Stanford eCorner

More Innovation Through Education [Entire Talk]

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Richard Miller, president of Olin College, describes disruptive ideas about education and learning that universities should adopt to graduate more creative, entrepreneurial and impactful engineers. He explains how a focus on math and science alone won't result in more innovation, and that higher education must instill traits like grit and independent thinking.

Transcript

(applause) - Well it's a real privilege to be here. Stanford's Technology Ventures program has been an inspiration to generations of people. And Tina in particular is my inspiration. She's the go-to person about learning about creativity, which is really critical for what we're doing. So, I wanna talk to you today about Olin. Where it came from, and what we've learned. So, it's sort of the outline for the talk. And the first is about the founding of Olin. And let me point out that this is a picture of Franklin Olin, who's the guy who created the revenue that generated Olin College. He's a Cornell graduate, 1880s.

He retired in 1938 from the Olin Corporation, and he died in 1951. But his legacy is what created Olin. So, for example, there are 78 buildings on 58 university campuses that say Olin Hall. So there's an Olin Hall for example, at Vanderbilt. There's an Olin Hall at Cornell. There's an Olin Hall at University of Southern California, and dozens and dozens of other places. The Olin Foundation decided to end that grants program and to start over in higher ed entirely. Because there was a great deal of unhappiness about the way engineers are prepared. You see, there are lots of surveys that show that if you talk to presidents and professors at universities, about whether the graduates are well prepared to enter the workforce, there's a very high percentage of them that say of course. We've never done a better job of preparing graduates for the workforce.

But on the other hand, if you talk to people in corporations about how well the graduates are prepared for entering the workforce, they have a different opinion. And these opinions are sort of diverging because they're not talking to each other very well. That's what the Olin Foundation was worried about. So this is sort of a timeline for how this school started. 1997 they came up with the charter. 1999 first employee, that's me. So when I showed up at Olin, it was not yet a place. It was an idea. The Olin Foundation consisted of four people and me. None of them is an engineer, and none of them has ever worked in higher education.

But they had very strong ideas about what needs to change. What can go wrong with this, right? So, it was a very interesting couple of years as we worked through this. Now, they had a lot of experience in working with buildings. And so, they basically said, I'll do everything else. So, go find the people, figure out what the curriculum is. By the way, you need to rethink what it means to be an engineer. And rethink what it means to be educated in the 21st century. And let's do it all over again. Oh, there's some other things. No tenure.

No departments. Everything has an expiration date, including the curriculum. And students won't pay for the educational experience. That was the original plan for the school. The most important thing on this is 2001, the Olin Partner year. That's probably, and it's sort of accidental, the way it worked, but it's the most important thing we did. So, what happened is we brought in 15 boys and 15 girls who lived in construction trailers on a parking lot for a year. They were not taking courses, and they were not employees. So we just called them partners. And we have to have them because you can't pretend that you don't know how to solve the calculus problem, and make a judgment about whether method A is more successful than method B.

You actually have to have some people who've never solved the calculus problem, so you can talk to them while they're doing it. And we did experiments during that year. That's what changed everything. The most important thing we learned? Almost without exception, young people are more capable of learning things on their own than we ever expected. And we basically structure the educational program, probably everywhere, probably in every grade, too much, It begins to put people in boxes and extinguish creativity. So, the person who was most responsible for starting this school is Larry Milas, who said, "There's a lot of unhappiness today "about the way engineering is taught." The principle advisors for this, at the beginning, were Joseph Bordogna, who was the chief operating officer at NSF, who had run something called the Engineering Education Coalitions Program for a decade. Spent over 100 million dollars trying to motivate universities to rethink engineering, and gave up. Because the data showed it doesn't work. They're not changing. The other person is John Prados, who was the chair of the Accreditation Board, that changed the entire accreditation criteria, because universities have forever said, well, we would change but, you know, the accreditation board wouldn't give us accreditation.

So you can't do this. So John re-engineered the accreditation criteria so that's no longer true. Olin is fully accredited. We've never had any problem with ABET accreditation, so that's not the issue. So, in the founding precept for the school is this description of why these folks spent almost 500 million dollars to start an entirely new institution. And basically what they said, the college "is intended to be different, not for the mere "sake of being different, but to become an important "and constant contributor to the advancement of engineering "education in America and throughout the world." In other words, Olin College is intended to be an education laboratory. So we're basically a privately funded national laboratory for STEM education re-design. That's what the school is about. What does that mean? I think this picture captures it. Higher education is this giant aircraft carrier that's hard to re-position.

Olin is a tug boat that's pushing it 90 degrees, trying to get it to move a little bit to the left or a little bit to the right. And that's what we do. So, we've been visited by 640 universities since 2009. We've had significant partnerships with everybody on this page and many others as well. And as a result of that, for example, our partnership with the University of Illinois at Urbana-Champagne, resulted in a complete redesign of their undergraduate program. All 1600 incoming engineering students at Illinois now take a different program that was co-designed with Olin. And that resulted in this book, which is co-authored by a senior faculty member at Illinois and at Olin. Okay, so that's an illustration. That's enough about Olin. Now I want to tell you what we've learned about engineering education in about 15 years of experimentation.

This is a very different kind of set of messages. The first thing that's happened is that we've noticed that there's a trend in higher education. Over time, there's changes going on at this sort of mega scale. The first one is what has often been called the knowledge economy. So, at Olin, we've noticed that there's an unspoken assumption about education, probably for 500 years. And it's simply the more you know the better your life will be. Okay, that's why we send our kids to school. So if we just send them to school, and they learn lots of stuff, trust me, their life will be better. However, that's actually a testable hypothesis, and James Heckman who is a Nobel Prize-winning economist, University of Chicago, has tested it. The correlation between how much you know and how well your life turns out to be is not very good.

In fact a three times better predictor of positive life outcomes than either knowledge or intelligence is what is called grit. What is grit? It's a combination of passion and perseverance. It's attitudes, behaviors and motivations. It's not knowledge. But, nevertheless, everybody does this. The knowledge economy is about putting content into kids heads. That's what we do. That's why you have a PhD cuz you're the expert. You stand in front of people in a classroom, they take notes, and at the end of the day, this is the sage on the stage model. Rows of seats and a blackboard is how you organize them.

You know if it worked by finding out what they know. So we sort of imagine this as testing at the end a little bit like a giant Jeopardy game, okay. So everybody raises these questions. If you get most of the questions right, we put a big check in the box. Higher education, it's done its thing. We're doing well. There's a problem with this. It's called Google. Now, while you're taking the Jeopardy exam, somebody's Googling the answer and they get it before you did, and they didn't go to school at all. This changes everything.

Now the value proposition of just knowing stuff has changed, probably permanently. And we're in the middle right now of a transition to what I call the Maker Economy. So it's not about what you know, it's about what you can do with what you know. This is a completely different paradigm. So we're now not just putting stuff into kids' heads, we're expecting some stuff to come out too. And so you might think of this Maker Economy. You're learning how to play the clarinet. So as a result, you watch somebody play the clarinet, and then you try it. It doesn't sound the same, so then you iterate. You try to do it a little bit better, imitating what they did until you build the skill to where you can replicate what they do.

Or maybe integrating by parts, and you're watching Khan Academy. They did this 17 times with these problems, and I got the pattern, I'm gonna do it myself. Okay, anything you can do by watching somebody else. Maker Economy. So what happens now is the teacher's not the expert, the teacher is the coach, okay. This is actually very important. You wanna have a coach.

The coaches are very important to football, for example. So is basketball. The best organization of students in this case is not in a large auditorium sitting in rows, but in small groups talking to each other on some kind of a maker project.

You know, it could be building a robot. It could be writing a book. By the way, life is a maker project. So learning how to do this is an important thing. Now it's not about what you know, it's about what you can do with what you know. This isn't the end. We can foresee what's happening in the future, which is more important. It's what I'd call the Innovation Economy. Now the value proposition is completely different. It's what comes out of kids' heads that's important.

It's not, I mean, obviously you're still putting stuff in, but what you're paying attention to is what comes out. It's the new ideas. We don't actually know who does the best teaching here. Whether it's the teacher. Whether it's peers. Whether it's mentors. It's a whole environment. Why? Because creativity has less to do with your DNA than it does with your environment. It's the community and the ecology of the environment that really matters. And the method of teaching is probably associated with intrinsic motivation and design thinking, is our best guess at this point.

It's still part of the research agenda for the future. And now, it's about what you conceive. Now, you can complain and say, aren't all these things important? Of course, but I can tell you the evidence that I'm seeing by talking to our placement office. If you look at where the graduates go, and how much money they get as a surrogate for the demand, the students who get the largest salaries, guess which one of these three areas they come from. It's the one on the far right. It's about the most creative people who conceive new products, who do the developing new markets, is where the market is. Okay, so that's where this is going. Now I want to talk about why education must change. What's driving all this? Have you seen this graph? This is the graph of human population over all of human history. Two and a half million years ago all the way though, you can see where the black death was, or the bubonic plague.

In 1920, I think there were two billion people on the planet, or 1927, something like that. Today there are seven billion, we're on the way to nine billion. I don't think there's a single aspect of human existence on the planet that won't be affected by that graph. The education system that we're using, by the way, was designed way before the peak in this started. It's not taking into account these changes. That, by the way, that graph, is an existential threat. Population biologists have seen graphs like this before. Like the explosion of population of rabbits on the plain in Australia. What do they know? When it gets to a graph like that, about one generation later there aren't any more rabbits. Usually the species is extinct.

If we're gonna avoid that, we're gonna have to use the stuff between our ears, and to do things differently in order to manage what we've created. So, the National Academy of Engineering in the US has been looking ahead at the kinds of challenges that our species is going to have to deal with. And these are the sorts of things that they found. By the way, these all fit into four major areas: security, sustainability, health and the enhancing of life as the number of people grows. These problems are not technology problems. Technology has something to do with all of them. In fact, some of the challenges are here because of the technology, the unintended consequences in the previous generation. Nevertheless, they're about human behavior. And we have to take human behavior into account if we're going to solve any of them. So that, we have to have the right people in the room to frame the problem.

We can't just have engineers talking about this. We need a broader community. So this involves coupled scientific, social, economic, political, even religious dimensions. Because the population has to accept it or it doesn't work. What this really means is that we need a new kind of engineering innovator. Other populations have faced extinction, and so one of the research projects we've had is, so what did they do? How did they get where they are? So some folks think that maybe the dinosaurs had trouble with their diet. Others think maybe they had some behavior issues with alcohol, tobacco, other sorts of things. They also didn't really anticipate security very well. So this particular group said, "All I'm saying is now is the time to develop "technology to deflect an asteroid." And obviously they didn't pay any attention to that. And finally, maybe they missed the boat.

They just were distracted. Noah took off and they had all the other animals but the dinosaurs are sitting on the shore, they were playing basketball that day or something. We need to pay attention. Which raises the question, what exactly is innovation? Now there are lots of definitions of this. So the one I want to talk about is the kind of innovation that changes the planet. This is not just the kind of innovation that develops a new product, or a new industry, but it changes the way people live on a very large scale. So, if you have a very profound innovation, it changes the way people live so profoundly that people can't remember the way life was before it happened. So my kids, for example, can't imagine how the cave man lived before the cell phone. I mean they've sort of always been here. So, how could you possibly make that work? The point of this is that you have to implement ideas or you don't change the way people live.

So, without implementation, it's just an idea. Ideas are cool, but innovation requires adoption of the ideas. It requires people on a large scale to choose it. Now, if you think about this, I think our traditional model for education may actually be preventing us from producing innovators. Let me explain why. So, if you graduate from high school, and you go on to college, you need to choose a major. This might be a map of a large state university campus. Maybe the dimension of the whole page is a couple of miles in each dimension. And then once you go to, say the engineering school, you're going to spend four years in that little region of that map, which is called the engineering quad. Okay, that's where people learn engineering.

By the way, for accreditation, you're going to spend 75% of your time taking courses from people with PhDs in science, math and engineering. If you look at the kinds of questions that they examine in all of those courses in science, math and engineering, they're about the feasibility of ideas. What we really study is is it feasible to do this based on what we know about the natural law? Almost exclusively. And on the other hand, if you went to the business school, on the other side of campus in the green circle, they have to spend half of their time, according to the accreditation standards, studying things like management, marketing, organization, accounting, and that's all about viability. What does this do to producing dollars? Do you have enough capital? Is it legal to do this? How can you sustain it over time? It's a very important set of questions. They don't spend much time over in the blue circle learning about science. What about the people in the middle, in the red circle? I know about this, cuz I have a couple daughters that did this. So, in the red circle, this is where everything else in the university sits. The main campus library. People who are majoring in psychology, in arts or humanities.

So they have a different kind of question. Questions like what is the meaning of love? What is the meaning of truth? What is the meaning of beauty? These, by the way, integrating by parts doesn't help you in this set of questions. Neither does having a spreadsheet. Are these important questions? Answers to those questions determine motivation at the deepest level for all of humans. If people don't choose to do things, nothing happens on a large scale. So this is actually about what people desire, what drives people from the center. And the observation is, you have people that we separate that just look at feasibility. Other experts that we separate that just look at viability. And then we have the people who just think about what's desirable. The problem with that is very obvious.

And that is, based on work that was actually done at Stanford, all innovations, the kind of innovations that change the way people in a large scale, only happen at the intersection of all three. I'll bet you can't think of a single innovation that isn't simultaneously feasible and viable and desirable. So if you're going to be an innovator on a large scale, you have to be able to see all of the pieces of the jigsaw to put them together. And if we only study one kind of piece of the puzzle, it's going to be a rare person who understands how they all fit. And if we're going to create innovators, we need to do a better job of integrating these in the same head so that one person can see the whole picture. The big message for engineering schools? No amount of doubling down on math and science courses is going to improve the output of innovators. We're just going to produce experts in science and math. Those are cool, we need them, they're not innovators. Now, 20th century innovators require a lot more than technical knowledge; this is a really important point. So for example, attitude plays a really key role.

Entrepreneurial mindset is a really important attitude. This is an old cliche: more often than not, your attitude determines your altitude in life. This guy doesn't even have legs, and he's climbing mountains a lot better than I ever could. By the way, it's not about your aptitude. It doesn't matter how good you are. It really matters how determined and how committed you are to making a success. This is the grit part of what we were talking about. This is what Heckman found is three times more likely to produce positive outcomes than what you know. So there's this whole thing of mindset, attitudes, behaviors, and motivations, which is critical to producing innovation. What do you mean by mindset? Well, there's a whole list of them.

I'm not making these up, this is a compendium of what we're finding from different industries that are identifying them. Entrepreneurial mindset, ethical behavior, teamwork and leadership, global perspective, interdisciplinary thinking, and so on, and so on. By the way, the National Academy of Engineering in the U.S. did a study recently called "Educate to Innovate". This was the primary conclusion. This is what's missing. They're not alone; the Council on Competitiveness has been putting together a series of national meetings on the national engineering forum, many different cities. The main outline for this is capacity, capability, and competitiveness, and what's missing in the capability is this set of mindset skills. STEM Connector which is a really interesting group of about 5,000 corporations and organizations working together to define the workforce for the 21st century. Their conclusion, in particular, is employability skills and innovation excellence is critical.

If we unpack that, what's it about? Mindset, almost all the things they call for that are not in the curriculum now. And then IBM has been doing this for at least 25 years, this sort of T-shaped person, and the T-shaped person is what? It's a person who has technical depth, but has a mindset, a set of attitudes and abilities to work across disciplines and with people in different fields, in order to integrate those three circles so you can find the intersection in the middle. That's the idea. So all of them are calling for the same change. So what are the other lessons learned that we've found out? Well, in the U.S., do you know what fraction of the Bachelor's degrees that are being awarded in the next couple months across the United States, go to students who study any kind of engineering on any university campus in America. Any guesses? 4.9%, 4.9% the Bachelor's degrees in America that go to kids that get any kind of engineering degree. By the way, about half of the GDP in this country over the last 30 years, has been produced by those 4.9%, and this is a bit of a risk there, don't you think? And if you look at it a little more, so why 4.9%? What's happening, and you'll find out that the students who leave engineering, they come in, they're prepared according to their test scores, and they choose to leave, which is actually 60% of the freshmen who come in nationally to study engineering, never graduate in engineering. They might graduate in something else, they're not in engineering. Almost half of the ones who leave have higher grades than the ones who stay. They're not flunking out, they're choosing to leave.

Why? Because of the way we teach it, okay, it's been described by a number of our friends as the math/science death march. Look to your left, look to your right. It'd be better if at least one of you wasn't here for the next semester, we just keep winnowing it down cuz it's technical superiority that really matters, right, that's what we do, from the 1950s. So how do you fix this? After 15 years at Olin, we've concluded the best way to do it is to work on three things. How we teach, we're teaching the wrong people. So we're teaching the wrong people to start with, we're teaching the wrong stuff, and we're using teaching methods that are known to be largely ineffective. Otherwise though, we're doing a great job. So how do you deal with this? One of our colleagues, Tony Wagner at Harvard, recently wrote a book on "Creating Innovators:" "The Making of Young People Who Will Change the World". Tony's done case studies on this, research-based. The bottom line, the skill that you need is learning how to improvise.

It's the sort of question that doesn't have a unique answer. It's the question that has lots of answers that we don't emphasize enough in the engineering education. So, who we teach. Are we attracting the right people? 4.9%. What about people like Bill Gates? You heard of Microsoft, what about people like Steve Jobs, you've heard of Apple, what about folks like Mark Zuckerberg, you've heard of Facebook. By the way, what does Facebook sell? Think about that. It's not a thing. What Facebook sells is an opportunity to tell your personal story to a group of people who you really care about. Who knew that there's a business model in there. I'll tell you who knew: Maslow.

Have you heard of Maslow, the psychologist? He did this study on what are the most important human needs? It turns out that after oxygen and after water, the next most important need is to be the most important person in somebody else's life. The way we have structured our society today, and the way we are genetically wired, has made that very difficult. You prove that you are the most important, the tool you use for creating the community and the belonging is telling your personal story. And yet, as people move away on the other side of the country, and families have more kids coming from single parent homes, there's a lot of need for this. It's basically the insight that made Facebook work. Didn't come by the way, from a Nobel Prize in Physics. It came from that red circle on desirability. By the way, how many of these guys were engineers? Zero. None of them majored in engineering: math/science death march. Didn't seem like it was relevant to what they wanted to do.

Maybe we're not attracting the right people. We need, by the way, if we're going to attract the right people, we need a broader definition of what it means to be an engineer in the 21st century. If you look at definitions in the dictionary, it says engineers are people who contrive a solution to a problem using science. How many kids are going to wake up in the morning and say, "That's what I want to do." Our definition of engineering, by the way, engineering is not a body of knowledge. Our kids taught us that. It involves knowledge, there's no question about that. It's not a body of knowledge, engineering is a process. Have you heard of the aircraft industry? You know the guys who developed that were the Wright brothers. The Wright brothers were actually two bicycle mechanics in Ohio. How did they do it? They jumped off a hill a zillion times with these wings on their back, and they kept crashing.

They said, well there must be a better way to do this, so they changed something and they keep doing it until they get a little farther down the hill. Eventually they developed the field of aeronautics, who then the physicists in university said, oh I guess you can fly when you're heavier than air, I wonder why, and they began to ask the questions that developed the theory. So experimentation often precedes theory in the development of new technologies. Engineering is the process of iterative improvement on ideas. We do this in one course, usually at the end of year, which we call The Capstone. Kids are supposed to have an epiphany and understand, oh that's what all this was about and do this for the rest of their life. You know at Olin College, the average graduate completes 25 projects before they graduate. They start a business, and they also work for a company for a year. They do this all in four years, and by the way Stanford is one of the most popular places for Olin graduates to go to continue their graduate work, which is not the same in their undergraduate program. So they make that transition with much less concern then you would think.

We need multiple intelligences. So an engineer at Olin is a person who envisions what has never been and does whatever it takes to make it happen. By the way, I'm here because of my math teacher in high school. She said, you know, you're good at math, so maybe you should be an engineer, whatever that is. By the way I had never met an engineer or a person with a PhD, until I was a freshman at the University of California, so I ran into one. I'm still not sure what they are, honestly, but apparently it has something to do with math. Our definition, it doesn't even mention math. It starts with vision. If you can't envision it, you will never make it. It starts with vision.

You might be a terrific applied scientist or applied mathematician, but you're not going to change the world if you don't have vision. Secondly, you need to have the determination of whatever it takes, the grit, to hang in there, to get the funding for it, to get the team together, to get the prototype to fly, and to sell it to the rest of the world, else it's not good to work. That's what an engineer is. They start with vision and they have drive. That's the people we need. Secondly, what we teach. But wait a minute, if you're trained as an engineer, you know what we teach, right. This is about statics and dynamics, it's about strength and materials, it's about stress analysis, it's about basic electrical circuits, it's about thermodynamics, fluid mechanics, all that stuff. That's what it means to be an engineer. Well, is this the right stuff? Who knows the answer to that? The people who are practicing as engineers, who were our students and are now out in industry.

It turns out that recently for example, a thesis at MIT, Kristen Wolfe, did a study of the alumni from their engineering department. What did they find out? I don't have time to go through the whole thing. In this they found out that what they did not learn at MIT, but was used pervasively in their career within five years, were these things: teamwork, communications, professional skills, personal skills, independent thinking. Does that look familiar? Did we see that before, on that list of mindset skills? This is not what they were taught. This is what they were actually required to be expert in. This is how their career advancement goes forward. By the way, these are not technical subjects. This is what they taught at MIT in mechanical engineering, and their graduates said, well, we learned this but only really seldom do we use this stuff. Unless you're actually going to be a professor of engineering at MIT, this might not be the right list of stuff that you should learn. I happen to also be on a panel at the National Academy of Engineering right now, looking at the Engineering/Education Workforce Continuum.

What goes forward, there's data where you ask engineers across broad industries, so this is not MIT. The number one thing, if you asked them, how do you spend your time? Designing. The number two thing, managing people. Solving equations and dealing with the physics is way down the list. Now, it's important, don't get me wrong, I'm not saying we don't teach that stuff. I'm saying we're emphasizing the wrong stuff, and by omission, we're sending the message that they're not important. These are hard sciences, so maybe we should rethink what the content is. And finally, I'm almost to the end here, how we teach. Let's agree that we need to attract the people who are not normally attracted to engineering by starting with vision, and expecting them to be innovators. Secondly, let's assume that the curriculum content needs to be revised somehow, so that we still have rigor and we still have science and math, but it has 25 projects involved, rather than one at the end.

Still have the question of how do you teach? What's the best way to teach today? There's lots of information on this. What I will focus on is one of the books that I think is really interesting. This is a book that has as a co-author, John Seely Brown. Has anybody heard of John Seely Brown? Yeah, he's from the valley, right. This guy was the Chief Technology Officer at Xerox, and the founder of Xerox PARC, the Palo Alto research center where personal computing was invented. In his years after Xerox, he's been really consumed with understanding how people learn and what technology can do at the intersection. So John's book, "A New Culture of Learning" kind of lays this out. If you look at the old model and the new model side-by-side, one of the things that you find out is the old model was about transferring knowledge. Remember that picture, with the arrow going into the kid's head, that's what this does. The new model is about teaching people to construct knowledge in their head.

So it's new to them, it may not be new to the world, but they learn how to construct these models day after day. In addition to this, the old model is about sending a message, you have to have the pre-requisites. You have to do it this way, in this order. You can't do that yet because you haven't had all the right courses. So that's why we have the Capstone course where you actually design something in the senior year, cuz apparently you break some kind of law of nature if you pick up a wrench before you've had two years of calculus and physics. Can't do, that's the main message, subliminal message. The new model is about can do. It's empowering you to try things. The old model said, follow orders. Put your pencil down, test is over, don't talk to your neighbors.

The new model is about following your passions. This is about, you envision something that you're really interested in, and then you empower yourself to go and find the data and make it work. The old model is about learning in class, that's why it's important to show up on time and to attend every class. This is why attendance is so important. The new model, you learn 24/7, the class is just one of the places that you learn. The old model was you learn alone, don't talk to your neighbor, don't share your data, that's cheating. The new model is about teamwork. It's about learning from others and building communities of learning. And finally, the old model is about problem-based learning. That's important right, solving problems.

The new model is about design-based learning. Well what's the difference? They both involve making things that don't exist now. Problem-based learning is what I would call painting-by-numbers. You remember those kits when you were a kid? It's like a coloring book, black and white with lines, they put little numbers in the boxes. You put the right color inside the box, and you make a painting. That's project-based, somebody had to pre-digest it, know how many parts there were, make sure your kit had all the stuff you need. That's better than not doing any kind of construction. It's not the same thing. Design-based learning is a blank sheet of paper. You have to decide what to draw, how big it should be, what colors it should be.

It exercises, in fact, a different part of the brain. It's that creative visioning part of the brain that's missing right now. That's what John Seely Brown says. By the way, I claim that's not new. We've been doing this for generations. That's very much the template of what we do in graduate school. That's how a PhD program works. You do a little bit of coursework, then you do this weekly independent study, you talk to the faculty member, you're the one who generates the vision and the drive, you care about this, you learn it independently, you talk to the other graduate students, and you eventually present your work. That's not new. Oh, but you say, that'll only work in graduate school.

You have to be really advanced in order to be able to learn this way. I have a question for you. Have you ever heard of the Montessori schools? Those are five-year-olds. By the way, did you know a disproportionate number of CEOs of major corporations are graduates of Montessori schools? Apparently they didn't get damaged too badly by this process. What's missing is in the middle. It's the Bachelor's degree, the under-graduate program, where we're losing, remember, 4.9%. That 95% of the kids who are not doing it, are being structured out of it because of the math/science death march. Okay, my most favorite quote from the book is this one: "For most of the 20th century, our educational system "has been built on the assumption "that teaching is necessary for learning to occur." It's not. You're able to learn on your own without any teachers. That's why kids don't come to class, and they still pass, because they know how to learn on their own.

Is that a bad thing? Finally, one of my favorite quotes from Dr. Charles Vest, who was one of our heroes. Chuck was not only the President of MIT for 14 years, he was also the President of the National Academy of Engineering. His thinking on this, "Making universities "and engineering schools exciting, creative, adventurous, "rigorous, demanding, and empowering milieus", in other words, the culture, is far more important than specifying any curricular details. So my message is, don't copy what Olin does. Invent your own process, make sure you create the culture where that's what people say. At Olin, what we've discovered, if you buttonhole kids at the water cooler and talk to them, they'll tell you two things, almost without exception; I've never worked this hard in my life at anything. Olin is not a party school, by the way. Princeton Review ranks Olin number two in the U.S., for the students study harder than others. So it's just a drudgery, work course, right.

No, the second thing they tell you, there's nothing else I'd rather be doing. When you get those two things together, I've never worked this hard, and there's nothing else I'd rather be doing, you've now lit the fire of independent learning on their own. That's the culture we need to be building. So what's happened at Olin, and this is the last slide. Olin, turns out, Princeton Review last year, identified Olin as having the best classroom experience in America. This is not just engineering schools, this is all universities. So NBC Today Show had a segment on Olin and so forth. Number two for the students study the most. That was what I was just explaining. Number 19, the happiest students.

I think we're the only engineering school in the U.S., that has been ranked in the top 20 in both of those things. There lots of schools that have hard workers. There lots of school that have happy students, but not at the same time. That's what you need to be working at. You might wonder, you must be losing something. I've given these talks before, particularly with faculty members: "look if they did "25 projects, they can't have as many technical "elective courses with the advanced pre-PhD graduate work. "They're not going to be prepared for doing "the really rigorous science and math." Well, maybe not. Last spring, one year ago, one of the Olin graduates from Austin, Texas, was the first Olin student to win a Marshall Scholarship. Now, a Marshall Scholarship has the same statistics as the Rhodes, they're 34 of them in the U.S., they go to the UK, the difference is in the Marshall you can study at any university. With the Rhodes Scholarship, you study at Oxford.

What this guy did, is he went to Cambridge University to study physics in the same lab as Stephen Hawking. Interesting thing, Olin doesn't offer physics. We don't have a degree in physics. He prepared himself for that through this engine of learning how to study on your own, and he convinced the folks at Cambridge that he's ready to do this. So maybe teaching is not necessary for learning to occur. Maybe students are capable of learning on their own. Okay, with that, I think I will stop, and I will answer any questions that people have, if you're still awake. (applause) - [Voiceover] So this all sounds fabulous. What are the barriers that you see to implementing these ideas in other schools? - That's a key question, what are the barriers to implementing these ideas in other schools. Well every school is different, but all of them seem to have some similar concerns.

It's basically faculty attitudes. Here's the thing, in every university that has tenure and has academic freedom, you don't change the curriculum unless the tenured faculty vote on it. Those are the people you need to persuade. Faculty members, in spite of the fact that they have academic freedom, are not prone to take risk. It's not that they're not concerned about change and about innovation and creativity. I think they're rightly worried that to make such a radical change, we might be losing something really important to the students. So, one of the things that we need is better assessment data on this kind of a model across other universities, so that you can be really confident that if you prepare them in this new way, you didn't hurt them in some way. They are, in fact, advantaged. The assessment data is still in process, so that's one of the most important barriers. Yeah? - [Voiceover] I also think the tenure structure is not aligned with other greater education.

At the top research schools, I've noticed that most of the faculty are focused on research and writing grants, and they don't really pay any attention for other graduate classes. I've just heard horror stories from--. - Yeah, so this is a very good comment. He says, in addition to the fact that they may be worried about outcomes for students, that faculty members are not incentivized and rewarded for working on teaching, as much as they are, for example, working on research, and I think that's right. One of the things that we've been worried about, this happened at Olin, "if I do this, will it count? "Are you going to punish me?" By the way, this is also a little bit of a red herring. This is not how innovation happens. Let's make the whole world flat, and then we can design a car. What you do, the pioneers are people who know that there are barriers, and they put themselves at risk, and they prove against all odds that it does work, and then people reluctantly say, what are we going to do about John, I mean, he changed the world. It's not in our manual, we're not supposed to reward that. Well, maybe we need to amend the manual to take care of John.

If you look at case studies, that's how it actually works. There are ways to fix this. The most important work that happened at Olin in the last two years, is re-inventing the faculty manual. What does that mean? Every university that we've been to, including the four that I've been at in my career, has a promotion criteria that involves three things: teaching, research, and service. This is documented in the dossier which is a three-ring binder that has three tabs. Our folks said, this is not well-aligned with what needs to happen. Let's throw it away, and let's redesign it from the beginning. So at Olin what happened, we don't have three tabs. We have a Venn diagram that has three circles that intersect. Instead of talking about service, which usually means working on a committee, we talk about building the institution.

Instead of talking about teaching, we talk about building student success, whatever that means. It includes mentoring and it includes even working with alumni. It's not just about teaching scores in your teaching portfolio. And the most important one, about research. So we've replaced research with nationally visible impact with what you do outside of the community. Now, researching FARC is one of the ways you can do that, working on committees is one of the ways you can show service, and getting good teaching evaluations is one of the ways that you can show that you're building student success, but there lots of others. Case in point, one of our faculty members built a case for promotion by in fact, generating letters from deans and presidents of three other universities, who said that because of this person's work on their campus, they were successful at changing their whole undergraduate educational program. It would not have been possible without this person's leadership. Do you think that's nationally visible impact? So in our case, that's equivalent to a faculty member who got a letter from a journal editor, and from three department chairs who said, John's work was among the five best in the world in his age group. We're not breaking any natural laws, as far as I can tell.

Newton's Laws still work, the only barrier between this is the will and the creative impulse of the folks who have to make decisions. Yes. - [Voiceover] K-12 schooling has been trying to teach 21st century skills, which include most of what you said, for a long time, and have not really succeeded. You're even saying further you want to do it without teachers in a sense, can you maybe explain a bit how your college did it. - Yes, so the question was, well some experience in some K-12 schools trying to teach these mindset skills have not been successful, at least people don't believe that they're successful at this point, so what is Olin doing that succeeds? Well number one, we don't have enough time for me to give you a complete answer, so my answer to that is come and visit us, number one. So we've got 640 universities have done it, let's make it 641. The only way you're going to really know it, is to talk to the people and see the students themselves. It's a culture thing. It's the last slide from Chuck Vest about creating this milieu. That's about values, that's about alignment of purpose, that's about relentless focus on student success along the way.

There's a lot of answers in terms of total immersion. For one of the things that we do, I'm sure that a lot of things that Olin does are not necessary. Because we've seen a lot of this change happen at the University of Illinois, at Urbana-Champagne, and they only made 10% of the total Olin Kool-Aid that they institute there, so I'm kind of reluctant to go through the outrageous things that Olin does from candidate's weekend in terms of selecting the right people, to the total immersion environment. Every student is required to live in the residence hall for all four years. It enables teamwork on weekends. So the simplest thing I can say to any university who's serious about improving the quality of teaching, does not cost a dime, and you don't need geniuses in students to do it. The two things, ask the faculty members to sit through the courses they assign the students to take. Isn't that amazing. This is a Yogi Berra thing. It's amazing what you can see by looking.

All of that coherence and the way the jigsaw all fit together, that you deduced from looking at a small paragraph in the catalog that describe what the course does, actually doesn't work as well, if you're sitting in the seat of students. The second thing that we ask every time you bring a new faculty member in, before they've been deployed on their own to teach their specialty, for the first year, they should be assigned to teach in teams, with faculty members from another discipline. The only thing they have in common is teaching and the students. It's not about being the expert on the stage. This change is 50% of the problem that needs to be dealt with. It changes the culture. Yes sir. - [Voiceover] I'm curious about what were some things that you tried during your partner sessions with those 15, 30 kids that you thought would work, and then it ended up really not working. - So here's the first thing that we did. We got the founding faculty members together.

Small room, we said we got this big job, we have to re-think what it means to be educated, engineer, so forth. We asked them what could you remember from your own undergraduate experience. That was an interesting question. Little embarrassing. I remember I had physics, but I'm not sure, I think it was Halliday and Resnick, don't ask me to do quantum mechanics today, it's been a long time. But everybody, without exception, could remember in stunning detail, the senior project that they were working on, decades afterwards. In fact, I can even remember what I was eating at the time the breakthrough idea occurred to me why it didn't work, all these years later. So we said, geez, the difference in retention and real understanding of what you gained from the project was orders of magnitude greater than the coursework. Okay, so why did you wait until the senior year to do this project? Cuz everybody waited until the senior year. There wasn't a single person in the room that had that in the sophomore year.

Well, there must be a reason, probably it has to do with two years of calculus and physics. That if you picked up a wrench before you had two years of calculus and physics, it could cause a black hole or something that would absorb the earth, some really disastrous thing would happen, because nobody does it. So we decided, okay, we'll do an experiment. Let's try this, so we had those 15 boys and 15 girls. They don't know that you can't do this, so let's see what happens. We assigned them a challenge, right after they came. They had just graduated from high school, they had no college at all. We said, we want you kids to design, build, and demonstrate a pulse oximeter, and we want you to do that in five weeks. They said, excuse me, what's a pulse oximeter? So we spelled out the word, we said this is a medical instrument, it's that thing you find in the hospital, where they clip it on your finger and it measures the pulse rate and the oxygen content in your blood. Oh, by the way, it doesn't have a needle, it doesn't stick in you, it has a light, looks through the skin.

If you want to know more about this, we suggest you go to the Internet and look it up on the patent literature. The person who invented this has to have a little schematic diagram in a one-page description of how it works. They said, okay cool. We'll go off and start to do this. You've got five weeks to do this, and then we're going to move on and do some other experiment. If you have questions, we're here, but we're not going to give you lectures on how to do this. There's a shop over there that has soldering irons and transistors, whatever those things are, and it's up to you. So, we figured five weeks is enough time to get in serious trouble. After five weeks, they're going to be so frustrated. We will end it in five weeks, we sort of considered a mercy killing, and then we'll do the post-mortem.

Where did they get stuck on semi-conductor physics, they didn't even know what physics is. Turns out in five weeks, they had one working. They built it. So we brought in a hospital version and calibrated them next to each other. They're doing the same thing, it was amazing. Don't get me wrong, they weren't physicists, and they weren't really technicians either. It's kind of a miracle that this thing worked if you looked at the soldering, drops of stuff all over. They had a box full of fried transistors that all blew up, cuz they had "why is that three wires "sticking out the back?" They couldn't explain a lot of this, but they could make it work. Now, we should have known that they could do that. If we had been real engineers and not academics, we would have expected them cuz that's the way all engineering works is by trial and error until you get something to work.

We expected you needed to have all this theory first. There was something else we learned which was way more important. What we learned is that this experience of exceeding their own expectations and making something like that work, changed who they are. It was if they were two feet taller now. There was this sense of can-do, a sense that I can change the world now, if I have a group of people like me, and a shop to go experiment, and a couple old guys to ask questions once in awhile, anything I can imagine, I can do, and then we compared that with the way we felt as first-year students in an engineering school. It was not a can-do attitude. It was as John Seely Brown says, it was a can't-do attitude. For me, not even knowing what an engineer was, I thought they were people who made stuff. When I enrolled at the University of California in those days, I was amazed the first year that we never made anything. It was go take all this physics and calculus, all right, so they moved the goal posts.

We're going to do it in the second year. Come back in the second year, go take some more physics and math. They kept doing that. So it was an attitudinal thing which fueled the change in culture and the development of these students. - [Voiceover] I'm sure you all agree this was totally inspiring, please join me in thanking.