LETICIA BRITOS CAVAGNARO AND HUMERA FASIHUDDIN

A Moonshot Approach to

FEATURED TOPIC

GOOGLE FOUNDERS Larry Page and Sergey Brin revolutionized the way we access and use information. And they didn't stop there. Their bold thinking has led them to explore such "moonshots" as reimagining transportation with self-driving cars and making clean energy accessible to everyone with high-flying wind turbines. According to Google, a project qualifies as a "moonshot" if it meets three criteria: it tackles a huge problem, proposes a radical solution, and involves breakthrough science or technology.[1]

Technology has accelerated the pace of change in how we live and work, and it also has democratized who can be involved in shaping that rapid evolution. An increasing number of people can easily access the tools to realize almost anything they can imagine. On the flip side of this new world of possibilities are problems of growing complexity, such as climate change, cyberterrorism, and widespread income inequality.

Higher education needs to change in order to equip learners with the skills and mindsets they will need to tackle daunting challenges and to leverage tools of unparalleled potential. Let's explore these skills and mindsets, which students will need whether they join companies, become educators and researchers, get jobs in government or the nonprofit sector, or start their own ventures.

Students can be the change agents that spark accelerated and lasting impact at their schools

They will need to be comfortable with ambiguity and uncertainty. According to Nick Swayne, executive director of 4-VA, a collaborative partnership between five Virginia universities, "students need to learn to manage real-world situations—not artificial Disneyland-like ones—because they will soon be out in the real world. We need to allow students to get to the edge of the cliff, instead of keeping them away, because it's at the edge where the learning happens."[2]

The problems that expose students to the edge can be called "wicked problems." According to Horst Rittel and Melvin Webber, professors of design and urban planning at the University of California–Berkeley, a "wicked problem" has innumerable causes, is tough to describe, and doesn't have a right answer.[3] The Association of American Colleges and Universities calls them "unscripted problems."[4]

Students can and should tackle wicked or unscripted problems as part of their educational journeys. Yet, by contrast, the problems and case studies prevalent in most curricula are neatly defined and have a previously known answer—often a single right answer. Knowing that an answer already exists completely changes the way students think about a problem. Thus, far from providing "training wheels" for tackling problems in the real world once they graduate, these practice problems are counterproductive for the development of the needed skills and

LETICIA BRITOS CAVAGNARO *and* HUMERA FASIHUDDIN *are co-leaders of the University Innovation Fellows program. The program originated under the National Science Foundation (NSF)–funded National Center for Engineering Pathways to Innovation (Epicenter), a joint venture of Stanford University and VentureWell. Following the end of the NSF grant in July 2016, the University Innovation Fellows program will continue as part of Stanford's Hasso Plattner Institute of Design (known as "d.school").*

Change in Higher Education

Creativity, Innovation, and the Redesign of Academia

Lehigh University's Mountaintop campus occupies an industrial hangar that once belonged to Bethlehem Steel

Table 1. **School problems vs. real-world problems**

	School problems/case studies	Authentic, wicked problems
Scope/parameters of the problem	Defined, given to the student; hypothetical or historical	Not well defined; there is uncertainty and ambiguity
Solution	One or more right solutions, known by the instructor (or determined by history)	No known or right solution (or the challenge is to find solutions that are better or radically different from those in existence)
What students are required to learn	Predetermined body of knowledge deemed relevant to the problem given by the instructor	Emerging areas of inquiry, which may span different disciplines
Skills that are fostered	Analytical skills, problem-solving skills	Problem-finding and problem-framing skills, synthesis skills (to make sense of data) and creative skills (to come up with new solutions)
Ownership of the process	Usually instructor driven	Usually student driven
Role of the instructor	Sage on the stage	Guide on the side

attitudes. Table 1 compares both types of problems across different dimensions.

As humans, we have a natural tendency to want to find solutions quickly when faced with a problem, and we become very uncomfortable under the uncertainty and ambiguity that characterizes unscripted problems. Favoring well-defined problems that have a known right answer reinforces the habit of jumping to the first evident solution, or that of avoiding complex problems altogether.

They will need to be problem solvers and problem finders. To come up with solutions that will make a difference, it is crucial to determine whether we are solving the right problem. Consider the following example, as described by Tom and David Kelley in their book *Creative Confidence*.[5] Students in the Design for Extreme Affordability course at Stanford University's Hasso Plattner Institute of Design ("the d.school") are placed in interdisciplinary teams to design affordable solutions for daunting problems proposed by nonprofits in the developing world.[6] In 2007, one of those student teams was presented with the problem of infant incubators that are expensive to maintain in rural hospitals in Nepal. Reducing the cost of existing incubator designs by eliminating parts and using less expensive materials was an obvious way to solve the problem. But it's the non-obvious solution that comes from a deep understanding of a problem that gives rise to true innovation.

All students should be exposed to important notions about how we learn, as this will influence their behavior and outcomes

With that goal in mind, the students traveled to Nepal to immerse themselves in the world of the people involved in the problem—doctors, nurses, mothers—and better understand their needs and perspectives. What they saw and experienced allowed them to challenge their assumptions about the problem. They found functional yet empty incubators at the hospital, and learned that the babies who needed them were often born in villages so far away that many could not make it to the hospital. The students reframed the problem, from the need for a cheaper hospital incubator to the need to help parents keep their premature babies warm and transport them to the hospital. The solution, a portable baby-warming device called the Embrace Warmer, is currently being used in eleven countries and has received numerous awards.[7] In this case, reframing the problem was the key to reaching a solution that saves lives.

They will need to be empathetic. The Embrace Warmer case also demonstrates the need for a skill that is essential to tackling complex problems: understanding the perspectives of the (usually multiple) stakeholders involved. At the heart of the methodology taught to d.school students is empathy. Commonly and mistakenly conflated with sympathy, empathy can be defined as the ability and disposition to step into the shoes of others in order to

understand their perspectives and motivations. By seeking and understanding the perspectives of the mothers, the Design for Extreme Affordability students were able to focus on an opportunity that was at the root of the problem.

They will need to be bold thinkers. Once a problem that matters has been identified, coming up with a solution that makes a difference requires creative thinking. Beyond understanding "what is," we must envision "what could be." Critical thinking is another skill that education must bolster in order to prepare students for the complexity of the twenty-first century. Doing so will require educators to dispel the prevalent myth about the existence of two kinds of people: those who are creative, and those who are not.

Is it reasonable to expect that one might master math problems without practice solving them? Or is it possible to become a pro at a sport without setting foot on the field? Why would we concede that we are not creative without doing any work to hone our creative skills? Producing creative work, like anything else, requires intention, deliberate practice, and the belief, by both students and educators, that everyone has the capacity to produce it.

Astro Teller, "Captain of Moonshots" at Google's parent company, Alphabet, claims that it is easier to come up with a solution that is ten times better than existing solutions than it is to improve something by 10 percent. He calls this "10x thinking." The logic is that, when aiming for incremental changes, it is inevitable to focus on existing tools and assumptions; by contrast, when we aim for 10x solutions, we must really challenge our assumptions about what is possible.[8]

According to the 2015 National Survey of Student Engagement, coursework that emphasizes creative skills (e.g., generating new ideas, taking risks, inventing new methods to find solutions) is positively related to student engagement in several areas. However, there are pronounced differences by field of study in the extent to which students felt they could take risks in their coursework without fear of penalty.[9] So, the degree to which students in certain disciplines exercise their creativity might vary greatly.

They will need to be lifelong learners. In his *Reflections on the Human Condition*, Eric Hoffer wrote, "In a time of drastic change it is the learners who inherit the future. The learned usually find themselves equipped to live in a world that no longer exists."[10] Stepping into the uncharted territory of "what could be" requires curiosity and just-in-time, self-directed learning skills that enable us to dive into areas of knowledge that emerge as we explore problems and imagine possible solutions. Confidence in our learning skills is what can put us at ease when we find ourselves faced with ambiguity.

All students should be exposed to important notions about how we learn, as this will influence their behavior and outcomes. The work of Stanford psychologist Carol Dweck on the difference between a *growth* mindset and a *fixed* mindset is especially relevant,[11] as is the work of David Yeager, one of Professor Dweck's graduate students. Currently assistant professor of psychology at the University of Texas at Austin, Yeager showed that incoming freshmen who get, as part of their orientation, an article about the malleability of the brain and how practice makes it grow new connections are more likely to stay on track in their first semester, which is an indicator of graduation rates. If a simple "mindset intervention" has a demonstrable effect on academic outcomes, then integrating these concepts more broadly has great potential to revolutionize the educational system.[12] In addition, more often than not, what is evaluated in classes is what the student produces, and that sends a strong signal about what is valued. The use of explicit language and holistic assessment tools like e-portfolios can be leveraged to signal the value of the learning process to students.[13]

If a simple "mindset intervention" has a demonstrable effect on academic outcomes, then integrating these concepts more broadly has great potential to revolutionize the educational system

What learning experiences might produce these outcomes?

According to research done by Harvard professor Clay Christensen and his colleagues, the skills and mindsets discussed above map well onto the skills and behaviors that characterize the innovative entrepreneurs who have revolutionized the ways in which we live and work.[14]

Over the past few decades, centers and institutes devoted to innovation and entrepreneurship (I&E) have been proliferating at universities nationwide.[15] While many operate within business or engineering schools, they increasingly serve a broader student population. Both within and beyond academia, two broadly applicable I&E approaches have gained considerable traction: "design thinking" and "lean startup." The design

thinking approach, championed by the d.school among other institutions, can be described as a human-centered and experimentation-driven process to define and solve problems creatively. But the process is only a scaffold for the development of skills and mindsets that can be applied in no prescribed order. The lean startup approach, made popular by serial entrepreneur Steve Blank, is based on the premise that those leading new ventures and initiatives within existing organizations must search for a viable business model through experimentation, customer feedback, and iterative design, and they must do so in a hypothesis-driven fashion that parallels the way scientists work.

While design thinking is commonly associated with innovation and lean startup with entrepreneurship, both frameworks overlap in significant ways. First, both approaches aim at uncovering the needs of the people who will be served by a given solution, product, or service (design thinking labels those people "users" or "stakeholders," while lean startup calls them "customers"). Second, making ideas tangible and testing them early in the process is a cornerstone of both approaches ("prototyping" in design thinking; creating a "minimum viable product," or "MVP," in lean startup). Moreover, both innovation and entrepreneurship are about putting ideas out into the world. Thus, educators who teach these approaches generally resort to a hands-on, active pedagogy and emphasize the development of skills and attitudes (mindsets), rather than just knowledge acquisition.

Students' first contact with a discipline or area of study can either inspire them to dig deeper, or it can turn them off and reduce the subject to a requirement to be checked off

What makes I&E learning experiences valuable for all students?

These experiences give students the autonomy to work on projects that are connected to their passions. Most, if not all of us, can remember a teacher who inspired us to love a subject or discipline. The role of inspiration in teaching and learning is elevated in maxims such as Plutarch's "the correct analogy for the mind is not a vessel that needs filling, but wood that needs igniting." This is especially critical in the experience of first-year students. Students' first contact with a discipline or area of study can either inspire them to dig deeper, or it can turn them off and reduce the subject to a requirement to be checked off. Unless we engage the whole student as a human being with emotions and not merely a rational machine that receives information, we won't be able to achieve deep learning.

Giving students the autonomy to learn new skills while exploring areas they are or might be interested in is key to fueling their intrinsic motivation and love of learning. At Lehigh University's Mountaintop campus, which occupies industrial hangars that once belonged to Bethlehem Steel, students from diverse majors and levels come together in the summer to work on projects of their own choosing.[16] While faculty mentors are on hand, the students independently define the goals of their projects and determine how to pursue them. They get resources, can borrow equipment, and are assigned a space in the open building, which they must configure and maintain. Projects in the summer of 2015 ranged from low-energy sustainable farming to the design of exoskeleton appliances to aid in rehabilitation for patients with muscle disorders.

Beyond capstone courses and other projects of similar scope, like the Lehigh Mountaintop experience, how might we integrate this practice into the fabric of the educational experience? In the spring of 2013, the d.school embarked on a year of exploration into possible futures of learning at Stanford—through classes, workshops, and the development of tools that involved students, faculty, administrators, and a diversity of partners. The project, named Stanford 2025, aimed at inspiring further exploration and experimentation by the broader community invested in the future of higher education.[17] For example, the project explored the concept of purpose learning, whereby students would declare a mission, not a major. They would couple their disciplinary pursuit with the purpose that fuels it. "I'm a biology major" would be replaced by "I'm learning human biology to eliminate world hunger."

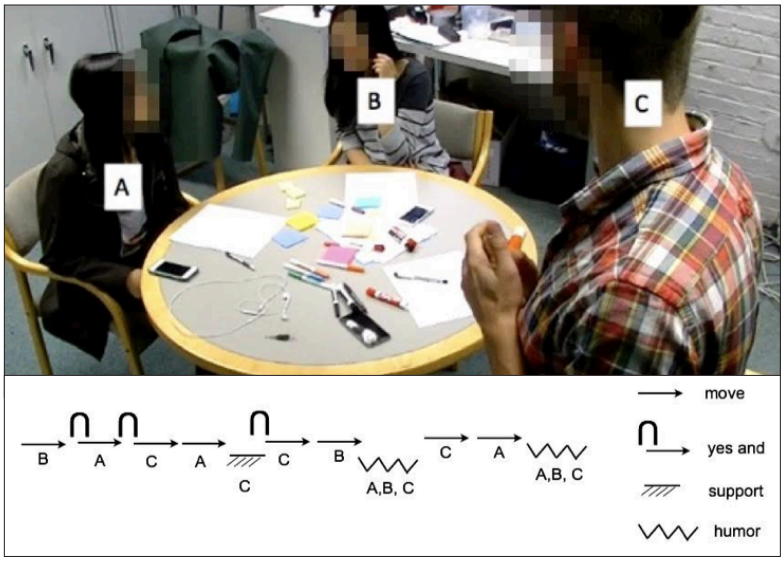
They give students opportunities, space, and tools to become better collaborators. Complex problems require approaches from multiple perspectives, so it is imperative that students have ample opportunities to learn to work in multidisciplinary teams. In the Lehigh Mountaintop experience described above, the student teams get their own space in the building and are responsible for configuring and maintaining it. It is important that the space belongs to the team and that the project is on neutral grounds, as this sets the stage for equal participation by

all team members. In the book *Make Space*, Scott Doorley and Scott Witthoft describe how the d.school uses space to promote effective and creative collaboration by multidisciplinary student teams working on design thinking challenges. Through the intentional use of flexible furniture configurations and vertical surfaces to display and manipulate shared information, the space promotes active and inclusive behaviors.[18] The Learning Spaces Collaboratory is another useful resource that helps educators think deeply about the "qualities and affordances of spaces for learning that reflect communal awareness of societal and institutional goals for what 21st-century students are to become."[19]

In addition, becoming an effective team collaborator within and across disciplines needs to be embraced as an important learning objective. While working on design challenges, student teams from the d.school's Creativity and Innovation class spend time at the lab of Neeraj Sonalkar in the Center for Design Research. There, the students' team dynamics are observed and captured using a custom notation developed by Sonalkar.[20] Afterward, the teams receive a report that describes such aspects as the balance of contributions and the type or interpersonal behaviors, making connections to research findings. This feedback, which is then discussed in class, allows the teams to work on improving their interactions and outcomes.

They give students the opportunity to experience productive failure. When exploring "what could be" and putting bold new ideas out into the world, failure is not only inevitable, but should be embraced as a key part of the learning process. While the default bias in education is to provide learners with guided instruction prior to, or concurrent with, their learning of new skills and concepts, researcher Manu Kapur from Singapore's National Institute of Education has conducted several experiments showing the value of productive failure. In one of those experiments, students who were allowed to solve complex problems without instructional facilitation significantly outperformed—when tested with higher-order application problems—students who were exposed to a traditional lecture and practice sequence.[21]

They expose students to different ways of thinking and learning. Play is an essential ingredient in how we learn as children. However, as we advance in the educational system, learning often becomes a solemn endeavor in which playfulness has no place. The Maker Movement, tightly linked to I&E and spreading rapidly across the United States and beyond, has the potential to change that misconception.[22] Spurred by easy access to new technologies such as 3-D printing and Arduino, an open-source electronics platform, and facilitated by online platforms and physical work spaces knows as "makerspaces," interconnected communities are demonstrating the value of ways of learning that engage our brains, our hands, and our whole selves.



At the Center for Design Research at Stanford University, Dr. Sonalkar observes and captures students' team dynamics using a custom notation

One in a thousand infants is born with missing fingers. Shea Stollenwerk, a third-grader from Mukwonago, Wisconsin, is one of them. When she saw robotic-looking prostheses on the Internet, she asked her mom whether she could get one for Christmas. State-of-the-art prostheses can cost thousands of dollars and, since children grow too fast, most don't get one. Shea's mom reached out to Frankie Flood, a professor at the University of Wisconsin–Milwaukee (UWM) and director of the Digital Craft Research Lab. Under the guidance of Flood and his colleague Andream Blair, UWM students designed and 3-D printed a hand for Shea. They also shared the design with E-nable, a network of volunteers who collaborate on open-source designs and print hands for hundreds of children. With names like "Cyborg Beast" and "Raptor," these hands are designed to stand out and evoke the superpowers of comic-book heroes, helping these kids shed the stigma of disability.[23]

"The Maker Mindset," a manifesto by Dale Dougherty, one of the founders of the Maker

Movement, asserts that "the biggest challenge and the biggest opportunity for the Maker Movement is to transform education."[24] We couldn't agree more. Beyond the creative and effective application of technology to solve real-world problems, learning by making can have a profound impact on the learner's mindset, causing a shift from learning *about* the world to learning *by changing* the world.

Our moonshot: Students as change agents

In this article, we have discussed the need for today's college graduates to be prepared to navigate an uncertain future. We've argued that innovation and entrepreneurship learning experiences provide a useful foundation for students to collaborate on team-based projects, work on wicked problems, and gain skills needed to bring radical, creative solutions to life. National organizations and researchers have been advocating for change in higher education in this direction for the last several decades,[25] yet the pace of change has been slow.

Beyond the creative and effective application of technology to solve real-world problems, learning by making can have a profound impact on the learner's mindset, causing a shift from learning about the world to learning by changing the world

We believe changing higher education needs a moonshot approach. During the past three years, we have been testing out a bold idea: students can be the change agents that spark accelerated and lasting impact at their schools. At first glance, this might sound counter-intuitive; students spend a relatively short time in school compared with faculty and administrators, and they are not directly tied to the machinery that makes strategic decisions about schools' operations and futures. Yet it is precisely for these reasons that students can be powerful change agents who can challenge the assumptions about how things are done.

Students can be engaged as designers. Compared to several decades ago, customers today have an incredible amount of influence when it comes to rating a movie, their dining experience, or their new cars. We have come to expect that our opinions matter, and we value the opinions of others when making purchases ourselves. Companies, nonprofits, and communities are learning that the best way to ensure a product is successful is to actively engage customers early in the design phase. Engineers call it "agile development," entrepreneurs call it "lean startup," and designers call it "design thinking." Regardless of their differences, they all agree that a state of permanent beta—where a constant flow of information from the customer informs the evolution of products—is best for business success. The most innovative companies in the world leverage what are called "customer evangelists," or incredibly passionate users, to co-design offerings hand in hand with product developers, and then champion those products to the user community. Why not in academia?

In fact, the most innovative colleges and universities are doing just that. Olin College of Engineering was established in 1997 with the mission to revolutionize engineering education. From the outset, Olin engaged students as co-designers. Students, referred to as Olin Partners, worked alongside founding faculty and administrators during a "pre-freshman year" while the school was being built in order to shape every aspect of the school, from admissions to curricula. Today, Olin is a model for hands-on, student-centered education that schools from all over the world seek to emulate.

Established schools have taken steps to engage students in the same way. At the University of Pittsburgh, six students partnered with faculty to design a brand new honors engineering course called The Art of Making. The students helped design not only the curriculum, but a "makerspace" classroom suitable for the hands-on nature of the course. In addition, they created a visually appealing website to attract students and served as teaching assistants to help facilitate successful execution.[26] The course met with such success that it is now being expanded outside the honors college.

Students have the power of peer-to-peer influence. Student leaders are uniquely positioned to accelerate the pace of change in academia because they have "street cred." They are at the grassroots with their peers, share the same experiences, and speak the same language. This peer-to-peer effect is a powerful one, giving students the unique ability to present new learning opportunities using language that will resonate with a broad range of students. Kent State University students Robin Bonatesta and Paul Dilyard created a student co-working space at the library, which they called "the Fridge."[27] The new space is an experiment in providing a place where students can meet and collaborate on projects that span different disciplines. There are no set schedules, no permanent

At the University of Pittsburgh, students helped design the curriculum and a "makerspace" classroom for the hands-on learning course "The Art of Making"

faculty or staff, and no rules about what students can do there.

In addition to new spaces, a new wave of extracurricular activities has emerged in the form of "hackathons," which are almost entirely student driven and draw thousands of students from across campuses to exercise their creative abilities and learn new skills. The innovations that emerge may include novel technologies with commercial potential. Student organizers are fostering a culture of creativity and innovation, while also providing a new means for students to pursue their professional interests through hands-on self-directed projects. In March 2015, students at James Madison University organized the first student-led hackathon in just eight weeks' time, securing sponsorship from several companies. Judges heard pitches from students who had spent forty-eight hours defining opportunities and building prototypes. The top prize went to an epidemiology student who had coded a working database and a smartphone app to allow the crowdsourcing of health information within a community to follow, for instance, the spread of the flu virus.

Students are not bound by the same constraints as faculty and administrators. Student change agents volunteer their time to make a difference on their campuses. They do not have the same reporting structures as faculty and are not required to build consensus through committees. As a result, they have much greater freedom to operate and can experiment with ideas that do not require a wealth of resources.

Tanner Wheadon, a student at Utah Valley University applied a prototyping/lean startup approach to create a makerspace at his school. When he first approached the administration, he was told that such an investment might be considered in the five-to-seven-year plan for the school, given space limitations. Undeterred, Tanner set out to prove the value of the idea. Scraping together what little resources he could locate, Tanner purchased an industrial cart and filled it with inexpensive prototyping supplies. He identified a general education course with a couple of unused weeks in the schedule and, using his mobile makerspace, experimented with a design thinking curriculum within that course. As a result of that inexpensive pilot, he was invited to train all the instructors teaching the course on his curriculum. Most recently, he led a design thinking workshop for the president and his cabinet and, as a result, received four offers of space to realize his original vision of a makerspace. The prototyping approach Tanner employed is crucial in defining, testing, and building support for new investments in academia. It can help ensure that we build the right spaces and resources, instead of spending millions of dollars up front on unproven concepts.

Kettering University student Alan Xia, a mechanical and electrical engineering major, had a key insight about lab assignments: students are given fairly prescriptive and rigid instructions on how to complete a set of tasks, which takes out of the equation the exploration and experimentation (and fun!) that are key to learning to think and work like a scientist and an engineer. Also, aside from the designated times when a course is in session, lab spaces are locked and the machines inside just sit there, unproductive. Convening student volunteers, professors, and lab technicians, Alan and other students created Open Lab Days. Once a term, the unused labs are open to all students for the whole day, during which they may work on any project of their choosing. Materials, support staff, and food are provided. Members of the community, including children, are also welcome. Open Lab Days challenge assumptions about who the teachers are. As Alan puts it, "Everyone learns!" Professors and lab technicians, along with students and community members, are both learners and teachers.

University Innovation Fellows at the 2014 Silicon Valley Meetup at Google

Activating student change agents

The student change agents from Kettering, Kent State, University of Pittsburgh, Utah Valley, and James Madison featured in the stories above are University Innovation Fellows. Over the last three years, our program has trained and supported close to six hundred student leaders. The process of becoming a fellow requires nomination by the institution and application by the student. Once accepted, a rigorous six-week online video-conference training prepares the students to survey the learning opportunities related to I&E on their campuses and to identify opportunities for improvement that inform a strategic plan of action. This is followed by an in-person event at Google headquarters in Silicon Valley and at Stanford's d.school, where the fellows are exposed to design thinking, lean startup approaches, and cutting-edge practices in learning experience design and facilitation. The skills and mindsets acquired during this hybrid training help the fellows in their quest to improve their schools in collaboration with faculty and administrators.[28]

Student change agents represent a moonshot approach because they can help achieve the momentum needed to catalyze a movement on campus

University Innovation Fellows are reaching hundreds of peers on campus, with new physical spaces for collaboration and creation, workshops, courses, and clubs. For faculty and administrators interested in expanding the accessibility of their innovation and entrepreneurship programs, University Innovation Fellows contribute fresh ideas for learning opportunities, as well as the speed and agility to bring those ideas to life. Those who nominate University Innovation Fellows are themselves change agents and find fellows to be powerful collaborators who not only have been trained to effect change, but also can leverage their student perspectives to engage their peers.

Student change agents represent a moonshot approach because they can help achieve the momentum needed to catalyze a movement on campus. Faculty and administrators who believe in a new model for education can push only so hard for change. For these "early adopters," student change agents are like rocket fuel, accelerating and scaling their efforts. However, gaining the momentum that enables institutional leaders to cross the proverbial "chasm" and achieve widespread change comes down to the bystanders. Faculty who observe a movement from the sidelines fall into two camps: the early majority and the late majority. The early majority will join a movement because they don't want to be left behind, ultimately engaging the entire campus community to form a tide of support for the change effort.

Transforming higher education so that it prepares students to thrive in the complexity and ambiguity of the twenty-first century will require that we all adopt the 10x thinking that leads to radical solutions. We must be willing to examine the core assumptions at the foundations of the system. One of those assumptions is that students belong on the receiving end, as the customers of the system. Our experience shows that they can be so much more. Our hope is that by 2025, most of the 4,500 accredited institutions in the United States will adopt bold change strategies that nurture and leverage their students as change agents to improve higher education. We invite you to join us in achieving this moonshot. □

To respond to this article, e-mail liberaled@aacu.org, with the authors' names on the subject line.

NOTES

1. See Miguel Helft, "Astro Teller: How Google X Works," *Fortune*, December 30, 2014, http://fortune.com/2014/12/30/astro-teller-google-x.

2. Nick Swayne, personal communication with the authors.

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4. See "The LEAP Challenge: Education for a World of Unscripted Problems," *Liberal Education* 101, no. 1/2 (2015): 16–21.

5. Tom Kelley and David Kelley, *Creative Confidence: Unleashing the Creative Potential within Us All* (New York: Random House, 2013). Tom Kelley is a partner at design consultancy IDEO, and David Kelley is founder of both IDEO and the Hasso Plattner Institute of Design at Stanford University (best known as the d.school).

6. For more information about the course, see http://extreme.stanford.edu.

7. For more information about the Embrace Warmer, see http://embraceglobal.org/embrace-warmer.

8. See Astro Teller, "Google X Head on Moonshots: 10X Is Easier Than 10 Percent," *Wired*, February 11, 2013, http://www.wired.com/2013/02/moonshots-matter-heres-how-to-make-them-happen.

9. *National Survey of Student Engagement, Engagement Insights: Survey Findings on the Quality of Undergraduate Education* (Bloomington, IN: Center for Postsecondary Research, Indiana University School of Education, 2015), 2.

10. Eric Hoffer, *Reflections on the Human Condition* (New York: Harper & Row, 1973), 22.

11. See Carol. S. Dweck, *Mindset: The New Psychology of Success* (New York: Random House, 2006).

12. See Paul Touch, "Who Gets to Graduate?," *New York Times Magazine*, May 15, 2014, http://www.nytimes.com/2014/05/18/magazine/who-gets-to-graduate.html.

13. For example, the Stanford d.school's website uses explicit language to identify the focus on "innovators, not innovations" as part of the point of view of the organization; see http://dschool.stanford.edu/our-point-of-view/#innovators.

14. See Jeffrey H. Dyer, Hal Gregersen, and Clayton M. Christensen, "The Innovator's DNA," *Harvard Business Review* 87, no. 12 (2009): 60–67.

15. See *Entrepreneurship Education Comes of Age on Campus: The Challenges and Rewards of Bringing Entrepreneurship to Higher Education* (Kansas City, MO: Ewing Marion Kauffman Foundation, 2013).

16. For more information about Lehigh University's Mountaintop initiative, see http://www1.lehigh.edu/mountaintop.

17. For more information about Stanford 2025, see http://2025.stanford.edu.

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20. See Neeraj Sonalkar, Ade Mabogunje, and Larry Leifer, "Developing a Visual Representation to Characterize Moment-to-Moment Concept Generation in Design Teams," *International Journal of Design Creativity and Innovation* 1, no. 2 (2013): 93–108.

21. See Manu Kapur, "A Further Study of Productive Failure in Mathematical Problem Solving: Unpacking the Design Components," *Instructional Science* 39, no. 4 (2011): 561–79.

22. The newly launched MakeSchools.org is an online repository of the maker movement in US universities and colleges.

23. See Jacqueline Mroz, "Hand of a Superhero: 3-D Printing Prosthetic Hands That Are Anything but Ordinary," *New York Times*, February 16, 2015, http://www.nytimes.com/2015/02/17/science/hand-of-a-superhero.html; "A Potent Purpose for 3-D Printing: Reaching Toward the Future of On-demand Prosthetics," University of Milwaukee 2015 Research Report, accessed December 20, 2015, http://uwm.edu/researchreport/ideas/3d-printed-prosthetics.

24. Dale Dougherty, "The Maker Mindset," Lifelong Kindergarten, Massachusetts Institute of Technology, accessed December 20, 2015, http://llk.media.mit.edu/courses/readings/maker-mindset.pdf.

25. See, for example, National Academy of Engineering, *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* (Washington, DC: National Academies Press, 2005); *The LEAP Challenge: Education for a World of Unscripted Problems* (Washington, DC: Association of American Colleges and Universities, 2015); President's Council of Advisors on Science and Technology, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics; Report to the President* (Washington, DC: Executive Office of the President, 2012).

26. For more information about the course, see http://pitt.edu/~mam503/.

27. The name, which started as a joke, grew out of the intention of coming up with a "cool" name for the space that did not include any buzzwords or jargon—such as innovation and entrepreneurship—that might not resonate with all students.

28. For more information about the University Innovation Fellows program, see http://universityinnovationfellows.org.

Creative Thinking VALUE Rubric

Creative thinking is the capacity to combine or synthesize existing ideas, images, or expertise in original ways; it is developed through experiences that enable the learner to think, react, and work in imaginative ways that are characterized by a high degree of innovation, divergent thinking, and risk taking.

The Creative Thinking VALUE Rubric helps faculty assess creative thinking in a broad range of transdisciplinary or interdisciplinary work samples or collections of student work. The rubric is made up of a set of attributes that are common to creative thinking across disciplines.

The Creative Thinking VALUE Rubric is one of sixteen rubrics developed through the Valid Assessment of Learning in Undergraduate Education project, part of AAC&U's Liberal Education and America's Promise (LEAP) initiative, and keyed to the LEAP Essential Learning Outcomes. For more information about the VALUE project or to download the VALUE rubrics, visit www.aacu.org/value.

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