis, *Educause Review, 4*, 25–38. https://er.educause.edu/articles/2020/10/the-60-year-curriculum-a-strategic-response-to-a-crisis



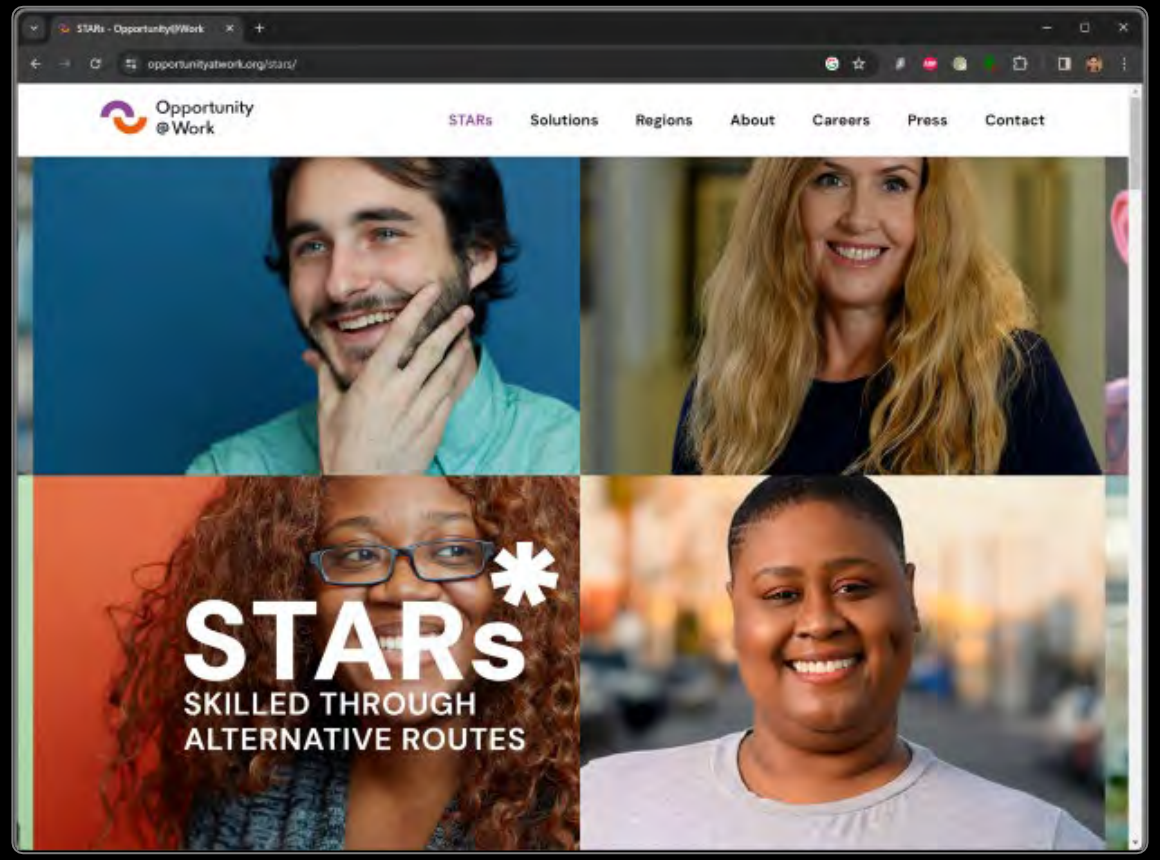
It’s not feasible for us all to spend 60 years in a Prussian-esque classroom. That’s *not* what the 60-year curriculum means. Rather, we’ll need to find more efficient, effective, and transparent ways to learn, grow, rehearse, and test—integrated throughout our lives.



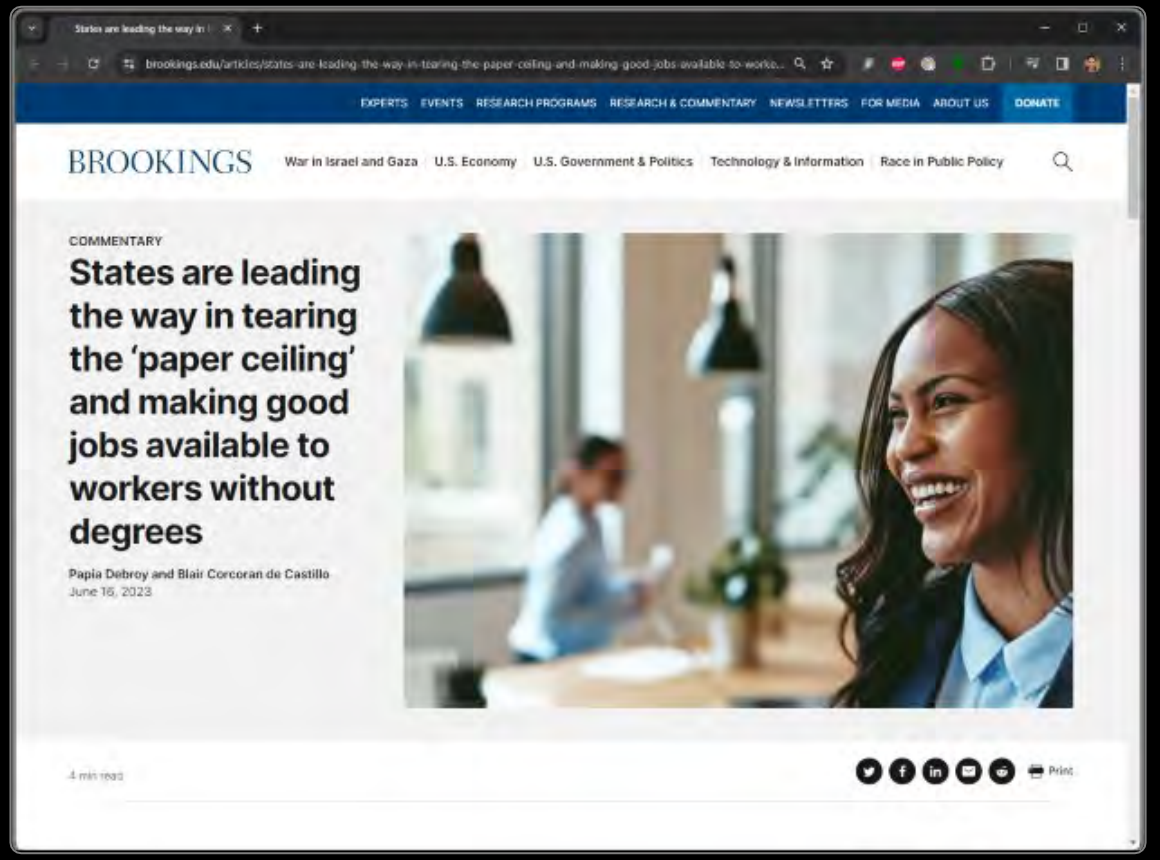
We can also expect to see a strengthening of the symbiosis between job requirements and learning/testing requirements. That doesn't necessarily mean everything needs to be about work, but rather that some expectations are set to evolve…

• Instructional offerings and desired job/task performance needs to become more tightly and reliably aligned, up to date, and validated. • Competency assessments need to reliably correlate with authentic performance, so that we're better able to predict transfer of learning and prescribe recommended next steps for personal/professional development or career advancement. • We'll see growing overlap among learning, rehearsal, performance, and assessment (more videogame tutorial and less Prussian classroom).

The lifelong learning model also necessarily recognizes that learning also happens outsides classrooms.

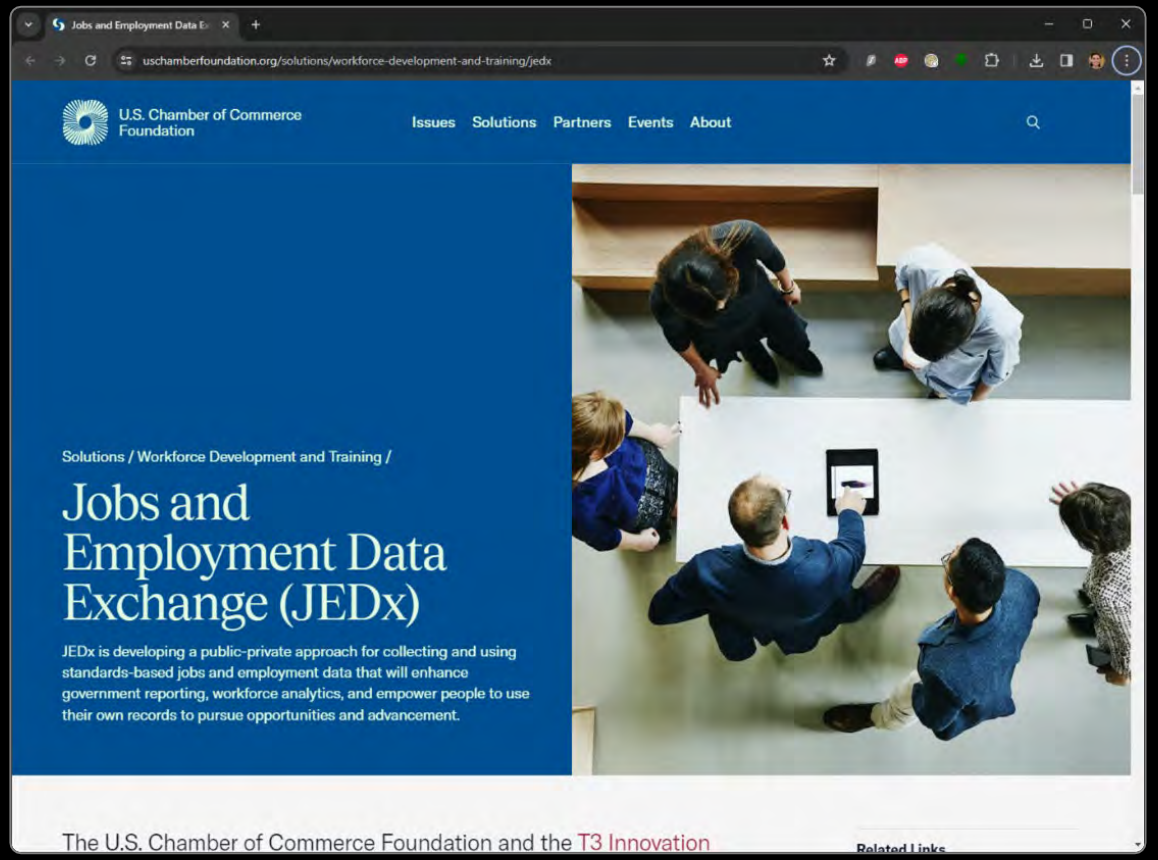


Increasing awareness and support for those Skilled Through Alternative Routes • https://opportunityatwork.org

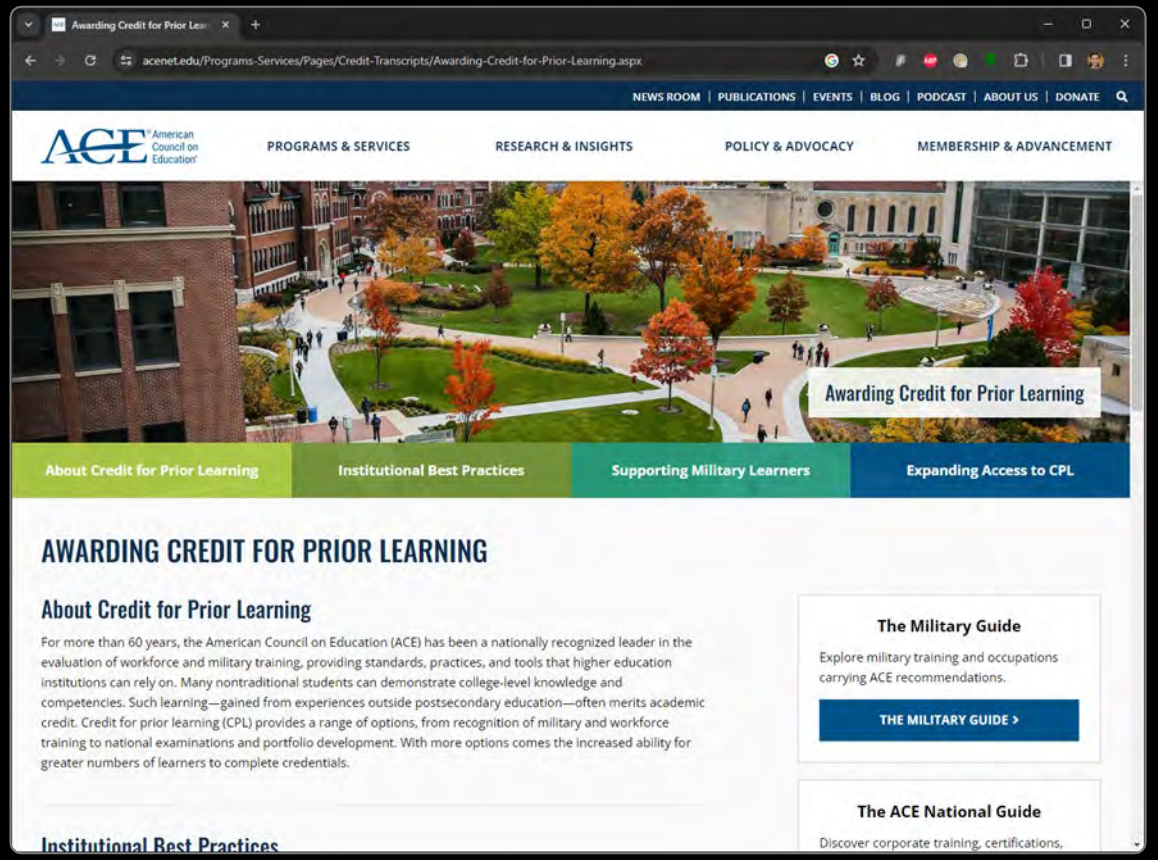


US Government HR systems swapping higher-education requirements for STARS • https://www.brookings.edu

Technologies, processes, and policies for enabling the 60-Year Curriculum are already manifesting.



US Chamber of Commerce Foundation working on data standards for jobs • https://www.uschamberfoundation.org



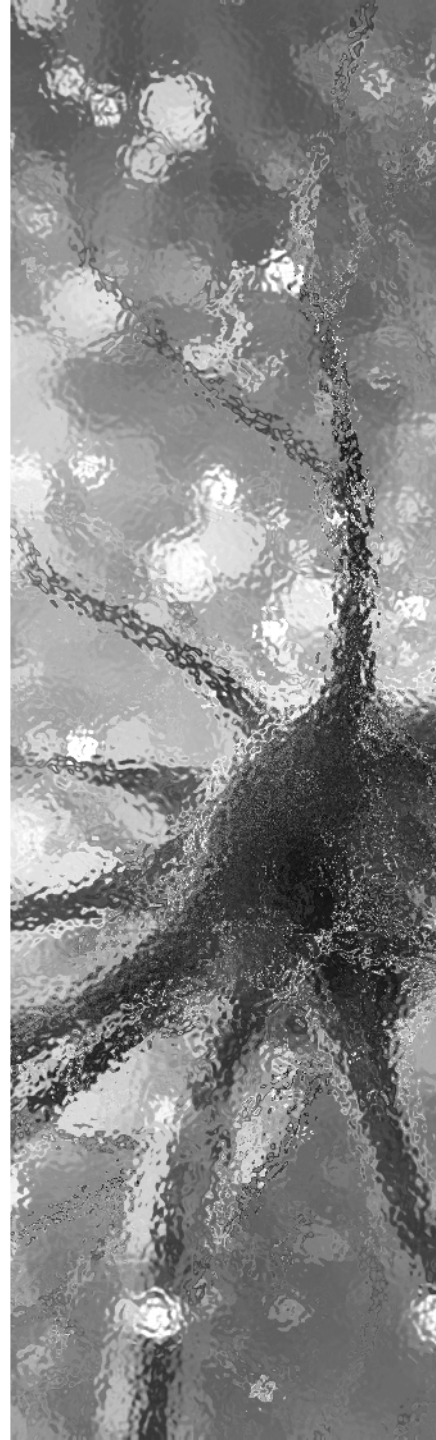
ACE awarding credit for prior work and life experiences • https://www.acenet.edu

LEARNING ECOSYSTEMS

GEN AI CONTENT

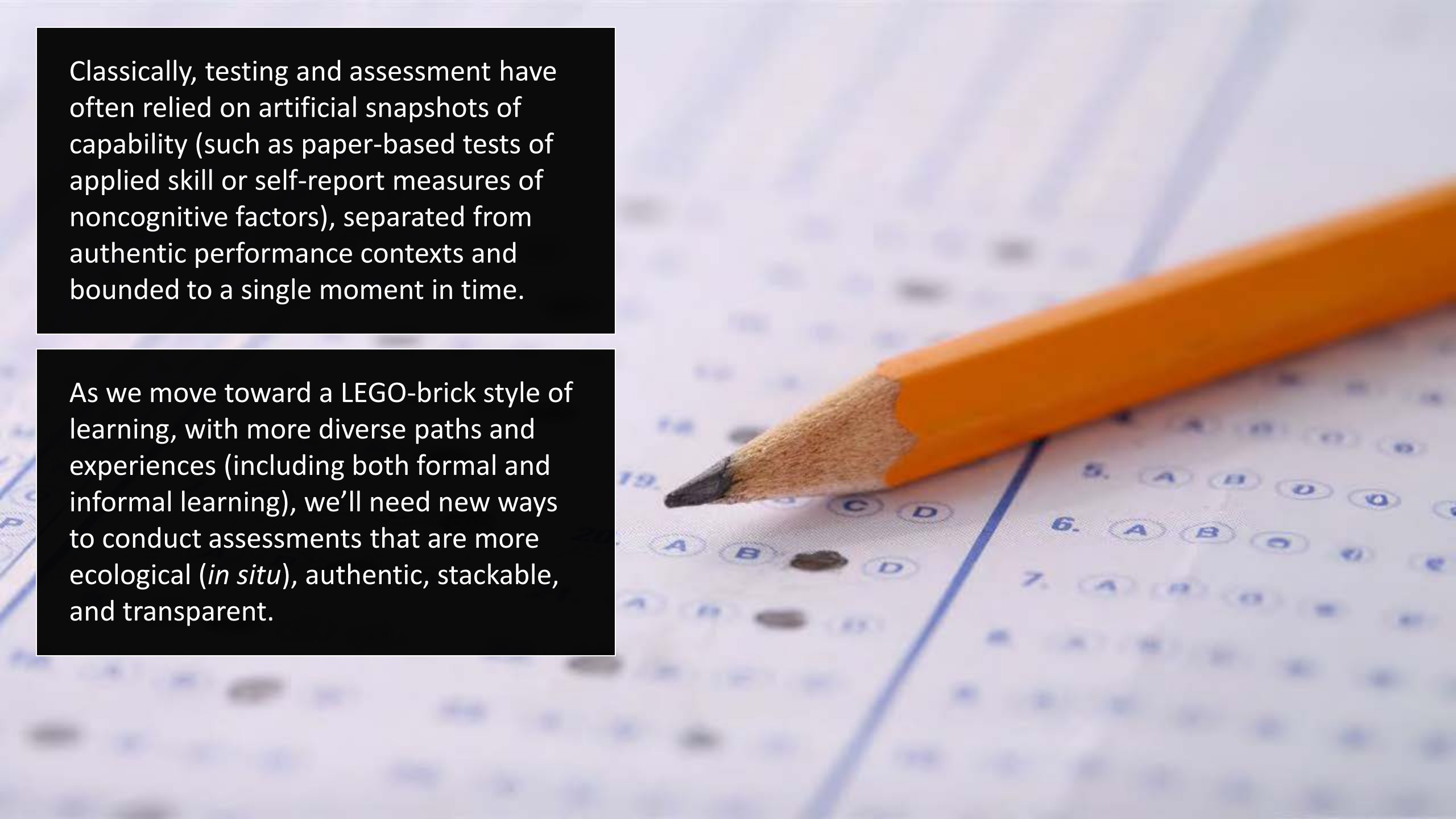
LIFELONG LEARNING

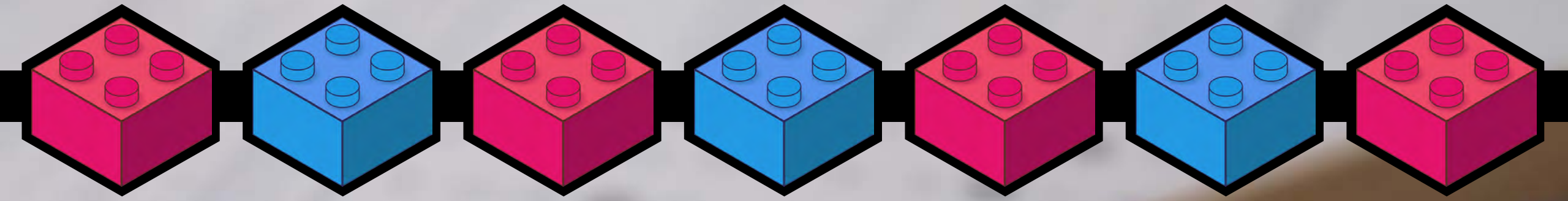
TESTING AND ASSESSMENT



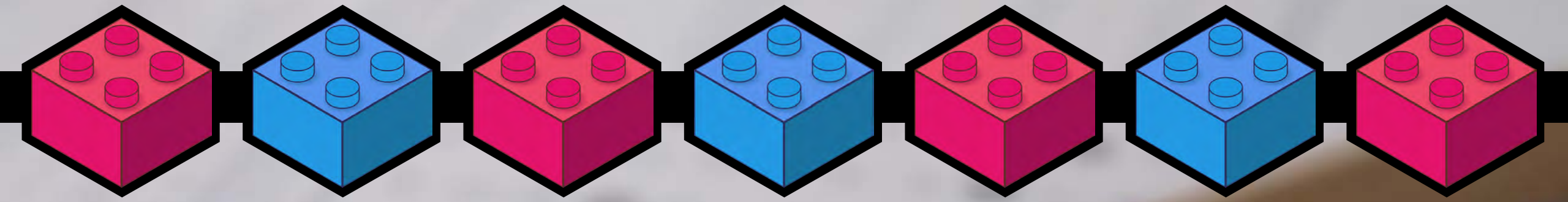
Classically, testing and assessment have often relied on artificial snapshots of capability (such as paper-based tests of applied skill or self-report measures of noncognitive factors), separated from authentic performance contexts and bounded to a single moment in time.

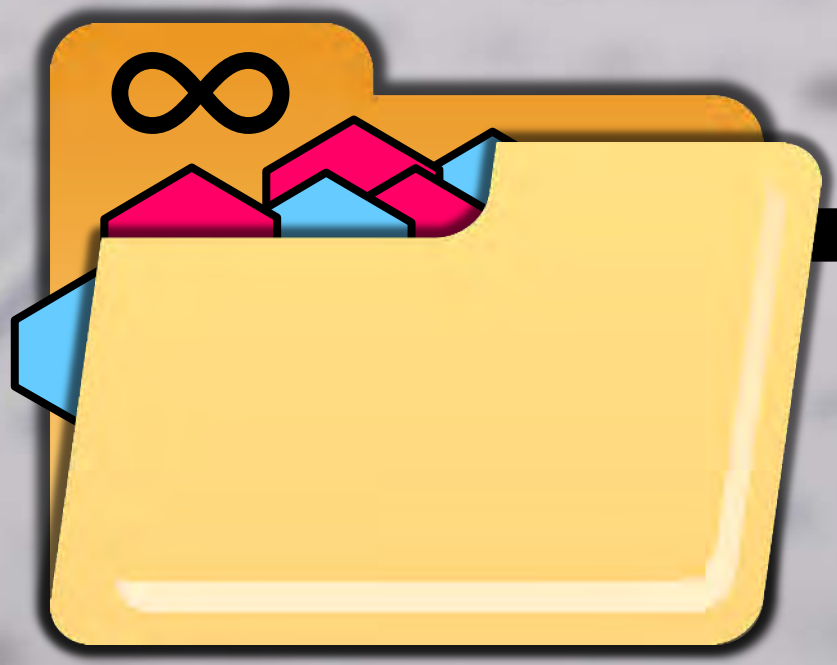
As we move toward a LEGO-brick style of learning, with more diverse paths and experiences (including both formal and informal learning), we'll need new ways to conduct assessments that are more ecological (*in situ*), authentic, stackable, and transparent.

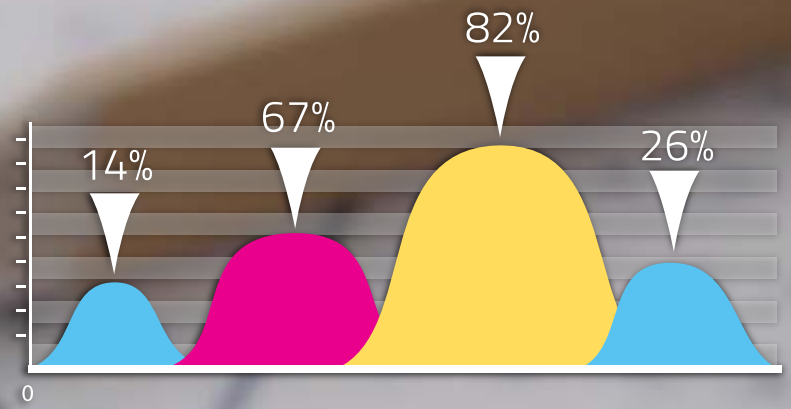




Fortunately, there are many new opportunities for integrated, continuous, and multifactor measures. Data can also be compiled over periods of time (versus snapshots), informing descriptive analyses and allowing future tests and assessments to be tailored based on those areas where there is uncertainty in individuals' learner-worker portfolios.







MULTIMODAL

ASSERTIONS

LEARNING ANALYTICS

Integrated and multifactor measures can be transparent to those who are learning or being assessed. Computers and other devices can be instrumented to collect data, such as monitoring real-time behaviors and performance (e.g., with cameras, clickstream, and wearable sensors). Multiple simultaneous data feeds can be aggregated to give more reliable results, and learning analytics can be used to make inferences from the aggregate data.

DESCRIPTIVE

INFERENTIAL

PREDICTIVE

PRESCRIPTIVE

These diverse, multimodal data can also be collected over time and processed via Learning Analytics methods to provide descriptive, as well as inferential, predictive, and prescriptive analyses, both immediately and longitudinally.

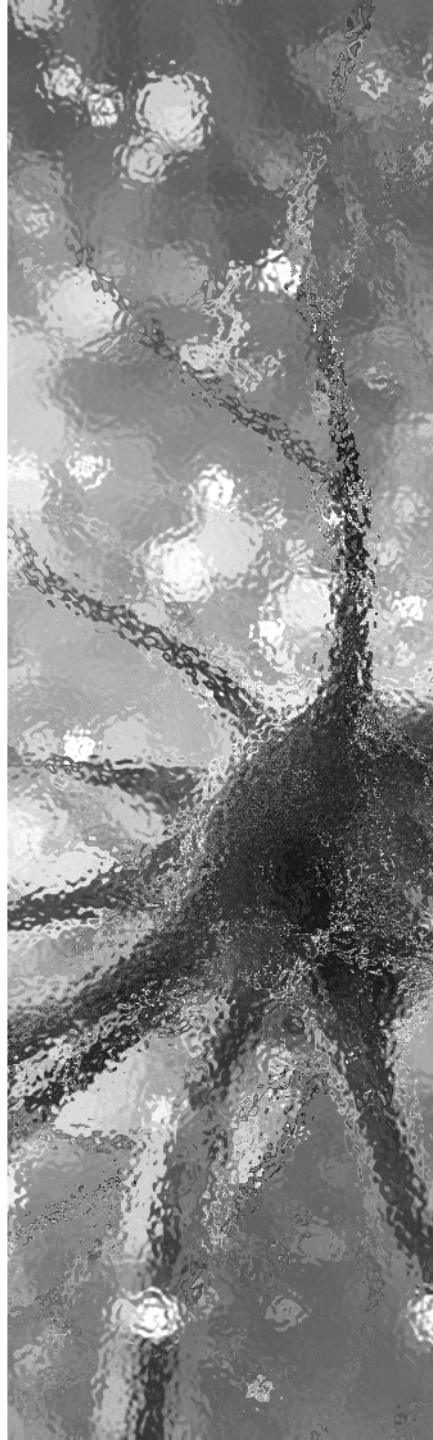
LEARNING ECOSYSTEMS

GEN AI CONTENT

LIFELONG LEARNING

TESTING AND ASSESSMENT

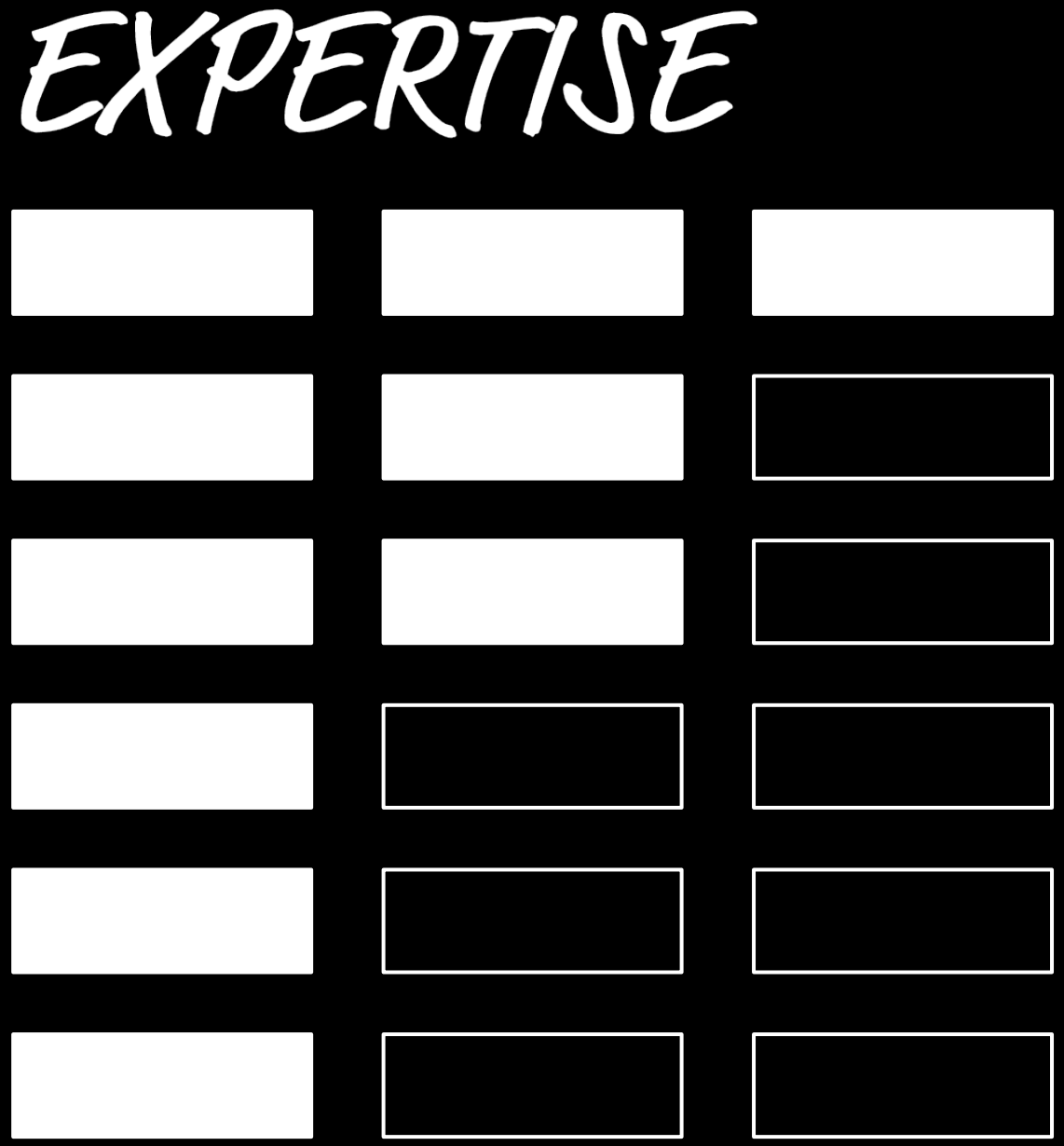
AUGMENTED INTELLIGENCE

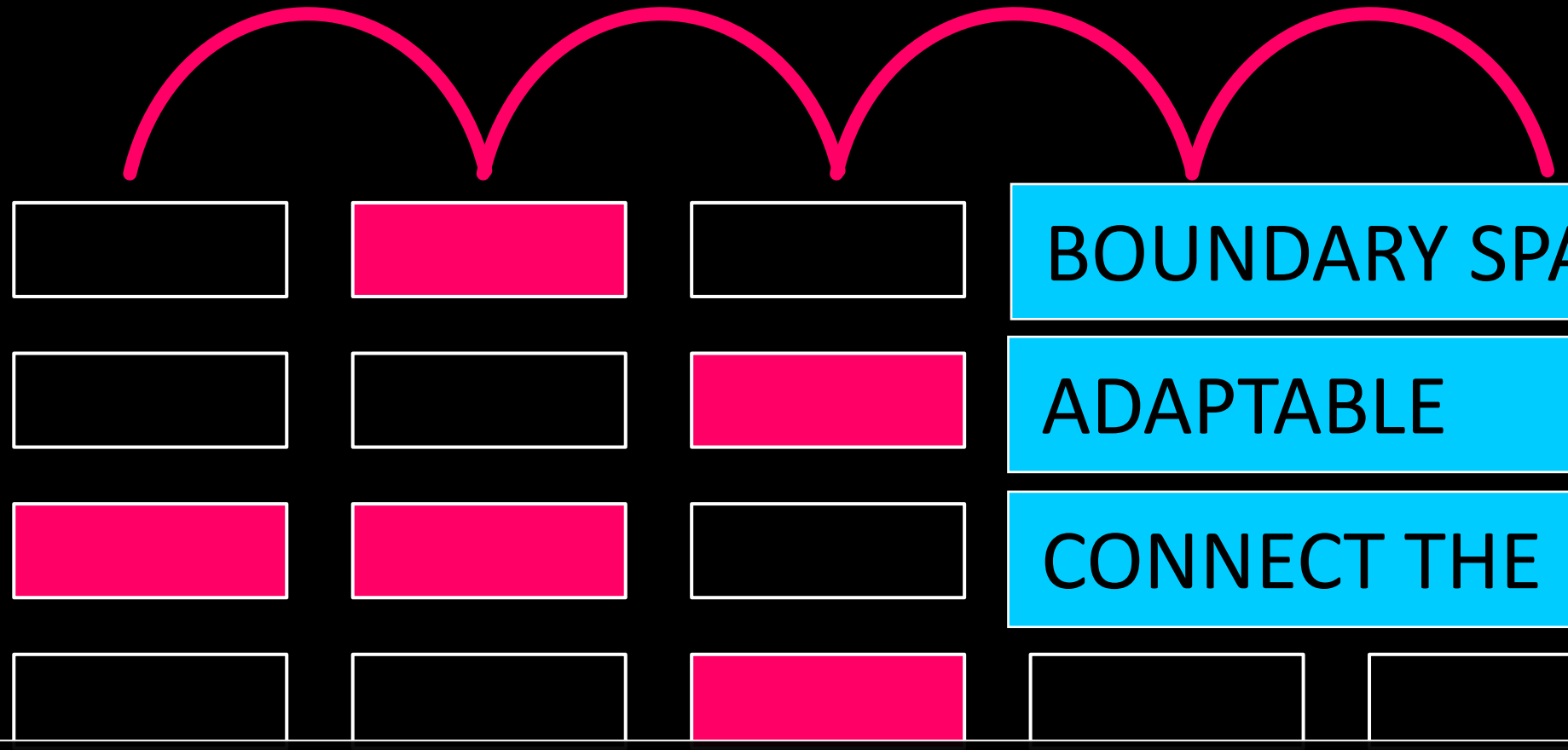


Once upon a time, expertise was mainly defined as deep knowledge and skill in a single vertical, with, perhaps, some supplementary skills in adjacent verticals.

Today and into the future, we can expect to see more augmented intelligence—the integration of AI with human intelligence to enhance our cognitive work.

In combination, people and programs can accomplish amazing feats, better than either alone. Even average individuals paired with AI teammates have shown that they can best (human) grandmasters or standalone algorithms.





BOUNDARY SPANNING

ADAPTABLE

CONNECT THE DOTS

Today, many organizations are seeking more diverse “experts” who have a smattering of knowledge and skills across different domains. These are “expert generalists.” Expert generalists are in high demand due to the increasing interdependency of systems and—most notably—the increasing use of technology to supplement our knowledge and skills. An armchair “pseudo expert” from today with the aid of Google and Wikipedia could likely compete against any deep, traditional expert from the Prussian era.

Philip Tetlock helped popularize the “Fox and Hedgehog” analogy.

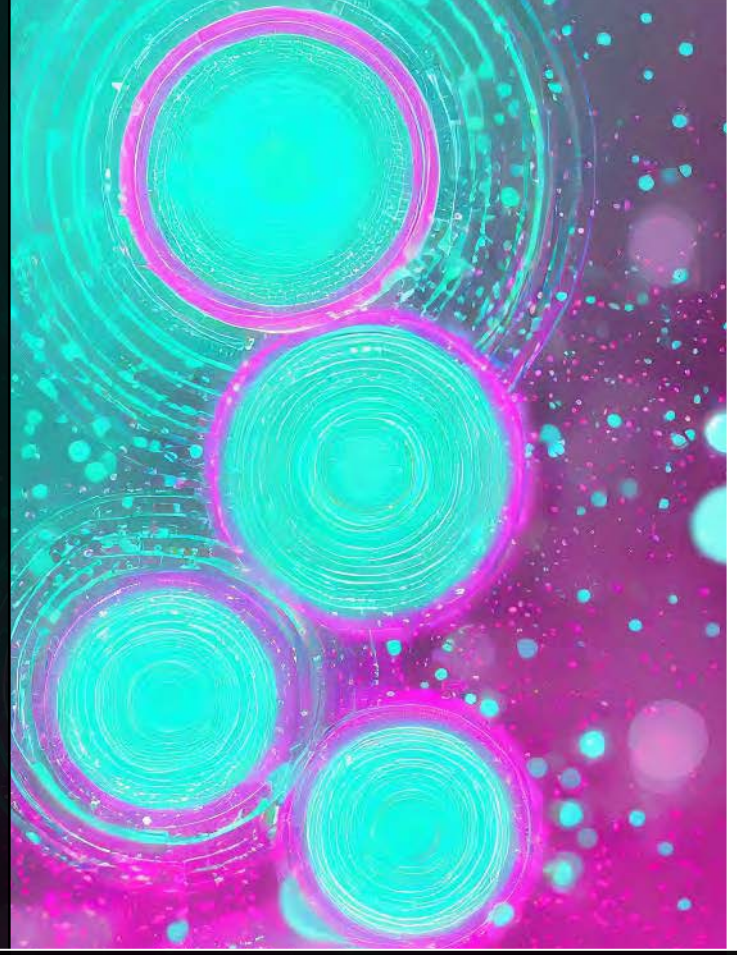
Foxes represent expert generalists; they tend to pursue many ends, often unrelated and even contradictory, and they’re typically skeptical of grand theories.

Hedgehogs are narrow experts. They relate everything back to a single central vision, are eager to extend their theories into new domains, and are relatively confident in their abilities.

EXPERT GENERALISTS

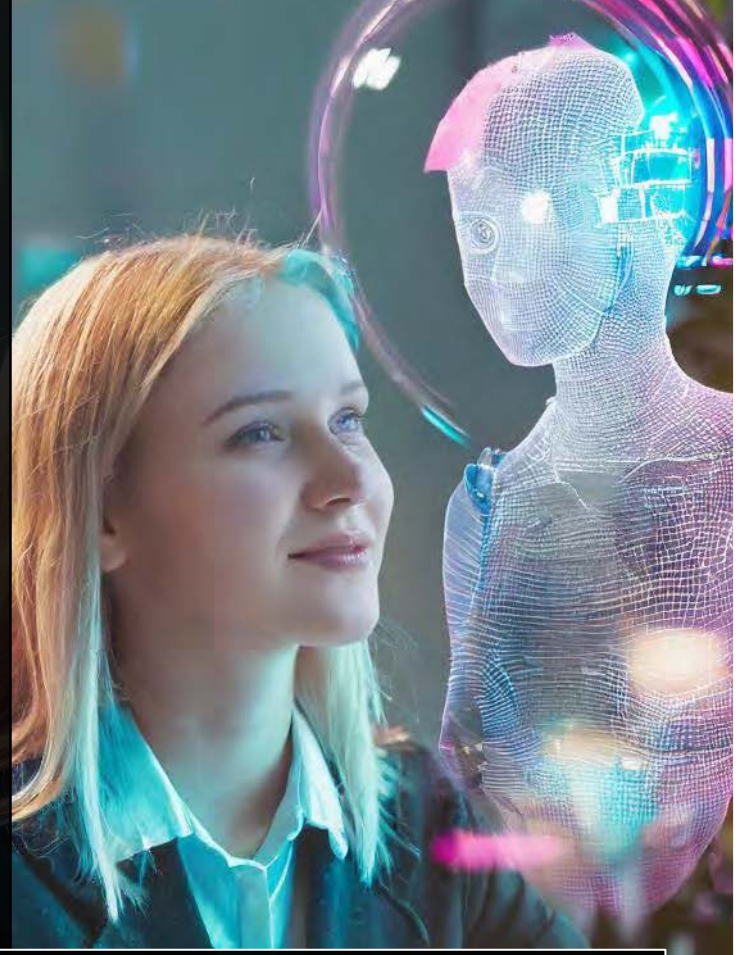
The fox knows many things; the hedgehog one great thing

Collapsing Boundaries



Developing Youth and Novices

"Cheating"



These trends encourage us to think about: • the boundaries between learning, rehearsal, evaluation, and performance spaces. • Our notions of how to develop novices into experts. If AI can simply perform the lower-level cognitive actions, then how do we provide enough practice for novices to develop their organic knowledge and skills? Do they even need those augmented knowledge and skills anymore? • And the notion of "cheating"—on homework, on tests, and at work.

SPECIAL ARTICLE

The "online brain": how the Internet may be changing our cognition

Joseph Firth[1,2], John Torous[3], Brendon Stubbs[4,5], Josh A. Firth[6,8], Genevieve Z. Steiner[7,8], Lee Smith[10], Mario Alvarez-Jimenez[8,11], John Gleeson[8,12], Davy Vancampfort[13,14], Christopher J. Armitage[2,15,16], Jerome Sarris[1,17]

The impact of the Internet across multiple aspects of modern society is clear. However, the influence that it may have on our brain structure and functioning remains a central topic of investigation. Here we draw on recent psychological, psychiatric and neuroimaging findings to examine several key hypotheses on how the Internet may be changing our cognition. Specifically, we explore how unique features of the online world may be influencing: a) attentional capacities, as the constantly evolving stream of online information encourages our divided attention across multiple media sources, at the expense of sustained concentration; b) memory processes, as this vast and ubiquitous source of online information begins to shift the way we retrieve, store, and even value knowledge; and c) social cognition, as the ability for online social settings to resemble and evoke real-world social processes creates a new interplay between the Internet and our social lives, including our self-concepts and self-esteem. Overall, the available evidence indicates that the Internet can produce both acute and sustained alterations in each of these areas of cognition, which may be reflected in changes in the brain. However, an emerging priority for future research is to determine the effects of extensive online media usage on cognitive development in youth, and examine how this may differ from cognitive outcomes and brain impact of uses of Internet in the elderly. We conclude by proposing how Internet research could be integrated into broader research settings to study how this unprecedented new facet of society can affect our cognition and the brain across the life course.

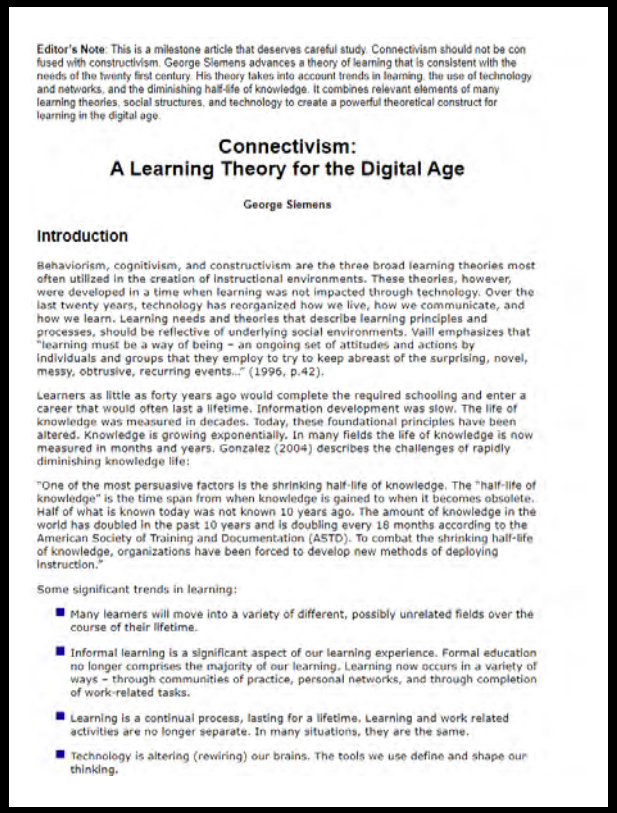
Key words: Internet, cognition, attention, memory, social structures, social media, addiction, virtual reality

(World Psychiatry 2019;18:119-129)

The Internet is the most widespread and rapidly adopted technology in the history of humanity. In only decades, Internet use has completely re-invented the ways in which we search for information, consume media and entertainment, and manage our social networks and relationships. With the even more recent advent of smartphones, Internet access has become portable and ubiquitous to the point at which the populations of the developed world can be considered "online"[1-3].

However, the impact that this new channel for connection, information, communication, and screen time is having on our brains and cognitive functioning is unclear. Prior to the Internet, a large body of research had convincingly demonstrated that the brain is somewhat malleable to environmental demands and stimuli, particularly with regards to learning new processes, due to its capacity for neuroplasticity[4]. Various scenarios have been observed to induce long-term changes in the neuronal architecture of the human brain, including second-language acquisition[5], learning new motor skills (such as juggling)[6], and even formal education or exam preparation[7]. The widespread use of the Internet across the globe has introduced, for many, the necessity and opportunity to learn a myriad of new skills and ways to interact with society, which could bring about neural changes. As an example, even simple interactions with the Internet through the smartphone's touchscreen interface have been demonstrated to bring about sustained neurocognitive alterations due to neural changes in cortical regions associated with sensory and motor processing of the hand and thumb[8]. Beyond this, the Internet also presents a novel platform for almost-endless learning of new information and complex processes, relevant to both the online and offline world[9].

Along with neuroplastic mechanisms, other environmental and biological factors can also cause changes in the brain's structure and function, resulting in cognitive decline[10]. In aging samples, for instance, there is evidence to indicate that age-related cognitive decline may be partly driven by a process of atrophy. Some studies have shown that adopting a less engaging lifestyle across the lifespan may accelerate loss of cognitive function[11], due to lower "cognitive reserve" (the ability of the brain to withstand insult from age and/or pathology)[12]. Some emerging evidence indicates that disengaging from the "real world" in favor of virtual settings may similarly induce adverse neurocognitive changes. For example, a recent randomized controlled trial (RCT)[13] found that six weeks of engaging in an online role playing game caused significant reductions in grey matter within the orbitofrontal cortex - a brain region implicated in impulse control and decision making. However, the study did not address the extent to which these results were specific to online gaming, rather than general internet usage. Nonetheless, this raises the possibility that various types of Internet usage could differentially affect the brain and cognitive processes - in both adverse and beneficial ways. This may be of particular relevance to the developing brains of children and adolescents, as many cognitive processes (particularly those relevant to higher executive functions and social cognition)



Editor's Note: This is a milestone article that deserves careful study. Connectivism should not be confused with constructivism. George Siemens advances a theory of learning that is consistent with the needs of the twenty first century. His theory takes into account trends in learning: the use of technology and networks, and the diminishing half-life of knowledge. It combines relevant elements of many learning theories, social structures, and technology to create a powerful theoretical construct for learning in the digital age.

Connectivism:
A Learning Theory for the Digital Age

George Siemens

Introduction

Behaviorism, cognitivism, and constructivism are the three broad learning theories most often utilized in the creation of instructional environments. These theories, however, were developed in a time when learning was not impacted through technology. Over the last twenty years, technology has reorganized how we live, how we communicate, and how we learn. Learning needs and theories that describe learning principles and processes, should be reflective of underlying social environments. Vaill emphasizes that "learning must be a way of being – an ongoing set of attitudes and actions by individuals and groups that they employ to try to keep abreast of the surprising, novel, messy, obtrusive, recurring events..." (1996, p.42).

Learners as little as forty years ago would complete the required schooling and enter a career that would often last a lifetime. Information development was slow. The life of knowledge was measured in decades. Today, these foundational principles have been altered. Knowledge is growing exponentially. In many fields the life of knowledge is now measured in months and years. Gonzalez (2004) describes the challenges of rapidly diminishing knowledge life:

"One of the most persuasive factors is the shrinking half-life of knowledge. The "half-life of knowledge" is the time span from when knowledge is gained to when it becomes obsolete. Half of what is known today was not known 10 years ago. The amount of knowledge in the world has doubled in the past 10 years and is doubling every 18 months according to the American Society of Training and Documentation (ASTD). To combat the shrinking half-life of knowledge, organizations have been forced to develop new methods of deploying instruction."

Some significant trends in learning:

- Many learners will move into a variety of different, possibly unrelated fields over the course of their lifetime.
- Informal learning is a significant aspect of our learning experience. Formal education no longer comprises the majority of our learning. Learning now occurs in a variety of ways – through communities of practice, personal networks, and through completion of work-related tasks.
- Learning is a continual process, lasting for a lifetime. Learning and work related activities are no longer separate. In many situations, they are the same.
- Technology is altering (rewiring) our brains. The tools we use define and shape our thinking.

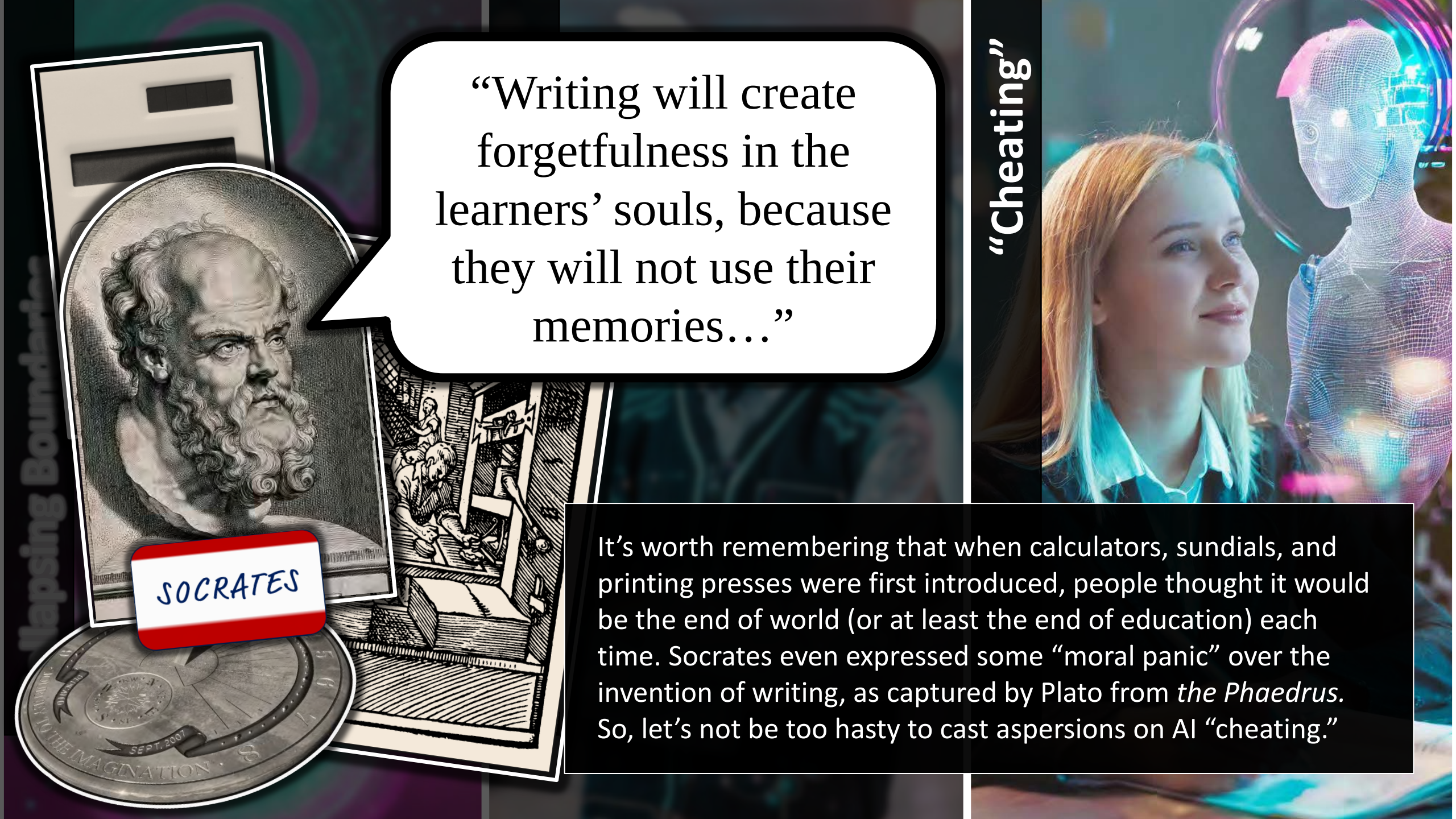
Firth, J., Torous, J., Stubbs, B. et al. (2019). The "online brain": how the Internet may be changing our cognition. *World Psychiatry, Jun;18*(2):119-129.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6502424/

Siemens, G. (2005). Connectivism: A learning theory for the digital age. International Journal of Instructional Technology and Distance Learning, 2(1), 3-10.

https://www.itdl.org/Journal/Jan_05/article01.htm

We've faced parallel challenges after the advent of the internet and rise of the Information Age and Social Age. Those informational and connective technologies augmented our lower-level cognitive skills, such as remembering and understanding, and in turn, shifted the ways our brains operate. And those new capabilities catalyzed a new paradigm of learning: Connectivism.


Leaping Boundaries
"Writing will create forgetfulness in the learners' souls, because they will not use their memories…"
SOCRATES
"Cheating"
It's worth remembering that when calculators, sundials, and printing presses were first introduced, people thought it would be the end of world (or at least the end of education) each time. Socrates even expressed some "moral panic" over the invention of writing, as captured by Plato from *the Phaedrus.* So, let's not be too hasty to cast aspersions on AI "cheating."

LEARNING ECOSYSTEMS

GEN AI CONTENT

LIFELONG LEARNING

TESTING AND ASSESSMENT

AUGMENTED INTELLIGENCE

LEARNING ENGINEERING

learning engineering [ˈlərniNG ˌenjəˈniriNG]

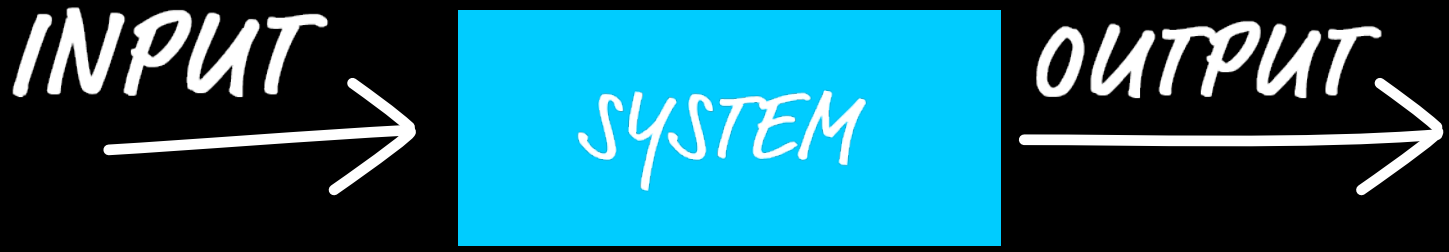
Learning engineering is a process and practice that applies the learning sciences, using human-centered engineering design methodologies and data-informed decision-making, to support learners and their development.

Goodell et al. (2022), *Learning Engineering Toolkit*

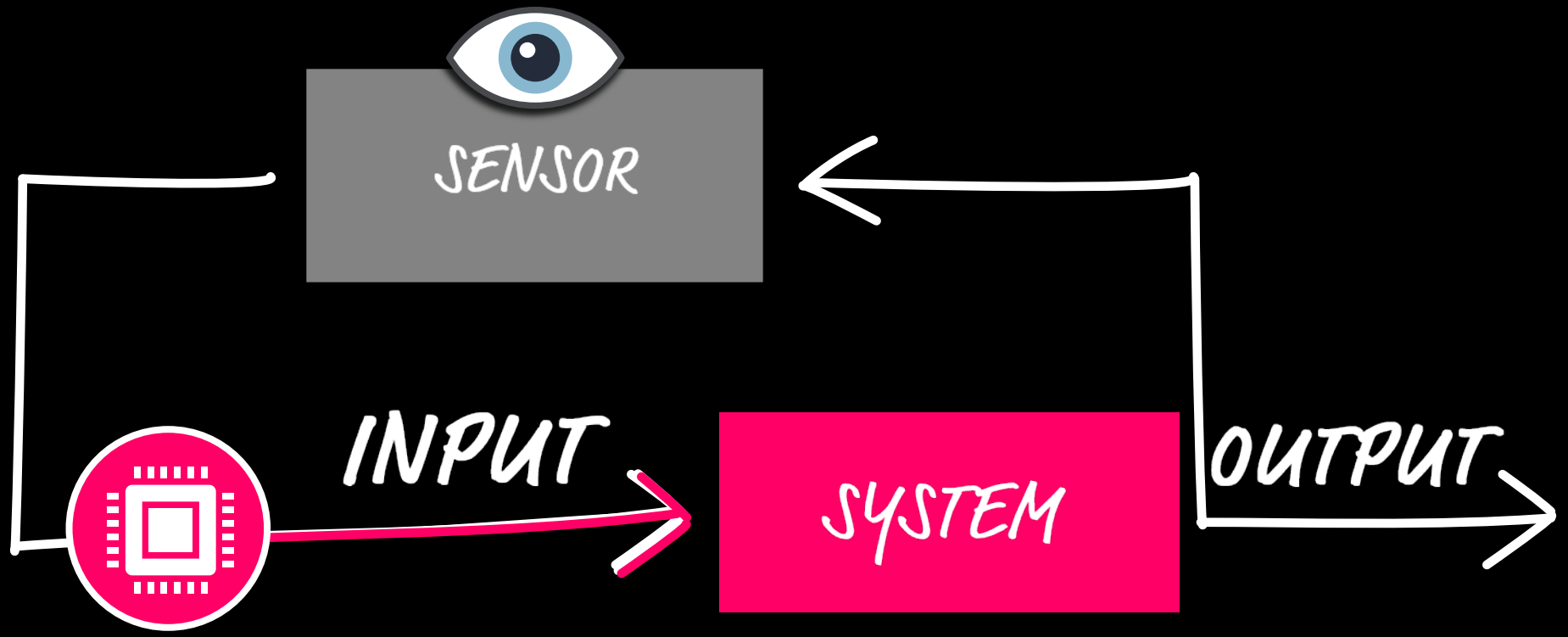
learning engineering [ˈlərniNG ˌenjəˈniriNG]

Learning engineering is a process and practice that applies the…

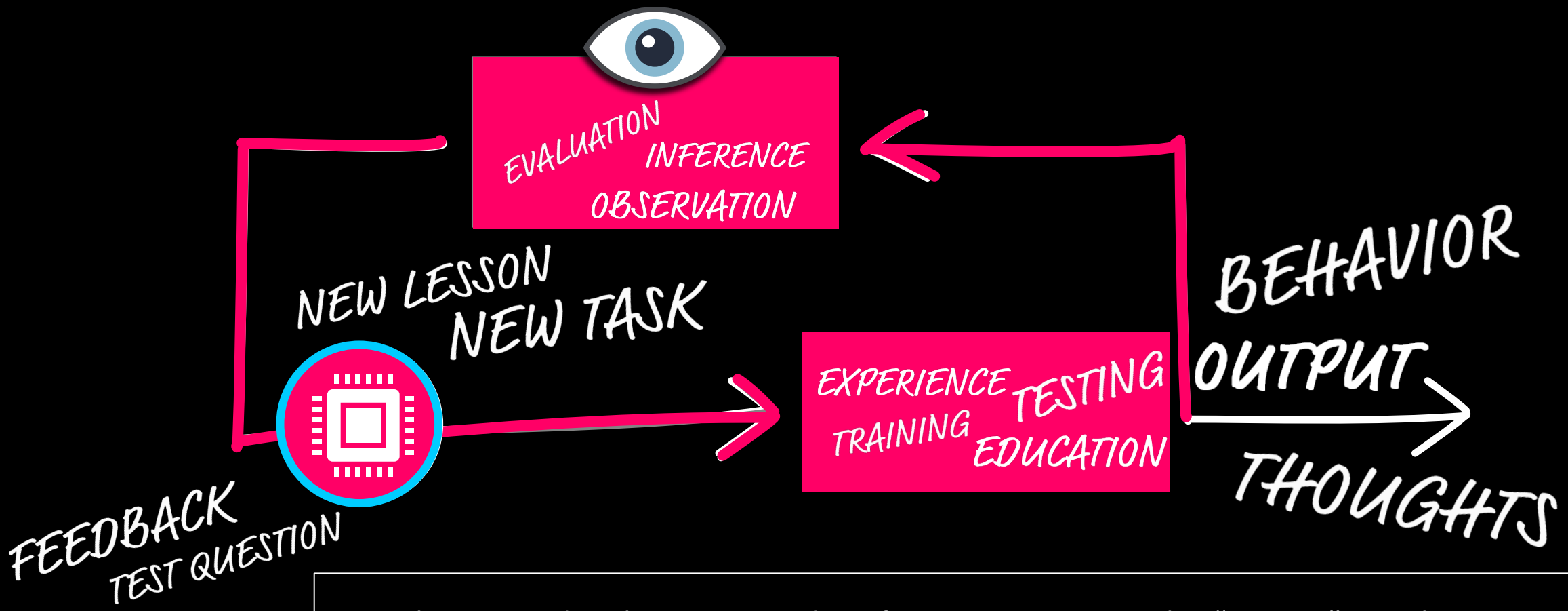
AN ITERATIVE



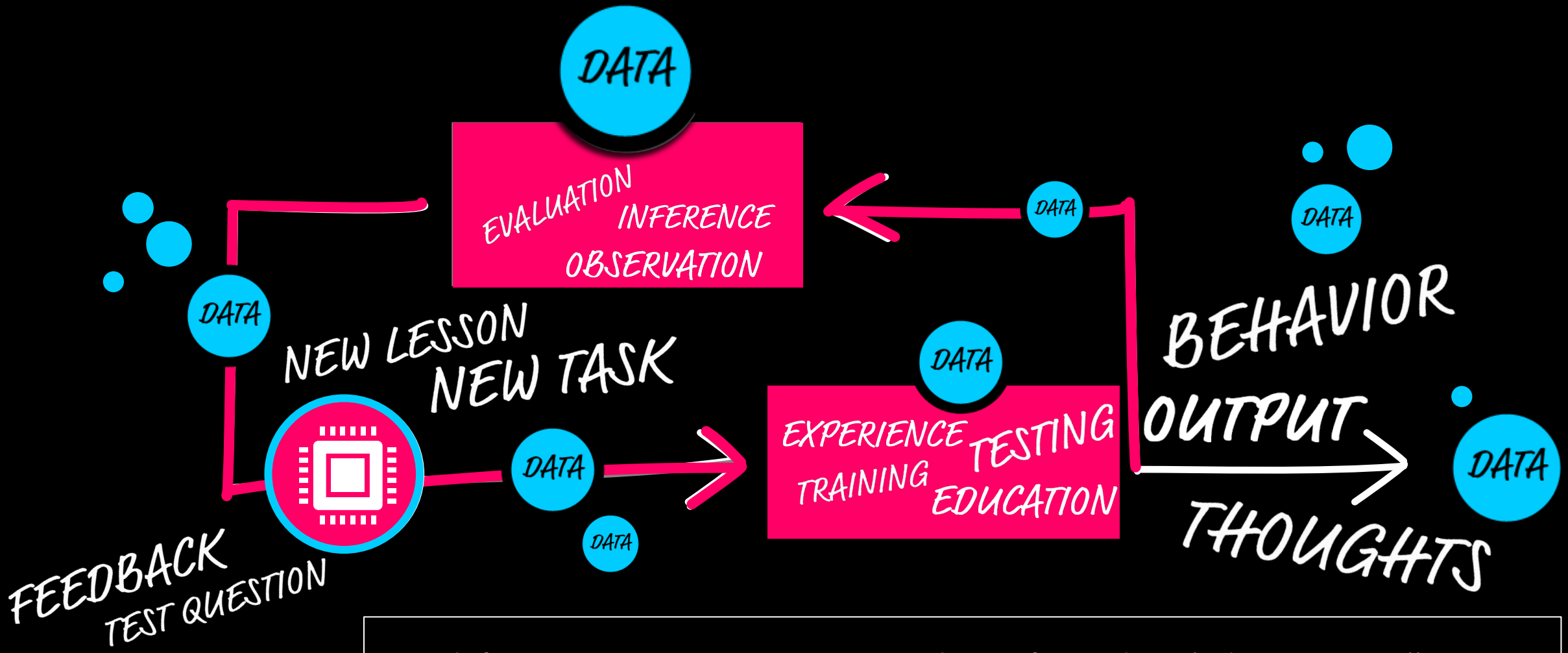
A process is a series of actions or steps taken to achieve a particular end. A process has: inputs, process steps, and outputs.



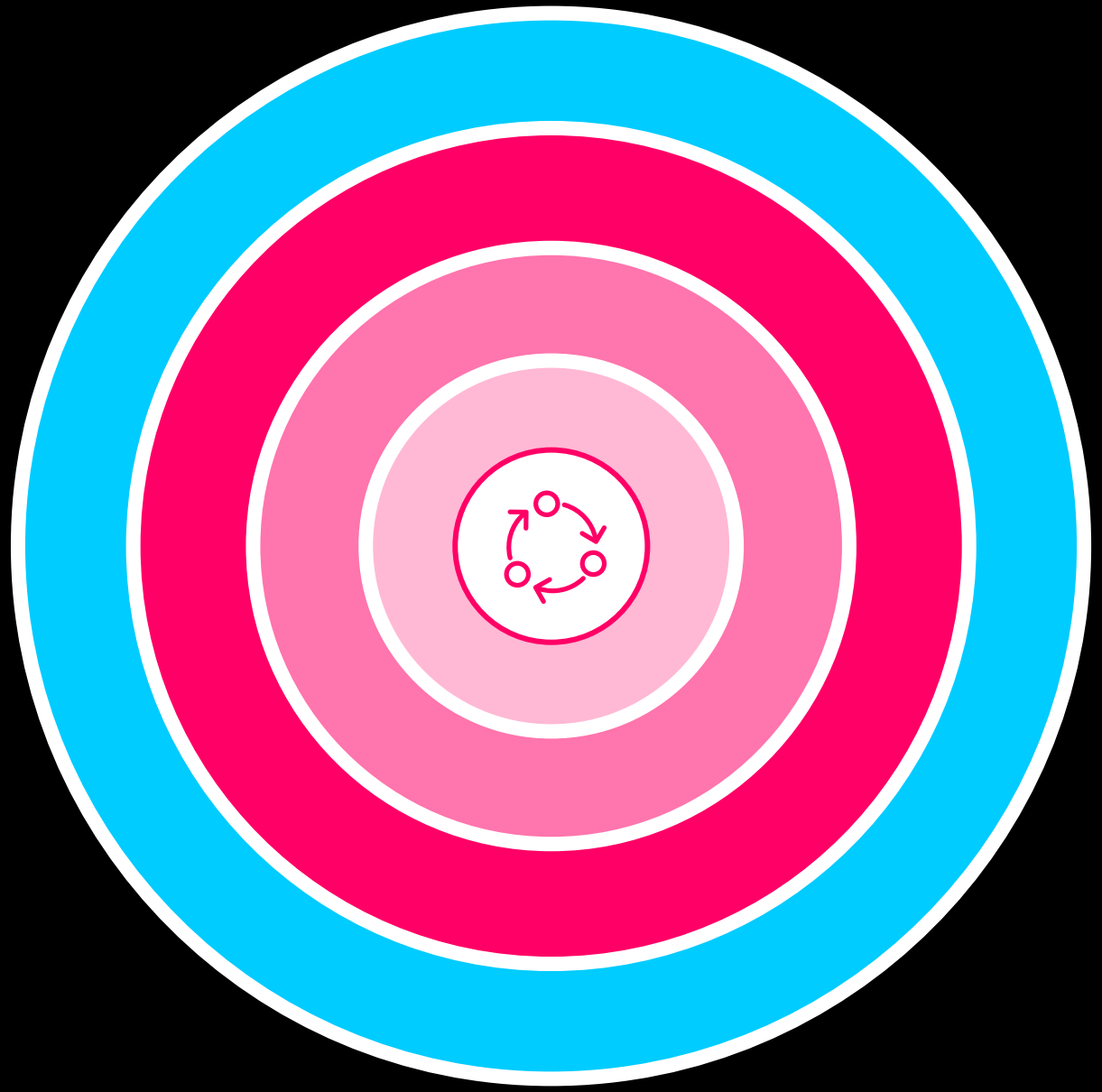
An iterative process uses feedback loops to continuously inform and improve the output.



In a learning, development, and performance context, the “system” may be education, training, testing, and so on; the “observation” may be simple behavioral documentation, evaluation, inference, and so on; and the “control” (inputs after the feedback loop) may be a new lesson, feedback, a different test, et cetera.



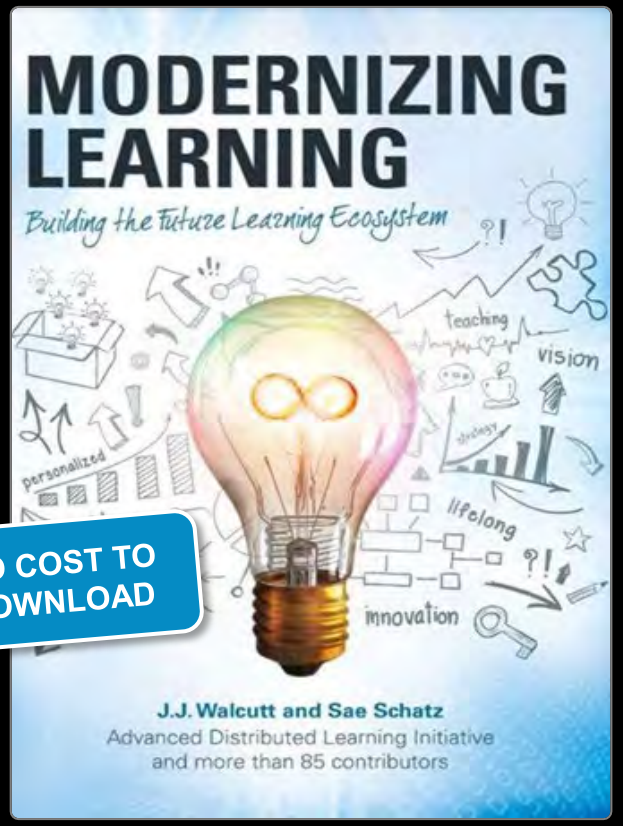
By definition, Learning Engineering is data-informed, with data potentially collected across all points of the process. Data are used to not only adapt the immediate feedback mechanism (the immediate “controller”) but also to drive continuous improvement of the process and at broader levels of abstraction.



These feedback loops can be applied within an immediate, local “micro” context, such as within a single exercise or adaptive test.

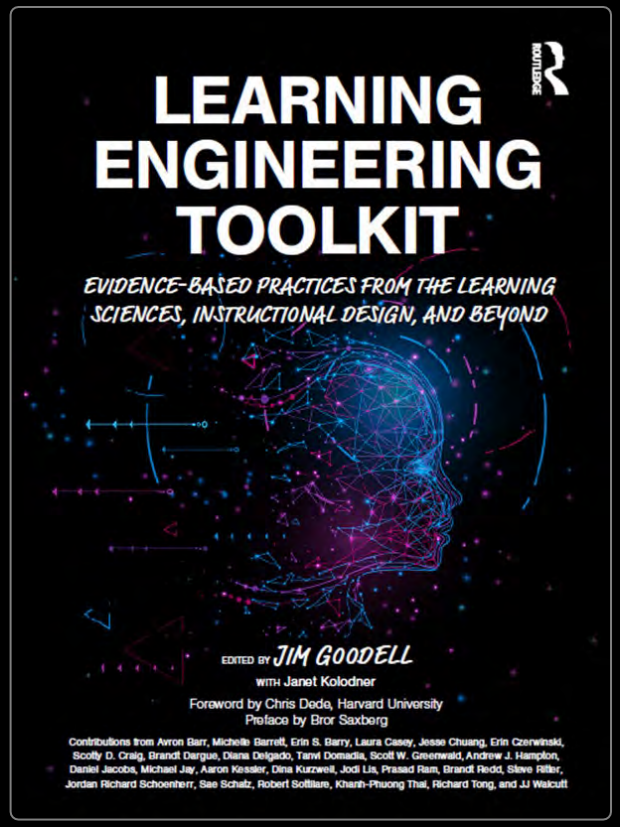
They can also apply at a more macro context, such as within a single course—and beyond. You can imagine a series of nested feedback loops surrounding a lifelong learner, with each potentially optimized through learning engineering processes: from the problem level, to the course level, to the credential level, up to the career/lifelong levels of abstraction.

The data collected during these loops can also inform feedback on the process itself, helping to drive continuous improvement of learning, development, testing, and assessment—so that they collectively become an integrated continuous service rather than a series of standalone products.



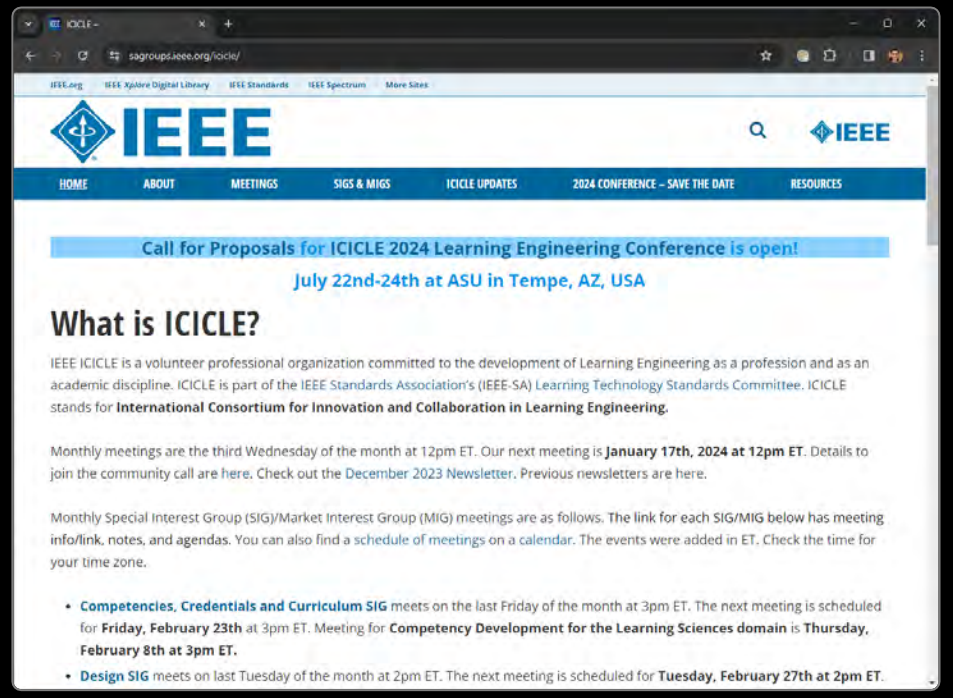
Walcutt, J. J. & Schatz, S. (Eds.). (2019). *Modernizing learning: Building the future learning ecosystem.* Washington, DC: Government Publishing Office.

https://adlnet.gov/publications/2019/04/modernizing-learning



Goodell, J., et al. (Eds.). (2023). *Learning engineering toolkit: Evidence-based practices from the learning sciences, instructional design, and beyond*. New York, NY: Routledge.

https://www.routledge.com



International Consortium for Innovation and Collaboration in Learning Engineering (ICICLE). Community of practice around learning engineering, hosted by the IEEE.

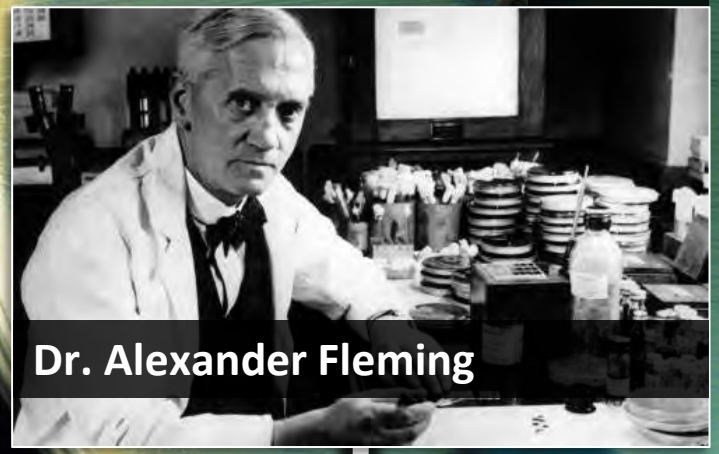
https://ieeeicicle.org

Why is this new discipline called Learning *Engineering*? Why isn't it considered an extension of the existing field of Learning *Science*?

For that answer, consider this anecdote, taken from the *Learning Engineering Toolkit*…

In 1928, Alexander Fleming discovered penicillin but couldn't produce the drug at scale. By June 1942, US labs had only enough to treat about ten patients. The urgency of lives being lost in the war meant that production of penicillin needed to move out of the laboratory and into mass-production. This was no longer just a scientific endeavor; it required engineering.

1928



Dr. Alexander Fleming

Engineers Begin to Scale

First Factory Opens

WWII

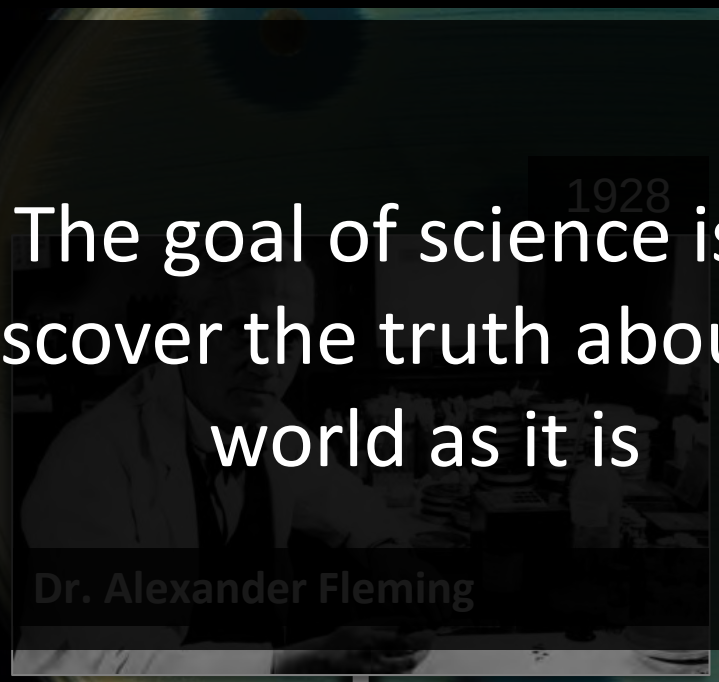
1939

1941

1944

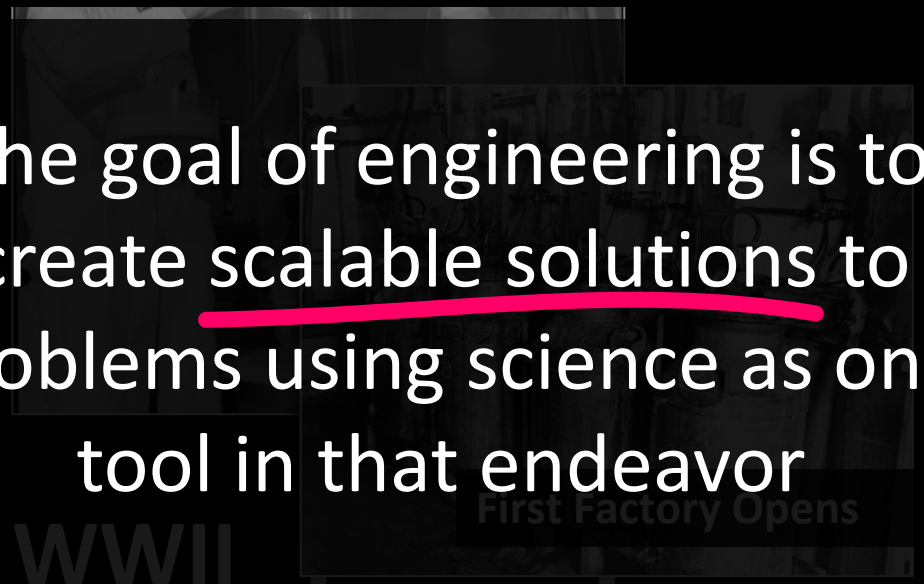
Science

The goal of science is to discover the truth about the world as it is



Engineering

The goal of engineering is to create scalable solutions to problems using science as one tool in that endeavor



WWII

1939 1941 1944

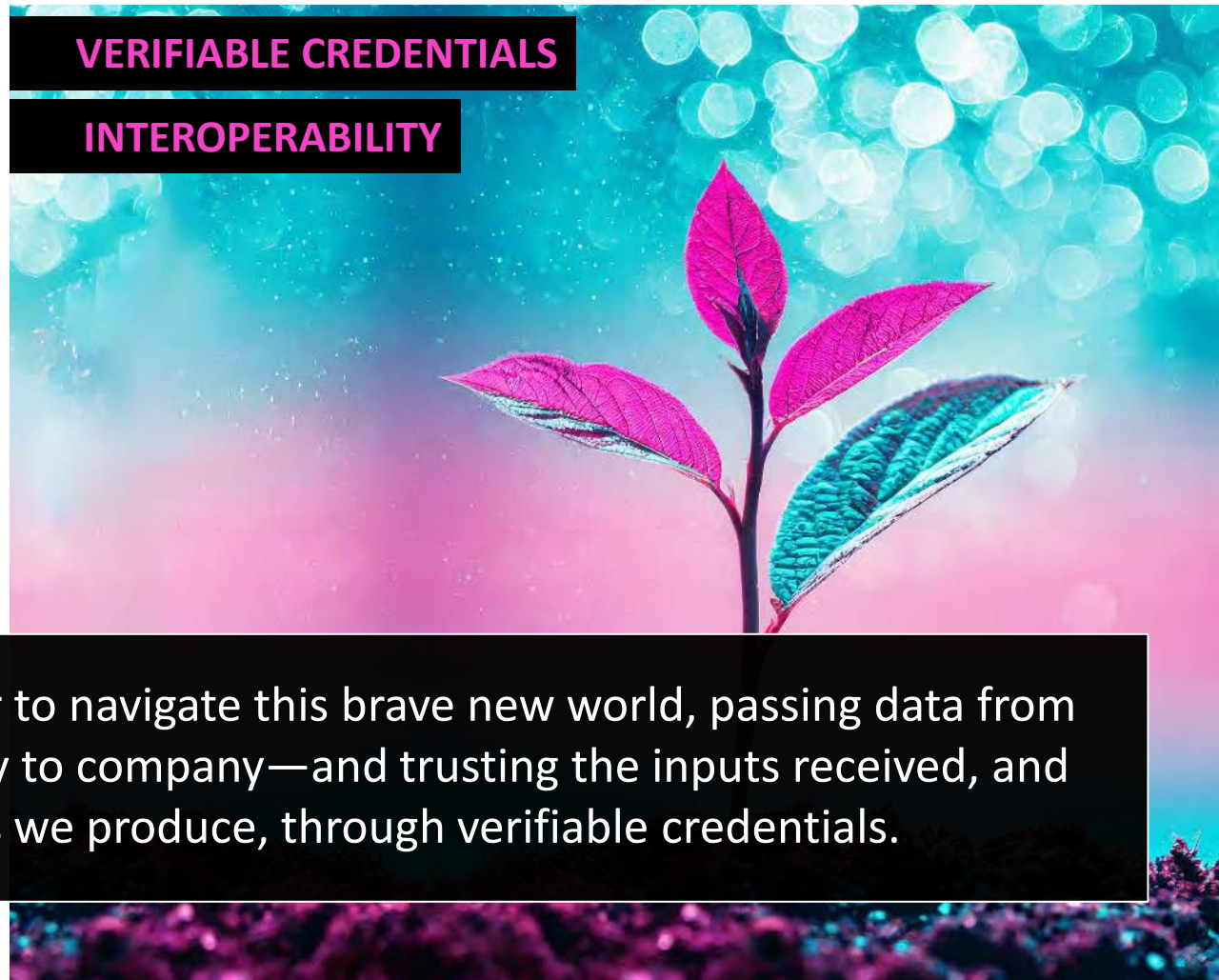
…and isn't this what we're all trying to do: Create scalable solutions using science and other disciplined processes? So that we can keep pace with our evolving work, developing the breadth and sophistication of knowledge and skills needed for our complex world, and so that we can overcome the modern Fog of War.

create scalable solutions to problems using science as one tool in that endeavor

LEARNING ECOSYSTEMS

VERIFIABLE CREDENTIALS

INTEROPERABILITY



We'll need to work together to navigate this brave new world, passing data from system to system—company to company—and trusting the inputs received, and creating trust in the outputs we produce, through verifiable credentials.

Each of us will need to creatively navigate the exploding accumulation of content, as well as growing expectation for mass customization at scale. This creates space for business competition and potentially new paradigms of disruption.

But we must simultaneously work together to create standards for the industry that enable trusted assessments of products, such as quality, reliability, validity, difficulty, and equivalence—at scale and across a heterogenous ecosystem.

GENERATIVE CONTENT

MASS CUSTOMIZATION

EFFICIENCY @SCALE

NEW BUSINESS MODELS

NEW SCIENTIFIC Qs

LEARNING ECOSYSTEMS

LEARNING ECOSYSTEMS

GENERATIVE CONTENT

LIFELONG LEARNING

We'll need these systems of interoperability and rapid, trustworthy content generation to enable a lifelong learning approach that blends learning, rehearsal, performance, testing, and assessment; elevates the use of informal and other diverse pathways of learning; and more tightly integrates learning and testing with jobs and applied performance.

DIVERSE PATHS (STAR)

TIGHTER INTEGRATION

LEARNING ECOSYSTEMS

GENERATIVE CONTENT

NEXT-GEN TEST, ASSESS, EVALUATE

CREATIVE DETECTION

MULTIMODAL CLUSTERS

LEARNING ANALYTICS

LIFELONG LEARNING

Future testing and assessment needs to fit into this lifelong learning ecosystem, leveraging more authentic and “stealth” forms, aggregated data streams, longitudinal portfolios, and learning analytics.

AUGMENTED INTELLIGENCE

EXPERT GENERALISTS

NEW MODELS OF LEARNING

COLLAPSING BOUNDARIES

GENERATIVE CONTENT

LEARNING ECOSYSTEMS

NEXT-GEN TEST, ASSESS, EVALUATE

LIFELONG LEARNING

These new technologies can also augment our (on the job) performance. This further drives the collapsing of boundaries and the increased need for expert generalists, whose intelligence is augmented by AI. And it raises questions about the ways we learn—and “cheat” at learning.

AUGMENTED INTELLIGENCE

LEARNING ENGINEERING

end.

LEARNING ECOSYSTEMS

GENERATIVE CONTENT

NEXT-GEN TEST, ASSESS, EVALUATE

LIFELONG LEARNING

Finally, the emerging field of Learning Engineering brings some answers—not in terms of concrete technical guidance but in the form of processes. These are the tools that we (as faculty, staff, engineers, teachers, operators, and psychometricians) need to implement and maintain the other components we've discussed today.

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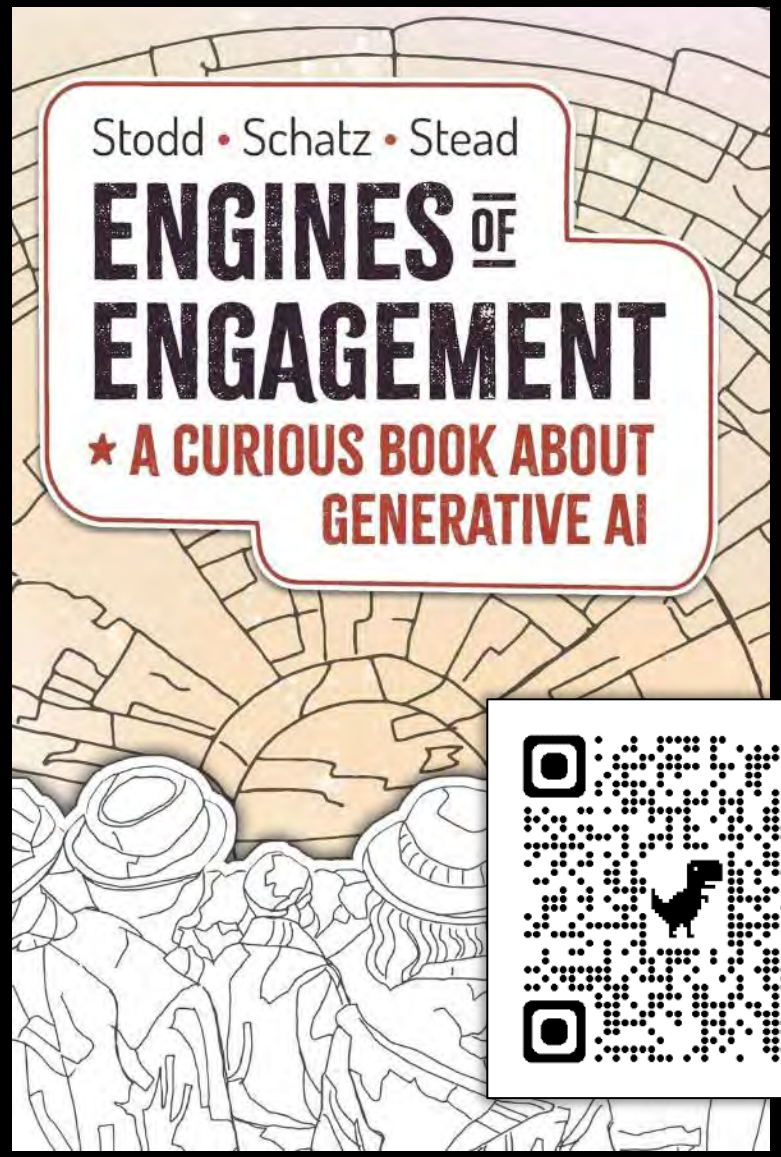

https://bit.ly/EnginesOfEngagement

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