Silicon Flatirons
A Center for Law, Technology, and Entrepreneurship at the University of Colorado

Silicon Flatirons Roundtable Series:
Emerging Shapes of Higher Education

Thursday, June 11, 2015, 1:00 PM - 4:00 PM
University of Colorado Law School, Colloquium Room 480

Traditional higher education is perceived by some to be deep in a specialty area and, additionally, an experience where a student typically works and is evaluated in isolation. To the extent this depiction is accurate (and proponents of a broad liberal arts education may disagree), this approach falls short in helping students prepare for a networked world of rapid change and cross-functional teams. Several efforts aim to reform higher education along these lines are underway. T-Shapes, design thinking, and entrepreneurial mindsets are three conceptions of how higher education should look different. These approaches have significant areas of overlap. For example, they each preference team based activities, cross-disciplinary configurations, and experiential modes of learning. Desired outcomes include improved preparation of professionals ready to work in team formations, helping individuals develop a networked perspective, and cultivating wider cognitive proximity that allows for boundary jumping and creative innovations.

The *Emerging Shapes of Higher Education* Roundtable aims to better understand and critically evaluate these emerging conceptions of higher education. Our Roundtable discussion will be framed by the following three questions.

1. ***What aspects of pedagogy and market demands should higher education aim to embrace?*** This portion of the Roundtable discussion considers evidence that might help identify objectives of higher education reform. Warren Binford's essay highlights aspects of law school that often fail to track what educational research shows regards as effective pedagogy. Across the campus, Terry Boult's essay takes aim at the need for new models of training appropriate for higher education. And most broadly, Gallup collects and examines significant data about characteristics of entrepreneurs as well as effective higher education.

2. ***What is a T-Shaped higher education?*** T-Shapes provide a metaphor for depth and breadth. Beyond the conceptual metaphor, however, how is a T-Shaped education defined and operationalized? If taken seriously within higher education, how would our teaching and training look different?

3. ***What new methods of training and teaching exist?*** In recent years, CU-Boulder has initiated courses and co-curricular offerings that teach lean methods, design thinking, and entrepreneurial mindsets. Broadly, these courses preference team based activities, cross-disciplinary configurations, and experiential modes of learning. What does the curriculum of these courses consist of? What objectives are targeted (i.e., prepare professionals ready to work in team formations? help individuals develop a networked perspective? cultivate wider cognitive proximity?)? How are these outcomes measured?

AGENDA

1:00 – 1:15 Introduction (Weiser and Bernthal)

1:15 – 2:00 What aspects of pedagogy and market demands should higher education aim to embrace?

- Warren Binford (Willamette Law School): catching up to sound pedagogy
- Sangeeta Bharadwaj-Badal (Gallup): looking at the data
- Discussion

2:00 – 2:45 What is a T-Shaped higher education?

- Bradford Brooks (IBM): the T-Shaped professional
- Sam Arbesman (SFC Sr. Fellow): sense making in a complicated world
- Discussion

2:45 – 3:00 Break

3:00 – 4:00 Emerging new methods of training and teaching?

- Zach Nies (Techstars / Adjunct, CU Computer Science)
- Sue Heilbronner (MergeLane, Adjunct, CU Law)
- Co Berry (Design Thinking, Leeds School)
- Discussion

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Participants

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Clif Harald, Executive Director, Boulder Economic Council
Sue Heilbronner, Chief Executive Officer & Co-Founder, MergeLane
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Background Sources

David Ing, *T-Shaped professionals, T-Shaped Skills, hybrid managers* (Sept. 6, 2008), *available at* http://coevolving.com/blogs/index.php/archive/t-shaped-professionals-t-shaped-skills-hybrid-managers/.

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T-shaped professionals, T-shaped skills, hybrid managers

Posted on September 06, 2008 by daviding

The science, management and engineering of service systems is associated with a call for *T-shaped people*. The most recent emphasis is on T-shaped *professionals*, which was preceded by T-shaped *skills*, with linkages back to a 1990 study on *hybrid* managers. Some insight can be gained by working backwards through the nuanced terms.

The 2008 Cambridge (IfM and IBM) report issues a challenge to universities for developing skills, and then seeks to enlist support from business and government.

Developing T-shaped professionals
Discipline-based education remains a vital role of modern universities. In order to close the skill gap, however, universities should also offer students the opportunity to gain qualifications in the interdisciplinary requirements of SSME. Such qualifications would equip graduates with the concepts and vocabulary to discuss the design and improvement of service systems with peers from other disciplines. Industry refers to these people as T-shaped professionals, who are deep problem solvers in their home discipline but also capable of interacting with and understanding specialists from a wide range of disciplines and functional areas.

Widely recognised SSME programmes would help ensure the availability of a large population of T-shaped professionals (from many home disciplines) with the ability to collaborate to create service innovations. SSME qualifications would indicate that these graduates could communicate with scientists, engineers, managers, designers, and many others involved in service systems. Graduates with SSME qualifications would be well prepared to 'hit the ground running', able to become immediately productive and make significant contributions when joining a service innovation project.

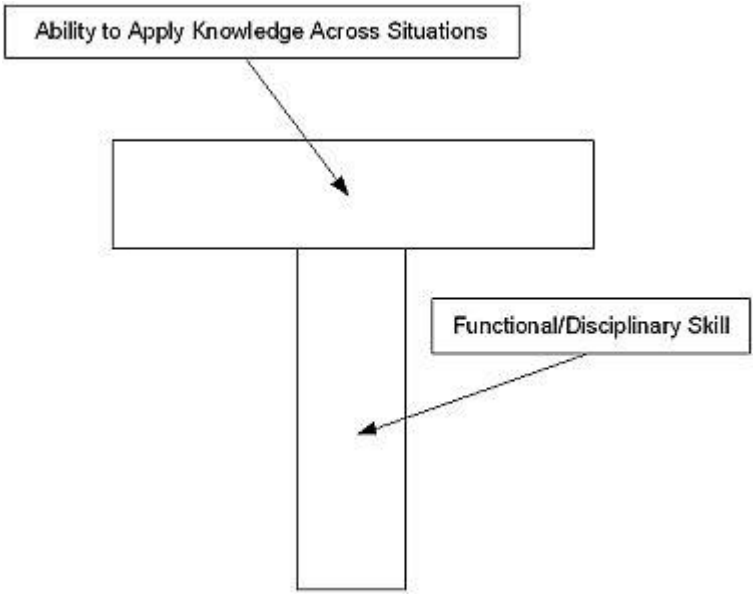
Support needed from business and government
Establishing SSME qualifications is a challenging task. Interdisciplinary course development requires significant effort to develop because different faculty members might find it hard to work together sustainably over time. Educational innovations are vulnerable because they are often reliant on the efforts of one or two people. Interdisciplinary programmes are even harder to organise, and more expensive to initiate and maintain, than conventional ones. Rapid progress in the design and delivery of these programmes would require support and resources from business and government. [p. 11]

This isn't nearly the first mention of the idea of *T-shaped*. Leonard-Barton (1995) provides a drawing of T-shaped skills, while describing the resistance of businesses to develop them.

The need for T-shaped skills surfaces anywhere problem solving is required across different deep functional knowledge bases or at the juncture of such deep knowledge with an application area. (See Figure 3-5). People possessing these skills are able to shape their knowledge to fit the problem at hand rather than insist that their problems appear in a particular, recognizable form.

Given their wide experience in applying functional knowledge, they are capable of convergent, synergistic thinking. [p. 75]

Figure 3-5 T-Shaped Skills



If people with T-shaped skills are an integral part of such an important competitive advantage, where do we find them? In most organizations, T-shaped skills are not created as a deliberate policy but emerge because individuals have been willing to risk a somewhat marginal career. Most formal organizational incentives encourage I-shaped skills — the deep functional experience represented by the T's stem. As a result, the individual is driven ever deeper into his or her expertise, which the organization continually draws on and rewards. At the same time, the organization provides no clear career path for those who want to top off the stem with a broad range of applications — i.e. the crossbar. [p. 77]

As a supplement to individuals with T-shaped skills, Leonard-Barton also describes complementary roles in A-shaped skills and multilingual managers.

People with A-shaped skills. Although rare, some individuals embody technology fusion. T-shaped skill implies deep know-how within one discipline (the stem) and more superficial knowledge about how it interacts with others (the crossbar). Some people actually learn more than one discipline (although more than two is unlikely) and so have two disciplinary "legs" on which to stand. Usually such skills are acquired sequentially. […. In] environments where technology fusion is the norm, some individuals may become bilingual. [p. 77]

Multilingual Managers. Additional organizational glue in diverse creative groups is provided by managers, some of whom describe themselves as "schizophrenic" or "multilingual" — i.e. capable of operating in more than one specialized realm and perhaps utilizing more than on cognitive style. [p. 77-78]

These mid-1990s articles see a subtle shift in emphasis from T-shaped *professionals* from earlier research into T-shaped *managers*. This shift is consistent with the rise of knowledge-based professionals operating in communities of practice, in contrast to industrial age management supervision.

Although the figure of the T-shaped appears is explicitly diagrammed in Leonard-Barton (1995), her text cites an Iansiti (1993) study of R&D groups in system-focused companies, emphasizing skills within a team as a whole.

Based on a study of the R&D organizations of 12 mainframe computer companies … system-focused companies achieve the best product improvements in the shortest time and at the lowest cost. [p. 138]

What follows is a typical profile for a successful integration team. In general, the members are the foundation of a system-focused approach to R&D. They possess a T-shaped combination of skills: they are not only experts in specific technical areas but also intimately acquainted with the potential systemic impact of their particular tasks. On the one hand, they have a deep knowledge of a discipline like ceramic materials engineering, represented by the vertical stroke of the T. On the other hand, these ceramic specialists also know how their discipline interacts with others, such as polymer processing — the T's horizontal top stroke. [p. 139]

Reading even earlier writings, Wordspy lists the earliest citation of the T-shaped people to David Guest in a 1991 article published in The Independent (London) in 1990. The core of that article reports on a 1990 study by the British Computer Society published by Palmer, linking back to Michael Earl at Oxford.

Hybrid managers are important. [….] The term was coined by Michael Earl, Director of OXIIM at Templeton College, Oxford. It arose as a result of a number of pieces of research that he and his colleagues had been undertaking. They noticed that in all the significant cases of successful implementation of information technology for competitive advantage or for achieving major change in organizations, there seemed to be a person at the heart of the development who displayed certain experience and characteristics. These were: an understanding of the business and what was required within the business, combined with a technical competence that enabled them to understand what was required in technical terms, including the scope of what was being planned. In addition to this, they displayed two types of organizational skills. They knew how to get about the business, and this implied that they knew the business and the people around it well, and they knew how to get things done, possessing a set of excellent social skills — to listen, understand, negotiate and persuade. [p. 232]

While the focus is on hybrid managers, they work in the context of visionaries, impresarios and specialists.

It was also clear from these cases that hybrids were not operating in isolation. There were other important roles that were being performed by other people in conjunction with the hybrids. These roles were described as visionary, impresario and specialist. The visionary was normally the leader who conceived a particular idea for the use of IT in the business; it was that person

who shared the vision with the hybrid, and the hybrid who took that vision, developed it and put it into action. The impresario was the provider of necessary resources and support to enable the hybrid to deliver what was required; this person was often the Information Systems Director. The specialist was the technical expert who was able to design and develop the specific system. [p. 232]

Presumably it's not so difficult to find visionaries, impresarios and specialists, but it is difficult to find hybrid managers. As part of the 1990 study, the British Computer Society suggested that MBA programs were a good direction to broaden the skills of technical specialists.

We came to the conclusion that an excellent route for individuals to bridge the career move from their IT specialism, was part-time MBAs. This is a universally recognized qualification, and over 4000 places are available parttime (in many instances company-sponsored) each year within the UK. The BCS is now seeking to encourage this activity and beginning to do some investigation work to define the requirement. It does seem to be the basic MBA, but with some attempt to broaden the skills of the IT specialist. [p. 235]

Part-time MBA training, however, tends to be correlated with career progression from hands-on work to management supervision. Leonard-Barton (1995) cautions that a generalist without deep relevant knowledge in a function doesn't have the requisite T-shape.

But creative problem solving requires us to manage between rewarding only deep functional knowledge and rewarding only application or integration skills. Iansiti found that the system-focused companies deliberately created T-shaped skills by carefully shaping individual careers to provide exposure. Of course, a risk is creating a class of generalists with no deep knowledge of any particular specialty but possessing only the crossbar of the *T*. [pp. 76-77]

The 2008 Cambridge IfM and IBM report suggests that the foundations for understanding service systems can be drawn from knowledge related to four resource clusters.

Resource clusters
The resources used to form service systems offer a useful starting point for the development of Service Science. They can be divided into four clusters:

- (1) Whole businesses and organisations: Studied primarily by schools of management (marketing, operations management, operations research and management sciences, supply chain management, innovation management)
- (2) Technology: Studied primarily by schools of science and engineering (industrial engineering, computer science, statistical control theory)
- (3) People: Studied primarily by schools of social sciences and humanities (economics, cognitive science, political science, design, humanities and arts)
- (4) Shared information: Studied primarily by schools of information (communications, management information systems, document engineering, process modelling, simulation) [p. 8]

The knowledge of service systems benefits from academic disciplines, which study some or all of the four resource clusters. The list is reproduced here as a table.

Academic disciplines	(1) Whole businesses and organizations	(2) Technology	(3) People	(4) Shared information
Architecture and designed systems	x	x	x	x
Behavioral sciences and education			x	x
Cognitive science and psychology	x	x	x	x
Complex adaptive systems theory	x	x	x	x
Computer science and AI/web services		x		x
Computer supported cooperative work	x	x	x	x
Economics and law	x		x	x
Engineering economics and management	x	x		x
Experience design, theatre and arts			x	
Financial and value engineering	x	x	x	x
Game theory and mechanism design			x	x
Human resource management	x		x	
Industrial engineering (IE) and systems	x	x	x	x
Industrial and process automation	x	x	x	x
International trade	x			
Knowledge management	x	x	x	x
Management of information systems	x	x	x	x
Management of technology & innovation	x	x	x	x
Marketing and customer knowledge	x	x	x	x
Mathematics and non-linear dynamics	x	x	x	x
Operations management (OM)	x	x	x	x
Operational research (OR)	x	x	x	x
Organisation theory and learning	x	x	x	x
Political science	x		x	
Project management	x	x	x	x
Queuing theory	x	x	x	x
Simulation, modellling visualization	x	x	x	x
Sociology and anthropology	x	x	x	x
Software metrics and development		x		

Statistical control theory		x		x
Strategy and finance	x	x	x	x
Supply chain management	x	x		x
System design and software architecture		x		x
Systems dynamics theory and design	x	x	x	x
Total quality management, lean, six sigma	x	x	x	x

Perhaps the skills of a T-shaped professional — in an era of science, engineering and management of service systems — can be drawn from the two dimensions above.

- Deep knowledge in (at least) one discipline related to a service system fills out the stem of a T-shaped professional.
- A generalist's appreciation of four resources of a service system — whole businesses and organizations, technology, people, and shared information — fills out the crossbar of a T-shaped professional.

In practice, there's sufficient breadth within undergraduate and graduate studies to gain expertise in more than one discipline. Keeping the big picture in view suggests commonalities in the four resource clusters.

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T-Shaped People, Jobs, and Recruiting

Recruiting is about to be forced to start looking for people and assessing them in very different ways than they have.

The nature of organizations is transforming right under our noses, but most of us are too deep in the forest to see what is happening. Over the past 100 years business owners and human resources folks created the concept of a job as a way of looking at and doing work. We define a job as a set of skills, experiences, and activities that a single person does. We record that set of skills, experiences, and activities in a document we call a job description. The idea is that many people, each doing a little thing, will produce something larger and more complex than they could have produced themselves.

Recruiters and hiring managers look for the people who are very good at doing the “little thing.” Recruiters and hiring managers use the lists of skills and experiences to search for people and assess them by looking for the ones that match the defined requirements.

This worked fairly well in the mechanistic, industrial world where there was some correlation between experience, training, and performance. In those kinds of organizations, it may still work well. But fewer and fewer organizations do this kind of work. Instead they need people who can do much bigger things and think more broadly. They are looking for out-of-the-box ideas and disruptive solutions to create innovative products and services and meet the far-more-complex needs of their clients and customers. They need people who are willing to experiment and take risks to find a disruptive solution. The old idea of cataloguing the required skills, experience, and activities runs out of gas. We don’t know what these skills, experiences, and activities are; they change constantly and they are interdependent on others in our team.

Many recruiters I talk with already know this in their gut, but have trouble expressing it or explaining it.

They know that work is more cross-functional, requires more collaboration and sharing, and relies less on how things were done in the past. Jobs today are harder and harder to define as they are constantly morphing around us. Nothing remains constant for very long. Part of the reason we have lost 14 million "jobs" since the start of the recession is because of this confusion. The "work" these people were doing, for the most part, has not gone away. It has been diffused into the organization or been transformed into technology. In some cases it may have been sent somewhere else, but this is temporary until a way to automate or eliminate the need for it is found.

New jobs will have an expectation of scope, responsibility, and effectiveness that we have primarily only seen in law firms and consulting companies until now. These new jobs will not be static and will require an eclectic set of skills. For example, a very successful WordPress template creator, who works for himself, started out as a computer science major. He then moved to engineering and after a brief stint as a computer engineer became a graphic designer and typographer. This then led him to start a business writing code to create beautiful templates noted for their outstanding focus on fonts and colors. He combined several "jobs" into one, but had to start his own business to earn money doing it.

I believe that we will evolve to focus on roles people can take on, rather than on specific skills and experience. We will look for people who have the ability and the mindset to find where they can add value on their own. And people who can move from technical to soft areas with ease will be in high demand. Many companies are experimenting with putting people into role-based work. Google, for example, often assigns engineers to a team where they work out, with the team members, the role they will play. The same happens routinely at IDEO, the well-known design firm in Palo Alto, California.

Organizations are realizing that when people are assigned to or choose *roles* to play in an organization they are often more creative and efficient than when they are confined to the duties prescribed by a title or position.

I just read an amazingly thought-provoking blog written by IDEO CEO Tim Brown. In it he talks about IDEO's quest for **T-shaped people**, who he believes are the engine of IDEO's creativity and success. He describes these people this way: the vertical shaft of the "T" represents the depth of expertise/skill that a person exhibits, while the crossbar of the "T" represents the amount they are willing and able to collaborate. People who are T-shaped are well-rounded and versatile. They are better able to contribute their ideas to a discussion and are able to take on a variety of roles. It's no wonder that IDEO is one of the firms pioneering the change to formalize role-based work and reduce the work that is based on position or title.

We have a ways to go to fully realize the potential of role-based work, as we are caught in a web that pays and promotes people based on such criteria as degrees, years of experience, time in the current position, and so forth. T-shaped people, free to take on different roles as work changes, are far more valuable than those trapped in rigid silos of scope and responsibility.

However, Baby Boomer/hiring manager attitudes about work, laws, and policies will have to change, and there will need to be sweeping changes in how human resources thinks about compensation, promotion, and development to fully transform organizations.

At the Future of Talent Institute, we are focusing our research this year on this issue and will be doing surveys and working with some organizations closely to better understand how role-based work will be defined and what skills recruiters will need to be successful. You can follow our thinking on this at my blog, Over the Seas, and also at our website, www.futureoftalent.org. I'd also love your comments and

thoughts on what you are seeing.

Post written by: ERE Articles

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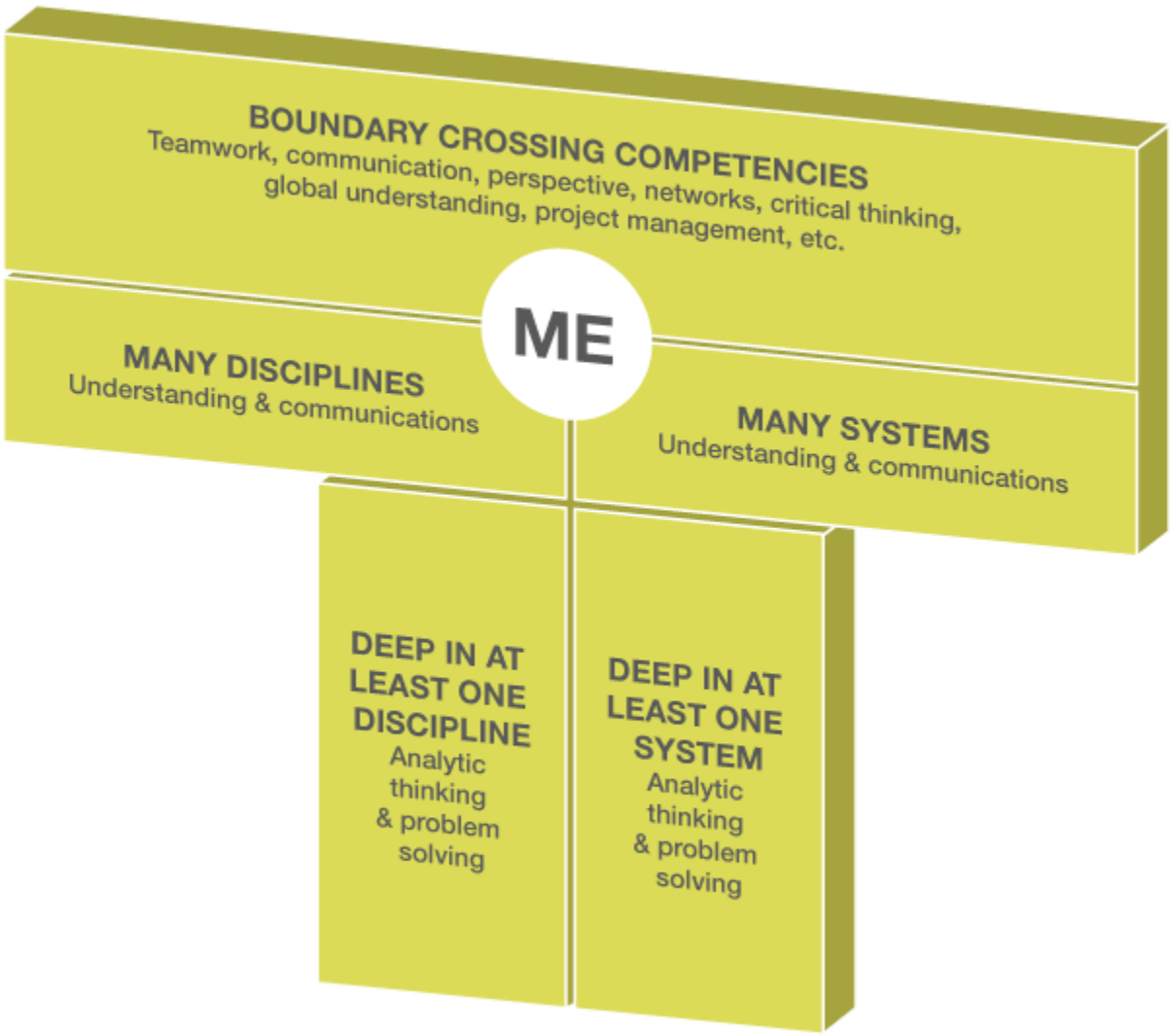
WHAT IS THE "T"?

Over the past decade, research has emphasized the need for today's young professionals to possess deep disciplinary knowledge along with a keen ability to communicate across social, cultural and economic boundaries.

What is the T?



What is a T-shaped professional?

Currently higher education is producing I-shaped graduates, or students with deep disciplinary knowledge. T-shaped professionals are characterized by their deep disciplinary knowledge in at least one area, an understanding of systems, and their ability to function as “adaptive innovators” and cross the boundaries between disciplines.

The two vertical bars of the "T" represent the disciplinary specialization and the deep understanding of one system. Systems describe major services, such as transportation, energy, education, food, and healthcare, that impact quality of life. These systems are comprised of interconnected components of people, technology, and services. To understand a system, one must know how it functions from the bottom to top in order to address challenges.

The defining characteristic of the “T-shaped professional” is the horizontal stroke, which represents their ability to collaborate across a variety of different disciplines. To contribute to a creative and innovative process, one has to fully engage in a wide range of activities within a community that acknowledges their expertise in a particular craft or discipline and share information competently with those who are not experts.

Why is it important to be a T-shaped person?

In comparison with the “T” shaped individual, the “I” shaped individual is focused largely on their particular knowledge and skill-set, views the workplace as a competitive environment, and works within disciplinary silos. Currently many college and university graduates have been trained to be productive in one field, but employers are placing increasing importance on skills that reach beyond a single discipline or focus. Upon graduation, students should be able to handle information from multiple sources, advance professional relationships across different organizations, contribute innovatively to organizational practices, and communicate with understanding across social, cultural, economic and scientific disciplines. Tomorrow’s workers will build their careers in a globally interconnected and constantly changing world with smarter technologies in an effort to effect positive global change.

Why is this a critical time for a T-shaped professional meeting?

Over the past decade, research has emphasized the need for today’s young professionals to possess deep disciplinary knowledge along with a keen ability to communicate across social, cultural and economic boundaries. These “T-shaped professionals” are in high demand for their ability to innovate, build relationships, advance research and strengthen their organizations.

Who should attend the T-shaped meeting?

This summit is aimed to provide leaders from industry, academia, government, foundations, professional organizations, and other stakeholders with the tools necessary to design educational models that foster and develop T-shaped characteristics that are in high demand today and in the future workforce. Through this meeting of like-minded innovators, we hope to prepare for an era of forthcoming professionals who use new technologies, business models, and societal innovation to make a positive impact on the world.

How to Be the World's Best Law Professor

Warren Binford*

It is always dangerous to start with a confession (unless you are a Catholic stepping into a confessional, of course[1]) but here is mine. The title of this essay was originally, "How to Be the World's Worst Law Professor." After all, we are supposed to write about the things we are expert on, aren't we? Some of you are expert on contracts law, others on immigration law, and those are the topics that you write about. What am I expert on? Good question. Sometimes I hope that I know a little bit about children's rights, but more often I fear that my greater expertise centers on what *not* to do as a law professor.

There have been many days that have ended with my head on my desk wondering why my students did not understand something I had taught, did not perform how I expected, or were seen scrolling through their Facebook newsfeeds during class. I could share with you all of the mistakes I have made as a professor and provide scientific research showing why my approaches were destined to fail. Who doesn't enjoy reading about someone who performs worse than we do? Isn't this the attraction of the Darwin Awards? I imagine you would find great comfort knowing that, although you might lecture occasionally, at least you never made a group of Scandinavian students in Cape Town sit through a three-hour lecture on international children's rights in a foreign language (English) while talking really quickly as Professor Binford once did (yes, I really did).

But when I sent an early draft of my essay to a more savvy colleague across the country, he immediately pointed out that for the rest of my life, anyone who Googled my name would see "World's Worst Law Professor" pop up in the search results. Now I might not be a social media genius, but I am smart enough to know what a marketing disaster that would have been! It is bad enough that I fear I may be the world's worst law professor, but it is a whole other matter for Google's algorithms to prove it. Algorithms are never wrong after all, right? So I accepted his challenge to reframe the essay from a more positive perspective, but presenting the same research. Now, instead of thinking I am not very bright, you think I am cheeky, which personally I prefer. Wouldn't you?

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[1] For the record, I was raised a Baptist, which means I can't dance, don't drink, and have a healthy wariness of confessions.

And so here you have a highly imperfect law professor, who sometimes fears she may be the world's *worst* law professor, telling you how to be the world's *best* law professor.[2] How is that supposed to work? This is how: we learn far more from failure than we learn from success.[3] This is one of the first truths of teaching. So through my failures as a teacher, I have been driven to research and find and read the latest pedagogical research on what works and what doesn't. It does not mean I know it all, and it certainly does not mean I do it all. But I am trying to learn from my own shortcomings and failures, and here are a few of the most important findings I have learned so far about teaching and learning in my own quest *not* to be the world's worst law professor.

One of the most important things I have learned in my endeavor is that there has never been a better time to be an educator. Advances in neurological research in the past thirty years have given us a better understanding of how the brain works and how humans learn than at any other time in human history.[4] Some of what we have learned from that research is not surprising and confirms what we have known and done for millennia. But other lessons directly counter mainstream teaching practices, and challenge educators—in law and other fields—to step back and re-evaluate how we teach our students. This essay will highlight some of the teaching and study methods most commonly used in legal education today, and share what the latest educational research shows regarding their effectiveness or, in many cases, ineffectiveness. It will also introduce legal educators to a few new teaching and learning methods that currently are underutilized in law schools. Finally, it will challenge legal educators to consciously select effective teaching methods and to abandon ineffective ones and to transform law schools into educational environments that yield high results from our students. Where to start?

1. Start with Failure, and Then Continue to Fail Until….

One of the most counter-intuitive lessons discovered recently through educational research is the power of failure to prime the mind for deep learning.[5] In legal education, we

[2] Those interested in becoming the "World's Best Law Professor" should read MICHAEL HUNTER SCHWARTZ ET AL., WHAT THE BEST LAW TEACHERS DO (2013). The book was published by Harvard University Press and profiles 26 law professors around the country who facilitate exceptional learning by setting high standards and modeling professional conduct by being prepared, accessible, and supporting their students' success. Although I agree with many of the lessons shared in that book, this essay is distinguished in that the lessons here are based largely on quantitative educational research, whereas WHAT THE BEST LAW TEACHERS DO is based largely on qualitative research. Both have value, and I found nothing significantly inconsistent between the qualitative research presented in WHAT THE BEST LAW TEACHERS DO and the quantitative research highlighted here.

[3] Anne Sobel, *How Failure in the Classroom Is More Instructive than Success*, THE CHRONICLE OF HIGHER EDUCATION (May 5, 2014).

[4] SOCIAL NEUROSCIENCE: TOWARD UNDERSTANDING THE UNDERPINNINGS OF THE SOCIAL MIND (Alexander Todorov, Susan Fiske & Deborah Prentice eds., 2011).

[5] Nicholas C. Soderstrom & Robert A. Bjork, *Testing Facilitates the Regulation of Subsequent Study Time*, 73 JOURNAL OF MEMORY AND LANGUAGE 99, 112 (2014); Harry P. Bahrick & Lynda K. Hall, *The Importance of*

spend an entire semester preparing our students to be successful on a high-stakes final exam at the end, but now we know that we actually should be giving our students exams at the *beginning* of the semester and hoping that they fail so that they will be mentally prepared to learn. Think about the irony of that. Legal education literally seems to have the learning process backward. Rather than end with testing, we need to start with testing. A recent study by Elizabeth Ligon Bjork, a psychologist at U.C.L.A., found that students' performance on a final exam was improved an average of ten percent by doing nothing more than taking a test at the beginning of the course.[6] That is one entire grade point, a whole letter grade. In other words, if we want our students to learn, we need to start by showing them what they do not know. Even better, it will help us to discover our students' gaps in knowledge so that we can adapt course content accordingly.

I know what you are thinking: "Is she really saying that in order to become 'The World's Best Law Professor,' I need to test my students more and create more opportunities for my students to fail?" Yes, I am, with the understanding that testing has consistently been proved to be a highly effective *learning* method when designed well, in addition to its value as an *assessment* method. In the end, the approach is likely to increase our students' learning and long-term professional success. Moreover, it is critical that we recognize that "testing" can take many forms. A student's knowledge can be tested in a classroom with pen and paper, on a smartphone or tablet, during an oral examination, or via a law practice performance in moot court or simulated or clinical courses. One should not limit one's view of testing to the anxiety-inducing high-stakes exams that have scarred many and been roundly criticized.[7]

The value of testing has been recognized by other professional graduate school programs. Many are already testing their students before they even begin their first week of classes.[8] Some of these tests are for remediation purposes.[9] Others are for determining what level courses to assign students.[10] Others allow students to waive out of some of their graduate school courses entirely.[11] Can you imagine a law school where students can waive out of their coursework? It is easy to do. After all, who wants or needs to take a course in which they can already demonstrate mastery or, at least, competency?

Retrieval Failures to Long-Term Retention: A Metacognitive Explanation of the Spacing Effect, 52 JOURNAL OF MEMORY AND LANGUAGE 575 (2005).

[6] Benedict Carey, *Why Flunking Exams Is Actually a Good Thing*, THE NEW YORK TIMES (Sept. 4, 2014).

[7] SHARON LYNN NICHOLS & DAVID C. BERLINER, COLLATERAL DAMAGE: HOW HIGH-STAKES TESTING CORRUPTS AMERICA'S SCHOOLS (2007); GREGORY J. CIZEK & SAMANTHA S. BURG, ADDRESSING TEST ANXIETY IN A HIGH-STAKES ENVIRONMENT: STRATEGIES FOR CLASSROOMS AND SCHOOLS (2006).

[8] W. Warren H. Binford, *Envisioning a 21st-Century Legal Education*, 43 WA. U. J. L. & POL'Y 157, 178 (2013).

[9] *Id.* at 175.

[10] *Id.* at 179.

[11] *Id.*at 183.

In a higher education system that is placing more and more value on learning outcomes, pre-testing becomes mandatory so that we can establish baselines; but more important, we now have confirmation of a century's worth of research that testing is not just valuable for assessment purposes, but is one of the most highly effective learning approaches.[12] Thus, every legal educator in the country should consider conducting testing not just at the end of the course, but at the beginning as well. Moreover, law schools should consider following the lead of other professional graduate programs and test their students at the beginning of the entire degree program, before classes even begin.

And if we want to be the best, we can't stop there. We need to keep testing, but in kinder, gentler ways across time.[13] A recent series of clinical trials by Professor Price Kerfoot at Harvard Medical School shows that introducing content to students repeatedly in a test format over time increases both acquisition and retention of content.[14] Professor Kerfoot refers to the technique as "spaced education."[15] His theory and results were confirmed by one of the most comprehensive meta-analysis studies of cognitive and educational research ever conducted ("the Dunlosky Study").[16] The Dunlosky Study reviewed over 700 scientific articles on ten popular learning techniques to determine which ones measurably advanced learning and which ones did not.[17] Their analysis determined that "self-testing" or "practice testing"—that is low-risk testing that can be administered outside of the classroom with low or no impact on the student's grade—is a "high utility" learning method.[18] In other words, we need to test our students earlier, more, and in low-risk settings if we want to increase their retention, comprehension, and test performance on that high-stakes final exam that we rely on for final assessment, as well as the bar exam after they graduate.

"But doesn't that mean more work for us?" you might wonder. Yes, but not much. Another wonderful aspect to the fact that we are law teachers in this day and age is that technology exists that allows us to create a test once, and then have that test administered and graded, and automatically provide customized feedback to our individual students. This, in turn, frees our time and energy to meet with our students to focus on the deep learning and complex

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[12] John Dunlosky, et al., *Improving Students' Learning with Effective Learning Techniques: Promising Directions from Cognitive and Educational Psychology*, PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST 14(1) 4, 26 (2013).
[13] NICHOLS & BERLINER, *supra* note 7; CIZEK & BURG, *supra* note 7.
[14] Craig Lambert, *Learning by Degrees*, HARV. MAG., Nov.-Dec. 2009, at 10, 11; *The Science Behind Qstream*, QSTREAM, http://qstream.com/products/the-science-behind-qstream/ (last visited June 16, 2013); B. Price Kerfoot & Erica Brotschi, *Online Spaced Education to Teach Urology to Medical Students: A Multi-Institutional Randomized Trial*, 197 AMER. J. SURG. 89, 92 (2009).
[15] *Id*.
[16] Dunlosky et al., *supra* note 12, at 4-58.
[17] Specifically with regard to practice testing, Dunlosky et al. reviewed over 120 articles primarily drawn from the past ten years, but recognized that research supporting the efficacy of testing as a learning method has existed for over one hundred years. *Id*. at 29-30.
[18] Dunlosky et al. define "high utility" learning methods as those that "are robust and generalize widely." *Id*. at 7.

questions that may be slowing down their learning process. Moreover, many ebooks and other digital resources include quizzes and practice questions at the end of book sections and chapters. All a professor has to do is assign these "tests," monitor the students' progress, and adapt course content and design accordingly.

Finally, adaptive learning software programs and apps—which combine spaced education, low-risk testing, and individualized content delivery—have been developed by Dr. Kerfoot, BarBri, the creators of Core Grammar for Lawyers, and many others.[19] More adaptive learning programs and apps should be developed in collaboration with legal educators, which would further support both efficiency and individualization while utilizing high impact learning methods supported by comprehensive pedagogical research. Given how easy it is to do and the proven effectiveness of the learning method, there really is no excuse not to engage our students more frequently with such exercises. Even if we do not assign these tests and exercises ourselves, we should at least teach our students about the effectiveness of this learning method, so that they can engage it themselves as part of their study strategies. We are, after all, professional educators and should be able to tell our students which learning methods work well and which ones do not.

2. Distribute Learning across Time.

The Dunlosky Study also confirmed that the second aspect of Professor Kerfoot's spaced education theory, which the Dunlosky team refers to as "distributed practice," has high utility for learning and increases retention of content and comprehension.[20] Distributed practice requires students to revisit topics across time rather than to cram them into a single study session or a series of study sessions, which is very different than the model of most law school courses. Customarily, we introduce a topic once or twice over the course of a semester and the student is subject to the possibility of being tested on the content, usually only once at the end of the course. The student normally will read the assigned material before class, witness and possibly participate in the class discussion, study for the exam, and then take the exam all within a matter of a few short months. For bar courses, law school students are then expected to recall the content when they sit for the bar exam two to three years later.[21] They may also need to recall the content of both bar courses as well as other law school courses years later in law practice.

[19] Binford, *supra* note 8, at 170.
[20] Dunlosky et al., *supra* note 12, at 35-40.
[21] Although many students do enroll in commercial bar examination preparation courses, such courses are expensive and many do not. The average annual tuition for a private law school in 2012 was $40,500. The average tuition at a public school that year was $23,600. Ethan Bronner, *Law Schools' Applications Fall as Costs Rise and Jobs Are Cut*, N.Y. TIMES, Jan. 31, 2013, at A1. One could argue that after spending over $100,000 at private law schools, law students should not have to pay thousands of additional dollars to an outside entity to prepare them to pass the

In a field where we know that we are educating our students to recall information years from now for bar exam passage, law practice success, or both, the endurance of the effects of distributed practice are especially valuable. Some of the most relevant research for legal educators regarding distributed practice examines the ideal length of time between practice sessions. One study suggests that in designing a learning experience, the educator should start by asking how long the learner needs to retain the content and then design practice sessions at intervals approximately ten to twenty percent of the length of time the learner needs to retain the material.[22] Apply this to the law school context where a student is introduced to the concept of offer and acceptance in a first-year contracts course. The student will need to retain that information for approximately 34 months at a minimum (from when the content is introduced until she sits for the first bar exam after law school graduation). According to the distributed practice research, legal educators should design a curriculum in which the student re-engages with the concept of offer and acceptance every three to six months or so to increase the likelihood that she will be able to recall the information when needed. This suggests that legal educators should be designing curriculum not only across semesters, but across all three years of law school study.

It also suggests that schools that use the quarter system should reconsider that practice. In one study of distributed practice, learners were tested on their conceptual understanding of content after the course had ended.[23] The learners were divided into two groups. One group took the course over an eight-week period while the other group took the course over a six-month period. The group that took the course over the six-month period scored more than ten points higher on average than the group that took the course during the shorter period, despite the fact that there were no other identified differences.[24]

Of the ten learning methods examined in the meta-analysis conducted by Dunlosky et al., low-risk testing and distributed practice were the only two learning methods that met the criteria for high utility learning techniques. Their distinction compels law schools and legal educators to consider ways to adapt course design and the law school curriculum to better utilize these highly effective methods to maximize student learning. However, there is a third learning method examined by Dunlosky et al. that holds promise and closely complements the only two methods (testing and spaced education/distributed practice) found to be high utility.

3. Interleave Studies.

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bar exam, except in cases where they are testing in a different state than the location of their law school. *See also* BRIAN Z. TAMANAHA, FAILING LAW SCHOOLS 108 (2012) (describing law school tuition costs).

[22] Nicholas J. Cepeda, Edward Vul, Doug Rohrer, John T. Wixted, & Harold Pashler, *Spacing Effects in Learning: A Temporal Ridgeline of Optimal Retention*, 19 PSYCHOLOGICAL SCIENCE 1095, 1101 (2008).

[23] Luc Budé, Tjaart Imbos, Margaretha W. van de Wiel & Martijn P. Berger, *The Effect of Distributed Practice on Students' Conceptual Understanding of Statistics*, 62 HIGHER EDUCATION 69, 72 (2011).

[24] *Id. at* 75.

Unlike testing and spaced education/distributed practice, which can no longer be challenged vis-à-vis learning efficacy given the significant amount of scientific literature supporting these learning methods, there is a more limited amount of research considering whether it is better to organize blocks of learning around a specific topic or to interleave various topics. The emerging research that has examined this learning approach fairly consistently finds that interleaving topics may lead to notably higher performance than blocking topics when one measures performance over time.[25] For example, in one study of interleaving versus blocking, accuracy was measured during learning and on a test afterward. Although students using a blocking method demonstrated higher levels of accuracy during the learning session, it was the students using an interleaving approach who demonstrated significantly higher accuracy on the test conducted afterward at a rate of approximately three to one compared to the blocked students.[26]

What might interleaving look like in the law school setting? Imagine a torts course or module that also included elements of civil procedure. When the student is tested, the legal educator ideally would test the student first on the topics most immediately covered (strict liability and jurisdiction, for example), but then may include a question about the concept of offer and acceptance the student learned about previously (ideally, the most recent topics are covered first and then more distant ones[27]). According to the research, the interleaving of these three topics in the students' study and testing appears to help students with, *inter alia*, organization, discrimination, and memory.[28]

When one starts to envision a curriculum that includes repetitive coverage of topics accompanied with low-stakes testing across the duration of law school, one quickly recognizes that a certain amount of interleaving of topics would be inherently necessary.[29] The fact that most of the research conducted on interleaving supports the effectiveness of the practice, especially with regard to comprehension and accuracy after the learning period, provides further support for redesigning the law school curriculum consistent with these scientific studies to maximize our students' comprehension and retention across time.

In other words, if we want to be "The World's Best Law Professors," we need to start envisioning a law school curriculum that is far more integrated with repetitive coverage of topics

[25] Dunlosky et al., *supra* note 12, at 40-44.
[26] Doug Rohrer & Kelli Taylor, *The Shuffling of Mathematics Problems Improves Learning*. 35 INSTRUCTIONAL SCIENCE 481, 492 (2007).
[27] Kristin H. Mayfield & Philip N. Chase, *The Effects of Cumulative Practice on Mathematics Problem Solving*, 35 JOURNAL OF APPLIED BEHAVIOR ANALYSIS 105, 116 (2002).
[28] Dunlosky et al., *supra* note 12, at 40-44.
[29] *See, e.g., id*. at 41. Indeed, Dunlosky et al. recognize that the measured benefits of interleaving may be partially a result of distributed practice, and then cite research that holds spacing constant, finding that interleaving appears to have benefits of its own. *Id*.

interspersed across semesters and even years. We need to set up low-risk practice testing opportunities for our students that allow them to recall content over time, and where we can measure their knowledge and understanding of topics through demonstrated learning outcomes indicating mastery. But how should we deliver that content?

4. Of Course Limit Lecturing, but What about the Socratic Method?

Not by lecture. Over 700 studies have confirmed what many of us know based on our own experience as students: lectures are among the least effective methods for achieving almost every educational goal ever identified.[30] In fact, for some education goals, lectures have been identified as *the* least effective learning method. Others suggest that they may be worse than no teaching at all since attending a lecture leads to less studying afterwards.[31] So why do we keep using them? Money.

Unfortunately, some institutions appear to be driven by the cost of a learning method rather than its efficacy. Thus, large lecture classes throughout higher education are sometimes favored by administrators over labs, clinics, simulated practice experiences, and seminars. The good news is that although many law schools tend to continue to favor large classes, especially in the first year, we use lecturing less than many other programs of study in higher education.[32] When we do use large classes and the "sage on the stage" approach, traditional legal pedagogy favors the Socratic method, which was identified in the recent "Carnegie Study" of legal education as advancing certain outcomes during the first year of law school.[33] These advances could be attributed to the fact that the Socratic method utilizes elaborative interrogation, which has been shown to increase learning and retention, at least in the short-term.[34] Elaborative interrogation was examined in the meta-analysis conducted as the Dunlosky Study, and was identified as a "moderate utility" learning method. Reasons why it was not rated higher include the fact that not enough research has shown whether the short-term advantages evident in the approach endure across longer periods as well as whether the effects would be evident among a wide variety of learner populations.[35]

Another reason why the Socratic method may work follows from its integration of the case study method,[36] which implicates two elements shown to contribute to heightened learning. The first is stories. Storytelling has played a central role in transferring knowledge across

[30] Graham Gibbs, *Lectures Don't Work, But We Keep Using Them*, TIMES HIGHER EDUCATION, November 21, 2013.
[31] *Id*.
[32] WILLIAM. M. SULLIVAN, ANNE COLBY, JUDITH W. WEGNER, LLOYD BOND & LEE S. SHULMAN, EDUCATING LAWYERS: PREPARATION FOR THE PROFESSION OF LAW, 52 (Jossey-Bass 2007).
[33] *Id.* at 186.
[34] Dunlosky et al., *supra* note 12, at 8-11.
[35] *Id*.
[36] The case method was invented by Christopher Columbus Langdell in 1870. A brief description and history of the method can be found in David A. Garvin, *Making the Case*, HARVARD MAGAZINE (Sept.-Oct. 2003).

generations for millennia. Indeed, study after study has shown the human mind's ability to retain content when organized in and around stories.[37] Every case that is read in the Socratic Method is organized around a case that includes a story. These stories serve both as touchstones for recalling legal principles as well as an organizational structure for elements and analysis. Mention Mrs. Palsgraf to a lawyer long after law school, and the individual is likely to immediately recall the concept of proximate cause accompanied by images of a railroad platform, exploding fireworks, and falling scales.[38]

In addition to the stories inherent in a study method organized around legal cases, the learning effectiveness of the Socratic method as used today is likely helped by another less likely characteristic: confusion. Although many assume that being straightforward is the way we should deliver content to learners, recent research suggests that a moderate amount of confusion leads to "significantly higher learning gains."[39] As many legal educators know, a moderate amount of confusion is largely what fuels the Socratic method today. Whereas Langdell eschewed the study of conflicting cases or those that departed from doctrine because he believed that they were decided wrongly, today law professors focus on those cases.[40] Before being elected to the United States Senate, Elizabeth Warren explained, "You know the difference between daylight and dark? Well, we spend all of our time [in law schools] on dawn and dusk."[41] According to Martha Minow, Dean and Jeremiah Smith, Jr., Professor of Law at Harvard Law School, when we use the case method, "We have conflicting principles and are committed to opposing values. Students have to develop some degree of comfort with ambiguity."[42] The finding that a certain amount of confusion yields higher learning outcomes is further supported by the educational research suggesting that problem-based learning, which engages students more, also leads to better learning.[43] Whether one portrays the Socratic method as elaborative interrogation, story-based, confusing, or focused on problem solving, there is educational

[37] KENDALL F. HAVEN, STORY PROOF: THE SCIENCE BEHIND THE STARTLING POWER OF STORY (Libraries Unlimited, 2007); Roger C. Schank & Robert P. Abelson, *Knowledge and Memory: the Real Story*, 8 ADVANCES IN SOCIAL COGNITION 121, 124 (2014); Kenneth D. Chestek, *Competing Stories: A Case Study of the Role of Narrative Reasoning in Judicial Decisions*, Sep. 2011, *available at* http://works.bepress.com/kenneth_chestek/3.
[38] Palsgraf v. Long Island Railroad Co., 162 N.E. 99 (N.Y. 1928).
[39] Sidney K. D'Mello, Blair Lehman, Reinhard Pekrun & Art Graesser, *Confusion Can Be Beneficial for Learning*, 29 LEARNING AND INSTRUCTION 165 (2014).
[40] Garvin, *supra* note 36.
[41] *Id.*
[42] *Id.*
[43] *See, e.g.,* Scott Freeman et al., *Active Learning Increases Student Performance in Science, Engineering, and Mathematics*, 111 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES 8410, 8412 (2014) (data collected indicate active learning increases examination performance by just under one-half a standard deviation, and that lecturing increases failure rates by 55%). *See also,* Candice Stefanou et al., *Self-Regulation and Autonomy in Problem- and Project –Based Learning Environments*, 14 ACTIVE LEARNING IN HIGHER EDUCATION 109, 112 (2013) (describing advantages of project-based learning as shown in various studies) and John E. Stinson & Richard G. Milter, *Problem-Based Learning in Business Education: Curriculum Design and Implementation Issues, in* BRINGING PROBLEM-BASED LEARNING TO HIGHER EDUCATION: THEORY AND PRACTICE 33, 40 (Luann Wilkerson & Wim H. Gijselaers eds., 1996) (noting a "paradigm shift" from "being the 'Sage on the Stage' to the 'Guide on the Side'").

research to support use of this method as leading to the gains identified in the Carnegie Study of legal education.

It is well-known that the Socratic method has had many critics starting with the Harvard Law School alumni and law school students who left in droves between 1870 and 1873, the first three years of Dean Langdell's administration when he introduced the case method.[44] The critics continue to voice their concerns today. [45] Criticisms include the use of the method in abusive and insensitive ways[46] and the fact that the approach is too narrow[47] and trains students "more for conflict than the gentler arts of reconciliation and accommodation" in the words of former Harvard President Derek Bok.[48] In light of the research documenting the shortcomings and disadvantages of the Socratic method, it is crucial that law schools employ this method selectively and with sensitivity, while avoiding the lecture at all costs—literally.

5. Let Your Students Teach.

On second thought, there is at least one person in the lecture hall who benefits greatly from lecturing: the lecturer. So if you want to be "The World's Best Law Professor," the first thing you should do is sit down and let your students go to the lectern. After all, we know that teaching generally produces the highest rate of long-term retention.[49] Unfortunately, if one

[44] Harvard Law School's enrollment dropped to 117 from 165 during that time, which prompted Boston University to open its own law school across the river. Up until that point, the preferred approach was the Dwight Method, which relied on a combination of lecture, recitation, and drill. Much of the students' "real learning" occurred after law school in actual law practice. Garvin, *supra* note 36.

[45] Benjamin V. Madison, III, *The Elephant in Law School Classrooms: Overuse of the Socratic Method as an Obstacle to Teaching Modern Law Students*, 85 U. DET. MERCY L. REV. 293, 295 (2008); Suzanne Dallimore, *The Socratic Method – More Harm than Good*, 3 J. CONTEMP. L. 177, 182 (1977). Stephen M. Bainbridge, *Reflections on Twenty Years of Law Teaching*, 56 UCLA L. REV. DISC. 13, 16 (2008).

[46] *See, e.g.*, Marina Angel, *Women in Legal Education: What It's Like to Be Part of a Perpetual First Wave or the Case of the Disappearing Women*, 61 TEMP. L. REV. 799, 810 (1988); Phyllis W. Beck & David Bums, *Anxiety and Depression in Law Students: Cognitive Intervention*, 30 J. LEGAL EDUC. 270, 286 (1979); Orin S. Kerr, *The Decline of the Socratic Method at Harvard*, 78 NEB. L. REV. 113, 118 (1999).

[47] Garvin, *supra* note 36 (citing Michael Meltsner, former visiting professor and director of the First Year Lawyering Program).

[48] Derek C. Bok, *"A Flawed System": Report to the Harvard Board of Overseers*, 85 HARVARD MAGAZINE 38, 41 (May-June 1983).

[49] The Learning Pyramid, http://www.simulations.co.uk/pyramid.htm (last visited Sep. 27, 2014). The Learning Pyramid was created by the National Training Laboratories in Bethel, Maine. The model explores how different teaching methods affect retention rates. The Learning Pyramid (alternatively referred to as the "Cone of Experience," "Cone of Learning," and several similar names) has been criticized repeatedly because the underlying research cannot be found. *See, e.g.*, James P. Lalley and Robert H. Miller, *The Learning Pyramid: Does It Point Teachers in the Right Direction?* 128:1 EDUCATION 64 (2007) and Kåre Letrud, *A Rebuttal of NTL Institute's Learning Pyramid*, 133:1 EDUCATION 117 (2012). Consequently, in every place where I cite the Learning Pyramid, which is familiar to many readers, I also cite at least one recent pedagogical study supporting the data presented. In the case of learning by teaching, s*ee* John A. Bargh & Yaacov Schul, *On the Cognitive Benefits of Teaching*, 72 JOURNAL OF EDUCATIONAL PSYCHOLOGY 593, 593 (1980) (concludes there are tangible cognitive benefits of teaching) and Logan Fiorella & Richard E. Mayer, *The Relative Benefits of Learning by Teaching and Teaching Expectancy*, 38 CONTEMPORARY EDUCATIONAL PSYCHOLOGY 281 (2013) (finds actual teaching produces greater retention than mere preparation to teach).

utilizes the lecture method to teach, it also yields the lowest level of long-term retention for those in the classroom—as low as five percent—so better than sending that student to the lectern, provide them with peer tutoring[50] and other more interactive opportunities to teach and to learn from one another by participating in both roles.[51] After all, there is considerable support for the effectiveness of collaborative learning.[52]

Opportunities to collaborate and teach during law school are not limited to peer tutoring and collaborative learning, of course. Law schools and their faculty can also identify opportunities to support students in teaching legal concepts and practice in the larger community. The most obvious of these would be through clinical courses where students teach their clients about legal rules and processes that are relevant to the client's legal needs. In addition, many law school students can also teach moot court sessions for high school or undergraduate students, or organize workshops or training sessions for the local community on topics ranging from estate planning to credit disputes to landlord/tenant law. Whether it is done for academic credit or simply as pure community service, it is critical that law schools recognize the high-retention yield of teaching and create and support opportunities for their students to find and create teaching opportunities so that they, in turn, can learn using the most effective learning method identified.

6. Practice Makes Perfect.

These practice experiences are not beneficial just because they provide teaching opportunities for law school students. Practice experiences are highly beneficial in their own right. Indeed, according to pedagogical research, practice by doing has the second-highest rate of long-term retention of any learning method (seventy-five percent).[53] In other words, those

[50] Martha D. Rekrut, *Teaching to Learn: Strategy Utilization through Peer Tutoring*, 77 HIGH SCHOOL JOURNAL 304 (1994) (finding that students who tutored their peers demonstrated higher retention after one-month delay than students who did not tutor).

[51] *Id.* DAVID A. SOUSA, HOW THE BRAIN LEARNS 100 (2011) (finding a 10% retention rate from lectures); JAMES J. DUDERSTADT, DANIEL EWELL ATKINS & DOUGLAS E. VAN HOUWELING, HIGHER EDUCATION IN THE DIGITAL AGE: TECHNOLOGY ISSUES AND STRATEGIES FOR AMERICAN COLLEGES AND UNIVERSITIES 64 (2002) (finding a 5% retention rate from lecturing); *but see* Robert L. Morgan, James E. Whorton & Cynthia Gunsalus, *A Comparison of Short Term and Long Term Retention: Lecture Combined with Discussion Versus Cooperative Learning*, 27 JOURNAL OF INSTRUCTIONAL PSYCHOLOGY 53 (2000) (a comparison of teaching techniques showed superior short-term retention in a classroom with lecture and discussion over a classroom of cooperative learning, but no difference in long-term retention). For information on the value of interactive learning, *see* ANGELA M. O'DONNELL & ALISON KING, COGNITIVE PERSPECTIVES ON PEER LEARNING (2014).

[52] CINDY E. HMELO-SILVER, THE INTERNATIONAL HANDBOOK OF COLLABORATIVE LEARNING (Routledge, 2013). Jan L. Plass et al., *The Impact of Individual, Competitive, and Collaborative Mathematics Game Play on Learning, Performance, and Motivation*, JOURNAL OF EDUCATIONAL PSYCHOLOGY (online first publication Sep. 9, 2013). David W. Johnson et al., Cooperative Learning Methods: A Meta-Analysis (2000), http://www.ccsstl.com/sites/default/files/Cooperative%20Learning%20Research%20.pdf.

[53] NATIONAL TRAINING LABORATORIES, www.ntl.org (last visited Sep. 27, 2014). *See* DUDERSTADT ET AL., *supra* note 51, at 65 (students retain 75% of information by doing); G. Hillocks, *What Works in Teaching Composition: A*

simulated-practice courses, externships, and clinics may cost more than placing 80 students in the room with a single lecturer, but they are far more likely to produce better learning outcomes for our students. Can you imagine a law school committed to designing and offering courses according to learning outcomes rather than cost input?

As law schools consider how to balance the budget and keep the lights on during the worst downturn in law school enrollment in modern history,[54] it is natural that some administrators may be tempted to conduct a casual analysis and conclude that high-enrollment courses are the answer and try to cut costs by reducing smaller experiential courses.[55] However, a familiarity with effective pedagogies and the retention yields of various methods reveals that not all courses are equal when it comes to learning outcomes. The value of courses and teaching methods should not be measured predominantly by teaching or staffing inputs, but rather by learning efficiencies, efficacies, and outcomes.[56] After all, if we hold ourselves out as educators, we owe it to our students to have a reasonable familiarity with effective educational methods and to utilize and prioritize those, rather than keep our heads in the sand and continue to offer course and curriculum designs that have been scientifically proved by study after study to be ineffective. Accepting tuition in exchange for enrollment in courses designed around learning methods that have been scientifically proved to be ineffective is unconscionable.

7. What about Reading and Rereading?

Of course, learning does not just occur within the classroom and so legal educators must also consider what and how students study outside of our presence. In legal education, we assign tens of thousands of pages of reading at a cost of thousands of dollars per student over the course of the student's law school career. These purchases contributed to a $4.4 billion law publishing industry in the United States in 2007,[57] but did it help ours students? Probably not as much as we

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Meta-Analysis of Experimental Treatment Studies, 93 AM. JOUR. OF ED. 133 (1984) (a meta-analysis finding that "environmental" learning ("guided discovery with structured activities") resulted in superior learning over lecture and teacher-led discussions).

[54] Karen Sloan, *Law School Enrollment Slump Continues,* THE NATIONAL LAW JOURNAL (July 21, 2014), http://www.nationallawjournal.com/id=1202663837843/Law-School-Enrollment-Slump-Continues#ixzz3F7E9zOQ8; Peter Schworm, *Waning Ranks at Law Schools*, BOSTON GLOBE (July 6, 2014), http://www.bostonglobe.com/metro/2014/07/05/law-school-enrollment-fails-rebound-after-recession-local-colleges-make-cuts/fR7dYqwBsrOeXPbS9ibqtN/story.html.

[55] For example, in fall 2014, Lewis & Clark Law School announced that it was closing the Lewis & Clark Legal Clinic effective January 2015 due to budget constraints. Email from Jennifer Johnson, Dean and Erskine Wood Sr. Professor or Law, to pmyles@willamette.edu, Assistant Dean for Placement, Willamette University College of Law (Sept. 3, 2014, 12:05 PST) (on file with author).

[56] *See also,* Robert D. Kuehn, *Pricing Clinical Legal Education*, 92 DENVER U. L. REV. 1 (2014) (finding that offering clinical opportunities to law school students has no net impact on tuition and concluding that offering clinical opportunities to students is determined by the law school's will to offer such opportunities to students).

[57] Michael Ginsborg, *Ending Our Conflicts of Interest to Protect Consumers of Legal Publications,* AALL SPECTRUM 28 (February 2011).

think. According to studies of learning methods, our students will remember only approximately five to ten percent of what they read.[58] You know what yields even worse results? Rereading more than once.

The Dunlosky Study included rereading as one of the ten common learning techniques it examined and concluded that rereading, especially after the second round, was a low utility learning method.[59] This finding is especially concerning in light of the fact that re-reading is such a widespread learning method.[60] In fact, a survey at one university where the average SAT score was above 1400 revealed that rereading of texts and notes was a study method used by 84 percent of students, and 55 percent of the students identified rereading as the study technique they used most often.[61] Our best and brightest can't all be wrong, can they? They are not.

Certainly, rereading does show some improved learning, but these gains are largely attributable to the second reading.[62] Moreover, the benefits are usually demonstrated in recall; it is not clear that rereading has a significant positive impact on comprehension.[63] Moreover, when the gains from rereading are compared with the gains from other learning methods, such as low-risk testing and distributed practice, it becomes clear that rereading is far less effective.[64] So why do students overuse it? Perhaps because it is easy for them to do, especially when professors do not offer them opportunities to use more effective learning methods and do not educate students about the best study methods.

Will highlighting help our students? Not one bit. Not only has highlighting proved ineffectual in multiple studies across diverse populations,[65] in the case of higher-level tasks such as those implicated in graduate education, highlighting might actually hurt performance by reducing the student's ability to make connections and draw inferences, individuating the information too much.[66] Nonetheless, it is among students' "security blankets" and should not be taken away, according to Dunlosky.[67] Rather, we need to ensure that students understand that

[58] NATIONAL TRAINING LABORATORIES, *supra* note 53. *See* SOUSA, *supra* note 51, and DUDERSTADT, ET AL., *supra* note 51.
[59] Dunlosky et al., *supra* note 12, at 29. It is worth noting that the only study that has been conducted on the effects of rereading using graduate students is J.T. Amlund, C.A.M. Kardash, and R.W. Kulhavy. *Repetitive Reading and Recall of Expository Text*, 21 READING RESEARCH QUARTERLY 49 (1986).
[60] Dunlosky et al., *supra* note 12, at 26-27.
[61] Jeffrey D. Karpicke, Andrew C. Butler, and Henry L. Roediger III, *Metacognitive Strategies in Student Learning: Do Students Practice Retrieval When They Study on Their Own?* 17 MEMORY 471, 474 (2009).
[62] Dunlosky et al., *supra* note 12, at 28.
[63] *Id.* at 28-29.
[64] *Id.* at 29.
[65] *Id.* at 18-21.
[66] Sarah E. Peterson, *The Cognitive Functions of Underlining as a Study Technique*, 31 READING RESEARCH AND INSTRUCTION 49 (1992).
[67] John Dunlosky, *Strengthening the Student Toolbox: Study Strategies to Boost Learning*, AMERICAN EDUCATOR 12, 20 (Fall 2013).

reading and highlighting are precursors to more effective learning strategies, and then support our students in being able to utilize those more effective strategies.[68]

Does it matter whether the text is on a screen rather than paper? The jury is still out. Research before 1992 suggested that individuals who read text on screens read more slowly, less accurately, and had a lower level of comprehension than when reading text on paper.[69] However, the studies conducted since then have been far less conclusive, although most still show higher gains when reading on paper, especially when the text is especially long or dense.[70] A 2003 study comparing reading media found that students who read text on screens could recall data at comparative rates to students who read the same material on paper, but demonstrated lower levels of comprehension.[71] Indeed, studies have shown that reading digital text on screens is more exhausting mentally and visually than reading on paper.[72] If you want to be the "World's Best Law Professor," these are the things that you need to be considering in the early 21st century: not just what text your students should be reading, but how the media you select may impact their learning of that text.

8. Make Them Take Notes—by Hand!

While we are taking a long hard look at those two-pound, 20th century-style casebooks, we might as well reopen the "laptops in the classroom" debate.[73] After all, as classrooms become more media-rich, students believe (and many professors agree) laptops facilitate students' ability to collaborate, extend learning through links and online activities, manipulate texts, and, of course, take more notes more quickly.[74] However, empirical study after study demonstrates that the use of laptops in the classroom has a negative impact on student learning by distracting them

[68] *Id*.
[69] Ferris Jabr, *The Reading Brain in the Digital Age: The Science of Paper Versus Screens*, SCIENTIFIC AMERICAN (April 11, 2013).
[70] *Id*.
[71] Jan M. Noyes & Kate J. Garland, *Solving the Tower of Hanoi: Does Mode of Presentation Matter?* 19 COMPUTERS HUM. BEHAV. 579 (2003)
[72] Erik Wästlund et al., *Effects of VDT and Paper Presentation on Consumption and Production of Information: Psychological and Physiological Factors*, 21 COMPUTERS HUM. BEHAV. 377 (2005).
[73] *See, e.g.*, Kristen E. Murray, *Let Them Use Laptops: Debunking the Assumptions Underlying the Debate over Laptops in the Classroom*, 36 OKLA. CITY U. L. REV. 185 (2011) and K. Yamamoto, *Banning Laptops in the Classroom: Is It Worth the Hassle?* 57 J. LEGAL EDUC. 477 (2007) (conveying professors' fear that laptops distract students from classroom discussions).
[74] Studies confirming students' belief that laptop use in the classroom benefits their educational experience include, for example, M. Barak, A. Lipson, and S. Lerman, *Wireless Laptops as Means for Promoting Active Learning in Large Lecture Halls*, 38 JOURNAL OF RESEARCH ON TECHNOLOGY IN EDUCATION 245 (2006); A. Mitra, T. Steffensmeier, *Changes in Student Attitudes and Student Computer Use in a Computer-Enriched Environment*, 32 JOURNAL OF RESEARCH ON COMPUTING IN EDUCATION 417 (2010).

from focusing on classroom tasks.[75] Moreover, students who use laptops in the classroom do not perform as well academically,[76] and are less satisfied with their educational experience.[77]

In addition, the latest educational research out of Princeton University finds that even when students are not distracted from classroom activities, the basic process of taking notes on a keyboard rather than by hand compromises a student's learning as measured by retention, comprehension, and ability to synthesize and generalize.[78] Across three separate experiments, it was clear that students who use keyboards take more notes, but learn less than students who take notes by hand.[79] This was true even when the students were instructed not to take notes verbatim. The researchers who conducted the research believe that the cognitive processes entailed in note taking by hand are different from those used on a keyboard.[80] Students who take notes by keyboard are able to type much faster and so tend to write close to what the instructor actually said, whereas students who handwrite their notes have to summarize the material, which requires a higher level of intellectual engagement than mere transcription.[81] Greater engagement heightens retention and comprehension, whereas students who are typing can transcribe a lecture while on mental "auto pilot." Indeed, the researchers found that there was an association between high-verbatim notes and low retention.[82] These results endured even with students who were given opportunities to review their notes after a moderate period (one week) between content delivery and assessment.[83]

The lessons from this latest research on note taking compels law professors committed to effective teaching techniques to approach the question of how best to integrate technology in the classroom with humility and caution. We know that when law students use laptops in class, one

[75] *See, e.g.*, R. Kay and S. Luaricella, *Exploring the Benefits and Challenges of Using Laptop Computers in Higher Education Classrooms: A Formative Analysis*, 37 CANADIAN JOURNAL OF LEARNING AND TECHNOLOGY 1 (2011); James Kraushaar and David Novak, *Examining the Affects of Student MultiTasking with Laptops During the Lecture*, 21 JOURNAL OF INFORMATION SYSTEMS EDUCATION 241 (2010); R. Skolnick and M. Puzo, *Utilization of Laptop Computers in the School of Business Classroom*, 12 ACADEMY OF EDUCATIONAL LEADERSHIP JOURNAL 1 (2008); and Jeffrey Sovern, *Law Student Laptop Use During Class for NonClass Purposes: Temptation v. Incentives*, 51 UNIV. OF LOUISVILLE LAW REVIEW 483 (2013).

[76] C.B. Fried, *In-Class Laptop Use and Its Effects on Student Learning*, 50 COMPUTERS & EDUCATION 906 (2008); M. Grace-Martin and G. Gay, *Web Browsing, Mobile Computing, and Academic Performance*, 4 EDUCATIONAL TECHNOLOGY & SOCIETY 95 (2001); Kraushaar and Novak *supra* note 75.

[77] C. Wurst, C. Smarkola, and M.A. Gaffney. *Ubiquitous Laptop Usage in Higher Education: Effects on Student Achievement, Student Satisfaction, and Constructivist Measures in Honors and Traditional Classrooms*, 51 COMPUTERS & EDUCATION 1766 (2008).

[78] Pam A. Mueller and Daniel M Oppenheimer, *The Pen Is Mightier than the Keyboard: Advantages of Longhand over Laptop Note Taking*, 25 PSYCHOLOGICAL SCIENCE 1159 (2014).

[79] *Id.*

[80] *Id.*

[81] *Id.*

[82] *Id.*

[83] *Id.*

study showed that ninety percent (90%) go online for at least five minutes, and approximately sixty percent (60%) are distracted for approximately half the class.[84] The practice is not unique to law students. A study of college students showed that when they use laptops in class, forty percent (40%) of their class time is spent using applications unrelated to their coursework.[85] Thus, decisions to block all Internet access, email, messaging, and other applications unrelated to coursework are tempting to consider in order to improve student learning outcomes.[86]

But now this latest research suggests that even such Draconian measures do not go far enough. To be the "World's Best Law Professor," it seems we may have to return to pen and paper. Where will it end? Remember that at one point in history, the invention of writing was decried by Plato as a threat to oral tradition and reliance on human memory, and Gutenberg's advances in movable type were seen by many critics as a threat to the art of handcrafted manuscripts.[87] The challenge, then, is to help our students to bridge the future without compromising their learning outcomes; but how, now that we know the data?

9. Can They at Least Brief Cases?

Shortly after a draft of this essay was posted online for feedback, a colleague from another school contacted me to ask about the utility of case briefing, especially for 1Ls. One of the most frustrating things about being a legal educator is that there is almost no quantitative pedagogical research focused specifically on legal education and our dominant teaching and learning techniques. Thus, most of the educational research cited in this essay is drawn largely from general pedagogical research on how the human mind learns with a discriminating eye favoring studies of populations of learners similar to law school students[88] or results that endure across varying populations of learners.[89]

Although I found no studies examining the effects of case briefing specifically, summarization is a technique that was examined in the Dunlosky meta-analysis.[90] The researchers ranked summarization as a low utility study method because in order for it to be effective, the learner must be skilled at summarizing and most people are not.[91] Thus, if law

[84] Sovern *supra* note 75.
[85] Kraushaar and Novak *supra* note 75.
[86] Cindi May, *A Learning Secret: Don't Take Notes with a Laptop*, SCIENTIFIC AMERICAN (Jun. 3, 2014).
[87] Christine L. Borgman, FROM GUTENBERG TO THE GLOBAL INFORMATION INFRASTRUCTURE: ACCESS TO INFORMATION IN THE NETWORKED WORLD 82 (2003).
[88] *See*, *e.g.*, the spaced education studies conducted of medical students by Kerfoot, *supra* note 14.
[89] *See*, *e.g.*, the high utility methods identified by Dunlosky et al., *supra* note 12.
[90] *Id*. at 14.
[91] *Id*. at 18. Dunlosky et al. note that summarization is a more feasible learning method for undergraduates and other more advanced learners who already know how to summarize, but case summaries have some unique characteristics that would justify further specialized training for law students to ensure that the learning technique is effective.

schools are going to encourage law students to use this technique, they should provide robust training to their students on how to summarize or brief cases.

The Dunlosky meta-analysis also rated summarization low utility because it does not show retention and comprehension across tasks.[92] For example, some studies suggest that summarizing helps performance with a generative test (such as an essay exam like we historically have administered in legal education), but not with a recognition test such as multiple choice.[93] The one study that did involve high-stakes testing, such as we use in legal education, showed no benefit from summarization, but that was a multiple choice exam.[94] In short, summarization will most likely help if students know how to do it well and if the assessment is generative rather than focused on evaluation and synthesis (in fact, some studies have shown a worse performance among students who used summarization as a study technique for assessments that include evaluative questions and those that involve synthesis of content).[95] Overall, Dunlosky et al. concluded that summarizing was a more effective learning technique than rereading, about comparable to taking notes, but less effective than other study techniques such as self-questioning or generating explanations.[96]

In response to my summary of Dunlosky's findings on summarization as a learning technique, the colleague who inquired about this study method shared his own qualitative experience using case summaries, and his perception that case summaries are probably more useful and efficient in the first few weeks of law school than later in a law students' career. Although I do not disagree with his perception, the fact is that neither he nor I have any quantitative research to support our qualitative experiences and perceptions—and this is a significant failing in legal education today. Too little time and energy has been devoted to supporting, conducting, and studying quantitative research on how law school students learn best. Law schools have been teaching students in the United States for over two hundred years. We have had more than enough time to study how best to teach our students using the most effective and efficient methods. Where is the body of pedagogical research reflecting the last 236 years of teaching experience in America's law schools? How can we be the best if we don't even know what works best?

Becoming the best requires us to reprioritize our research endeavors and create value around quantitative educational research focused specifically on law school students. We need to collaborate with our colleagues in schools of education, educational psychologists, and others to design and conduct studies to determine what works best for our population of learners. And

[92] *Id*. at 17.
[93] *Id*.
[94] *Id*.
[95] *Id*.
[96] *Id*. at 18.

once we identify those high utility methods beyond those highlighted in this essay, we have to then partner not just with one another within and across law schools, but with software programmers, textbook publishers, building designers, and others to develop the curriculum, resources, and experiences that our students need to learn as efficiently and effectively as possible.

10. Be There.

Finally, anyone who aspires to the "World's Best Law Professor" must be mindful of the voluminous data that continue to show the importance of the professor as a human mentor and teacher to her students.[97] In the 21st century, it is natural for educators to become excited by the myriad technological resources that are available to support our classrooms and our students. It is also understandable that we want to apply the research we are rapidly learning about the most effective teaching and study methods. But in the midst of our increasing knowledge and abilities, we must not lose sight of the fact that our students are human and so are we. Those human interactions—teacher to student—have a profound impact on our students' learning experiences.[98] Whereas computers and learning apps and the Internet can extend and enhance our teaching and our courses and help us to individualize our students' education and monitor their progress, they cannot replace the human presence and intelligence and emotion that we bring to the educational process.[99]

Whether one looks at the number of contact hours between faculty and students[100] or the promptness with which professors respond to student emails,[101] we know that the relationships that professors develop with their students matter not just during class or even school, but across a lifetime. Students who have "a professor who care[s] about them as a person, ma[kes] them excited to learn, and encourage[s] them to pursue their dreams" are more than twice as likely to be engaged at work after they graduate, and to be far more likely to thrive in all aspects of their well-being after graduation, than those who did not.[102] So, if you want to be the "World's Best

[97] Paul D. Umbach & Matthew Wawrzynski, *Faculty Do Matter: The Role of College Faculty in Student Learning and Engagement*, 46 RESEARCH IN HIGHER EDUCATION 153, 153-184 (2005).
[98] Guadalupe Anaya & Darnell Cole, *Latina/o Student Achievement: Exploring the Influence of Student-Faculty Interactions on College Grades*, 42 J. OF COLLEGE STUDENT DEVELOPMENT 3, 12 (2001).
[99] LACY N. KARPILO, ENGINEERING STUDENTS' AND FACULTY PERCEPTIONS OF TEACHING METHODS AND THE LEVEL OF FACULTY INVOLVEMENT THAT PROMOTES ACADEMIC SUCCESS (ProQuest 2008).
[100] Mario Guerrero & Alice B. Rod, *Engaging in Office Hours: A Study of Student-Faculty Interaction and Academic Performance*, 9 J. OF POLITICAL SCIENCE EDU. 403 (2013) (finding that teacher office hours have a substantial effect on student academic performance).
[101] MICHAEL HUNTER SCHWARTZ ET AL., *supra* note 2.
[102] GREAT JOBS GREAT LIVES. THE 2014 GALLUP-PURDUE INDEX REPORT: A STUDY OF MORE THAN 30,000 COLLEGE GRADUATES ACROSS THE U.S. (2014). It is interesting to note that students who have externships or applied learning opportunities (such as jobs or clinics) during school, are active in extracurricular activities, and worked on projects across one or more semesters are also twice as likely to be engaged at work after graduation than those who do not have these experiences.

Law Professor," take the time to get to know your students, care about and encourage them, and share your own excitement about what you are teaching.

Conclusion

Every day we come to campus, we each have a choice. Do we want to strive to be the best law professor possible, or are we willing to risk being the worst? If you want to be the worst, then your path is an easy one. Don't let your students teach or practice. Lecture a lot. Don't make time for them. Let your students surf the Internet during class and take notes on their laptops. Give them text-heavy reading assignments, a bag of highlighters, and encourage them to re-read their text and their verbatim notes while cramming for a high-risk exam at the end of your course. Pretend that you are being rigorous and preparing them for the "real world" of law.

But if you want to be the "World's Best Law Professor," it is going to require a lot more thought and a lot more heart. You will need to rethink your teaching methods, your students' study methods, even your law school's curriculum. You will have to figure out how best to harness the latest technologies to support frequent low-risk testing for your students and individualized content delivery at ideal intervals across time while interleaving subjects in meaningful and intentional ways. You will need to identify and create opportunities for your students to teach, collaborate, solve problems, and apply what they are learning through practice. All the while, you will need to maintain personal and enthusiastic teaching and mentoring relationships with your students if you want to have a positive, life-long impact on them.

But perhaps you do not want either. Perhaps what is driving you to read this essay and consider the latest educational research is not your desire to be the "World's Best Law Professor," but rather, your commitment to help your students to do *their* best. If this drive, coupled with a humbling awareness of your own inadequacies and failings, is motivating you to read and learn and grow as a teacher by learning as much as you can about how best to help others learn, then you already know that learning to be the best does not start with us. It starts with our students. It is only when our focus is on helping our students to do their best, that we, in turn, can become better, and maybe one day, our very best.

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Innovations in University Education in Innovation: Moving Beyond the B.S.

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Abstract
This article focuses on university education in innovation. We examine and present a novel system we have developed that is achieving our vision of instantiating a robust education that teaches, develops, and grades innovation in the education system. This paper is discussing a paradigm shift, offering new degrees with a common core focused on innovation, with teams of students learning and practicing the key elements of the innovation process. First we examine the motivation and need for a radically new approach, not a new major or a course, that is based upon a new common core and family of degrees. We describe how we knew that to effectively reach our goals the program had to span across departments, college boundaries, and beyond the very core of the university. Second, we show how in doing so we created a family of degrees that moved us beyond the centuries-old B.S. and B.A. educational constraints with a new, innovative "Bachelor of Innovation™" (B.I.) family of degrees that includes a core built around multi-disciplinary multi-year innovation partnering with real companies. Lastly we summarize the unique aspects of the program and the rationale behind them, from the 3-year multi-disciplinary team experience to the trademarked name. We present our B.I. program as its own case study in innovation within higher education, reviewing the key challenges we faced so that other innovative institutions and departments may learn from our experience. We conclude with lessons learned and the future of the B.I. family of degrees.

1 BACKGROUND AND INTRODUCTION

The Need

Innovation is at the core of modern economic growth. Executives and companies across the world are seeking new means to improve their innovation efficiency, and seminars and short programs for teaching and coaching innovation abound. The need to produce new innovative approaches to procure a new generation of innovators exists at both the national and international levels. Yet, as we started the 21st century, if one sought a fundamental degree program focused on innovation, one would find a few graduate courses and virtually nothing at the undergraduate level.

R. Florida[1] and others have argued the most significant output for an education or innovation system is knowledgeable workers who have the know-how to innovate, not any particular technologies to be transferred. The National Academy of Engineering report on "Educating the Engineer of 2020"[2] concludes:

> "If the United States is to maintain its economic leadership and be able to sustain its share of high technology jobs, it must prepare for this wave of change. While there is no consensus at this stage, it is agreed that innovation is the key and engineering is essential to this task; but engineering will only contribute to success if it is able to continue to adapt to new trends and provide education to the next generation of students so as to arm them with the tools needed for the world as it will be, not as it is today."

[1]Florida, R . . "The Role of the University: Leveraging Talent, Not Technology", Issues in Science and Technology, Summer 199

[2]National Academy of Engineering. 2004. *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: National Academies Press. Page 5.

Furthermore, it also reports[3]:

> "an undercurrent of awareness that current complexities are so daunting that tinkering at the edges — reforming one course, one program, one department at a time, developing isolated instances of success here and there – is no longer a viable response if we are to build the kind of robust programs in research and education now needed to strengthen the U.S. engineering community by 2020."

The need for a dramatic reform in education to focus on innovation is not something we are *claiming*. Rather, it is a nationally recognized need, which took us years to address. This article presents; 1) the content of the nation's first undergraduate program with a core in innovation, and 2) a case study illustrating in detail how we navigated the University hierarchical system of boundaries protecting the BA and BS degrees to achieve a unanimous and comprehensive acceptance of the B.I. family of degrees.

The comprehensive nature of the Bachelor of Innovation™ is directly in line with national reports and recommendations, taking a bold step rather than minor variations in majors. The Bachelor of Innovation™ (B.I.) is a unique multi-disciplinary program at the University of Colorado at Colorado Springs (UCCS). The B.I. is a family structure, much like a bachelor of science (B.S.) or a bachelor of arts (B.A.), in which particular majors are defined.

In terms of innovation, we sought, achieved and continue to provide a robust and disruptive innovation, rather than a small incremental innovation. As is often the case with industry innovation, the disruptive innovation creates a profound, rapid transformation when there exists a status quo that dominates the landscape. Even if we could have achieved the same results within an existing degree with incremental innovations over time, we would have encountered the same problem facing education in general and science, technology, engineering, and mathematics (STEM) education in particular: the speed of the marketplace and its rapidly changing landscape make baby steps irrelevant as soon as they are implemented. It was clear that a huge, robust and profound change was essential. As is often the case with disruptive innovation, we had to be willing to make a bold move and step into uncharted territory, guided by a vision of where we were going.

Defining Innovation

The term *innovation* bears different meanings to different people. The first issue in defining an innovation curriculum is therefore to clarify what innovation itself really means. Innovation is not creativity, though creativity can be an element of it. Innovation is also more than just invention or novel research, because it leads to specific outcomes.

As Ray Mears of 3M has said in multiple talks, "*Research is the transformation of money into knowledge – Innovation is the transformation of knowledge into money!"* With these two major misconceptions cleared up, we are ready for formal definitions.

Peter Drucker [4] offers the definition

> "Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced. Entrepreneurs need to search purposefully for the sources of innovation, the changes and their symptoms that indicate opportunities for successful innovation. And they need to know and apply the principles of successful innovation."

Clearly, Drucker considers innovation as a teachable subject, but his definition proved too focused on entrepreneurship to convince faculty outside of a business college to accept.

A broader formal definition from West & Farr (1990)[5] states that innovation is:

> "the sequence of activities by which a new element is introduced into a social unit with the intention of benefiting the unit, some part of it or the wider society".

In the end we took the essence of these definitions and put them in a form we hoped people would remember. We offer this crisp definition:

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[3]Ibid, Page 13

[4]Drucker, Peter "Innovation and Entrepreneurship" Harper and Row, 1985

[5]West, M.A. & Farr, J.L. 1990. Innovation and creativity at work: Psychological and organizational strategies, New York: Wiley.

INNOVATION IS THE TRANSFORMATION OF IDEAS INTO IMPACT.

Further, we view innovation broadly and consider it to be *the* central element of education for our century. Innovation is an educational attitude, a state of mind, and a creative process, as much as a specific task or action. It is not just knowledge; it has aspects of skill and art. Like almost any team sport, innovation is something to be practiced, and thus learning by doing is at the core of our program.

Effective innovation is more than just changing organizations; it is also a personal transformation: "Once you've worked on a truly innovative project you realize how important transformation is to the success or failure of a project. Your way of thinking changes, your priorities change, your company changes and your way of working changes forever. True innovation is not just about changing a product, a service or even a marketplace; it's also about recognizing and relishing the need to change yourself." [6] When one thinks about the general goals of education and life-long learning, this view of innovation is central. We cannot teach students all the *things* they need to know, but if we can empower them to learn to learn, and to relish the ever-increasing changes that will face them, then we truly have educated our students.

In business, an expected source of innovation typically streams from relatively new companies. Unfortunately, many experts in the field believe that once a small, innovative company becomes big, it becomes a non-innovative large corporate bureaucracy[7,8]. Ironically, however, people still look to old established research universities when it comes to innovation. Many among the academe, and even the government and public, mistakenly consider research universities cornerstones of innovation, even though innovation is more likely to exist in the smaller institutions. Top research universities produce and teach knowledge and research, not innovation. With a few noted exceptions such as Stanford and MIT, most universities talk about innovation as if it were a sideline technology transfer activity, and when innovations spring forth from such universities, it is usually because there is a concentration of the innovation raw materials — an abundant diversity of ideas, talent and natural innovators. Even then, the innovations build on university research, not university programs. Innovation often happens in spite of the university's educational programs, not because of them.

Looking deeper one sees that despite the research output, universities are typically the antitheses of models of innovation: they cling to a centuries-old model of how to operate and what "products" to offer. In their world, a "new product" takes 1-2 years to plan, 4-6 years to produce and 2-5 more for market assessment after release, so change presents serious investment and risk. Academic processes and products change more slowly than the ivy growing over their buildings, which is diametrically opposed to the pace at which society is changing.

It therefore comes as no surprise to find that top universities and established businesses are often unwilling to take significant risks.[9] As one administrator at a top 40 school said, as he rejected a plan for truly integrated business and engineering program, "why should we risk a radical change, we've been doing it this way for over 100 years and are doing well." This attitude is an academic example of innovation blindness[10] by a market leader.

The change needed to introduce innovation into education is further hampered by the deep silos within universities, where hyper-specialized experts spend decades building their reputations and the resources to pursue their research, generally without any regard to issues like profit or direct impact. And none of them want their areas to be removed or reduced from an existing degree. This begs the questions: "How can one add in serious work on innovation? What would be removed? How does one get the needed multi-disciplinary nature, with faculty whose skills don't usually include transiting from research to innovation?" With tenure, academic freedom and faculty governance as the norms, it's a very difficult environment for actual innovation to emerge.

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[6]Ralph Ardill oral presentation at the London Innovation Conference, 2003. Slides were online at one time, but no longer available. See also Jim Brown, "Lifting The Barriers To Innovation, A Practical View From The Trenches", in "IT innovation for adaptability and competitiveness : *IFIP TC8/WG8.6 seventh Working Conference on IT Innovation for Adaptability and Competitiveness*, May 30-June 2, 2004, Leixlip, Ireland"

[7]Afuah A.N., Bahram N. The hypercube of innovation (1995) *Research Policy*, 24 (1), pp. 51-76.

[8]Franklin M. Fisher ·The IBM and Microsoft Cases: What's the Difference? *The American Economic Review*, Vol. 90, No. 2, Papers and Proceedings of the One Hundred Twelfth Annual Meeting of the American Economic Association (May, 2000), pp. 180-183)

[9]Zoltan J. Acs and David B. Audretsch, Innovation in Large and Small Firms: An Empirical Analysis, *The American Economic Review*, Vol. 78, No. 4 (Sep., 1988), pp. 678-690

[10]Scott Jenson , "The simplicity shift: innovative design tactics in a corporate world", Chapter 9

Our problem, therefore, was determining how to introduce innovation into one of the most conservative forms of business, the university, to allow a new approach to undergraduate education, which includes substantial amounts of material on, and practice in, innovation.

2 "TEACHING" INNOVATION

It's not difficult to imagine introducing a course on innovation, but as has been well shown in innovation research, sustainable innovation needs a culture, and this cannot be created through a single course offering. The current educational BS and BA models yield students with knowledge, and we could consider adding some innovation theory and process to this curriculum. But how this would produce a culture with experience in the full innovation process is not at all clear.

A few graduate programs and isolated seminars on innovation could be a start, but what is really needed is an approach that develops and sustains an innovation culture wherein we can transform not just a few students, but many, into a next generation of innovators. Further, within a comprehensive innovation curriculum a key issue would remain: *how can we expect to develop innovators if we don't provide them experiences where they see, even once, the innovation process as it happens?* The need is self-evident: we need an innovation in the teaching of innovation.

Because innovation is not discipline specific, and is often multi-disciplinary or inter-disciplinary, innovation education needs to cross and combine fields. Because innovation is more than knowledge, learning by doing is a major emphasis.

Innovation, it's a team thing!

As we discuss our program, one of the most pressing questions is "can we really teach innovation?" The underlying question is really, "Can we teach students who are not necessarily geniuses how to be innovative?"

Our answer has been by analogy, to ask back in response, "Can one really teach another person to ride a bike, play an instrument, or play just about any sport?" And it becomes clear that one can teach people some basic principles, and show them examples, and then their efforts must be based on practice, coaching, practice, coaching, and practice, practice, practice. With a good coach providing useful feedback, most people can improve their abilities and become much more proficient.

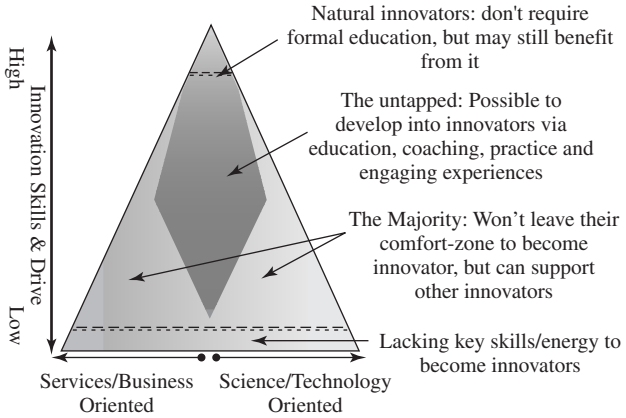


Figure 1. The space of natural and possible innovators

We describe the space of natural and possible innovators[11], shown in Figure 1. For natural or born innovators, innovation seems to come easily, but naturals are few and far between. And even for a natural, living up to their potential takes work.

Our B.I. program is focused on the large body of students with sufficient abilities, skill, and drive, who have the potential to become innovators. There are far more of these potential and untapped innovators than there are "naturals," and we have demonstrated that when we engage and coach them, we improve their spirit of innovation, as well as their capabilities. With the right experiences, practice, and coaching, untapped innovation talent can indeed be developed.

[11] Adapted from N. Maeda, "Japanese Society and Entrepreneur Development", Kochi University Graduate Program in Entrepreneur Engineering, Presented at Research Institute of Economy, Trade and Industry(RIETI) Policy Symp., 2/12/2003. from http://www.rieti.go.jp/en/events/03021201/report.html

In our view, even if members of the larger non-natural or innovation majority do not rise to the pinnacles of innovation leadership, they have an important role to play in overall innovation, for in following Edison's famed dictum that "Genius is 1 percent inspiration and 99 percent perspiration," one effective innovator can help lead a team of others who understand the basics of innovation to form an overall "winning" team. By way of analogy, one does not have to be team captain to be a valued team member, to enjoy the game and the victory.

One of our program tag lines is that "innovation is a team sport," and we refer to classes as team practice. This metaphorical approach also helps in recruiting. While many students are excited by the prospect of the B.I., some potential students lack the interest or confidence to want to "risk" pursuing innovation. We ask how many of them were naturals at the sports or music they now enjoy, and point out that after years of practice and coaching, only now are they good at these activities. However, we have also found that when we explain that people tend to enjoy what they are good at, with the sports/music analogy, they begin to see that maybe with practice they may become good at, and enjoy innovation. Most parents, however, understand the value of the B.I. right away, and we have received a lot of very positive feedback from parents.

For the B.I. program, the team/sports analogy runs deeper. The UCCS B.I. faculty are the innovation coaches, and even in our email aliases we use the coach title, as in "inov201-coaches@uccs.edu". Most innovation courses are team-taught, bringing together coaches with different skill sets, and allowing for more small-group coaching. We are also raising funds for Innovation Team scholarships, which are not merit or needs-based funding for attending school, but athletic-like scholarships which fund participants for practicing and for playing. It is pay to perform, which in our case, is to perform on real projects for real customers.

The teaming, and the learning by doing, is at the very core of the B.I. model, with a longitudinal sequence of Innovation Teams courses. We need students to see innovation, to experience it, and to do it. The students take 6 terms (3 years) of team classes, with many students working, for pay, on those teams outside of the required class component. These teams are generally working for an external customer. Some customers act more like mentors, working closely with the students on their desired innovation and guiding them through the process. Others act like the paying customers they are, and expect results with little guidance as to how to achieve them.

With multiple startups involved, and a wide range of customers and outcomes, during the 6 terms students experience innovation working and see innovation setbacks, redirection and failure. Managing these teams is the single most challenging part of offering the B.I. program, and it requires faculty with a very broad range of skills and a lot of time and patience. However, there is no substitute for experience, either for the students or for the faculty.

Not only do the B.I. students get to see innovation in action, they gain a wide range of experience in soft skills in dealing with customers and projects. Students are routinely faced with, and must learn to effectively address, ambiguity, uncertainty and customers or other points of interaction, who don't get back to the team with information or direction the team wants.

Team members have to learn to clearly communicate status and needs to clients, make assumptions with partial information, make suggestions on direction, and still make progress on their projects. They get to learn, first hand, that customers don't always know what they want, let alone how to do it. Inevitably, most also learn painful lessons about scheduling, management, and dealing with ineffective and non-productive team members.

It's a surprise the first time they lose points for doing another student's work, and realize they have to help the other person advance, and not just step over or side-step them. Even the best students get critical life lessons when things happen beyond their control and outside their meticulous plans. For example, we had a customer whose business division, including the direct point-of-contact, was down-sized/outsourced. In an instant, the team went from an exemplary, on-track project with a happy customer, to trying figure out how to try to salvage the project. Within hours they were working on one proposal to the original company, and a very different pitch to the point of contact who was now scrambling to form his own company.

One might read about something like that in a "case-study", but it is quite different when it happens to you or one of your friends, and you have to compose the response/proposal to the different parties involved. Innovation does not always follow one's plans, and the team classes provide an environment to learn that as well as to hone the skills of adaptation with a bit more support network and mentorship.

The case against teaching critical thinking

A common suggestion raised by faculty as we designed and launched our B.I. at UCCS was a push to include "critical thinking" as part of the program, but we chose instead to focus on creative problem solving and innovation team thinking. Critical thinking has many definitions, with two common ones being similar to "critical thinking is reasonable reflective thinking focused on deciding what to believe or do"[12] and "the art of thinking about your thinking while you are thinking in order to make your thinking better: more clear, more accurate, or more defensible."[13]

Our view is that "critical thinking" is put forth as an important skill by those in fields that don't actually address real problems, to suggest their courses have important value. Not surprisingly, a touted Delphi study on critical thinking[14] drew from a majority of philosophers (52%) while only 6% of those involved were from physical sciences.

People in fields that do solve problems (and drive innovation), however, concentrate on creative thinking, problem-solving skills and team work, which may explain why the Accreditation Board for Engineering and Technology (ABET) does not include "critical thinking" as an objective. Undoubtedly, thinking clearly is important, and there are valuable skills espoused by proponents of critical thinking. But we have found that the key skills include "the art of asking essential questions, detecting bias in information sources, ethical and logical reasoning," and they can more naturally be included as part of problem solving, creative thinking, and innovation team exercises.

Essentially, we do not teach critical thinking, we teach students to learn to value and accept diverse viewpoints, different rationales and arguments, different sets of fundamental values, and we insist that students learn to think creatively to find solutions in context, not in abstraction: *this* is innovation.

3 THE BACHELOR OF INNOVATION FAMILY STRUCTURE

The Bachelor of Innovation (B.I.) is a family structure, much like a bachelor of science (BS) or a bachelor of arts (BA), in which particular majors are defined. The B.I. is a unique multi-disciplinary undergraduate program initially supported by the College of Engineering and Applied Science (EAS) and College of Business (COB) at the University of Colorado at Colorado Springs (UCCS). The initial majors include (in alphabetical order) *B.I. in Business Administration, B.I. in Computer Science, B.I. in Computer Security, B.I. in Electrical Engineering, and the B.I. in Game Design and Development*. Each member of the family comprises an emphasis or major, an innovation core, a cross-discipline core, and the general education requirements.

We designed the B.I. family of degrees to be consistent with ABET and AACSB accreditation guidelines. The B.I. in Business Administration is offered by the College of Business, which is AACSB accredited, and we expect to seek formal ABET accreditation after we graduate our first class of students in the engineering-related majors.

Similar to how general education or common requirements are included in the BA or BS, the B.I. does not specify the content of a major. Rather the B.I. specifies the common elements for a family of degrees, where specialization areas define the details of their major. The goal of this family is to define the common cores, leaving the disciplines to define the majors. The B.I. Program has four significant "components" in each degree, as shown in the diagram.

The **Innovation Core** is 27 Credits, geared toward innovation and entrepreneurship. The program starts with a course in entrepreneurship in which each student pitches twice in the first term. The program also includes an entrepreneurship course in the senior year, building on the 3 years of experience to make it a true capstone experience.

The first course in the B.I., first semester freshman year, is introduction to entrepreneurship. Students work in teams to develop, vet and pitch their ideas. The first pitch is to community members and angels who provide a dose of reality. Based on the pitch, some of the teams (historically 30%-50%) are "defunded" and instructed to form new teams with new ideas. Teams can also defund themselves (and they earn more

[12] "A Taxonomy of Critical Thinking Abilities and Dispositions," in Teaching for Thinking: Theory and Practice, ed. Joan B. Baron and Robert J. Sternberg (New York: W. H. Freeman, 1987), 10. Also "A Streamlined Conception of Critical Thinking," Teaching Philosophy, 14 no. 1 (1991), 6.

[13] Paul, R. (1995). Critical Thinking: How to Prepare Students for a Rapidly Changing World. Dillon Beach, CA.: Foundation For Critical Thinking, Appendix B, pp. 521-552.

[14] Facione, P.A. (1990). Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Executive Summary "The Delphi Report". Millbrae, CA: California Academic Press.

Bachelor of Innovation™ program family structure

Degree/Major Emphasis (42-50 credits)	**Innovation Core** (27 Credits)
Differs for each degree, but almost the same as existing BS majors so that we can simplify seeking ABET/AACSB accreditation.	Shared across all BI majors with a 3 year multi-disciplinary shared team experience
BI in Game Design and Development is a totally new major	**Cross-discipline Core** 15 Credits (Choice from 1-3 cores)
General education courses (28-40 credits) to meet requirements of the appropriate college.	

credit if their decisions match the external consensus view). The students continue to develop their work, and by the end of the term each team presents a revised new pitch and a 15-25 page formal business plan that includes the idea, the team, the financial projections, and the marketing/sales plan. Community members have repeatedly been astonished at the quality of both ideas and the presentations.

Part of the goal of the class is to get students engaged in multi-disciplinary teaming, where no single student knows enough or has enough time to pull complete the requisite work alone in the given time frame. Part of the goal is for them to see how much more they have to learn, which encourages them to then take appropriate courses and electives, and take them seriously. If this first course is too much work, which it is for some, then it suggests that they are probably not ready to head down the innovation/entrepreneurship path.

At the center of the innovation core are additional multi-disciplinary, long-term team activities during the sophomore, junior and senior years. Teams are expected to include students from all years, possibly including graduate students, occasionally freshman and even high school students, with a long-term goal of virtualized teams with international team members. The teams have dynamic membership and the roles of team members will change on a regular basis.

Examples of these multi-disciplinary projects include development of video games used in teaching science to elementary school students and training for computer security; assistance in the development of a book on the innovation process; and the use of Web-based tools to improve Internet marketing and advertising for small businesses.

In some of these projects, student teams collaborated with entrepreneurs to apply for and win competitive grant funding for their innovations. In these projects, teams were required to understand the business, as well as technical issues associated with the project objectives, and to formally manage the project and interact with the customers, the client companies.

The innovation core also includes a freshman course on innovation processes, covering both theory and practice. We include topics on creativity, ideation, team-building, sustaining or permanent innovation, understanding and managing change. We also conduct multiple self-assessments of the abilities and interests of students, including discussions on the Myers-Briggs Type Inventory (MBTI) personality test, temperament, and other personality traits. One of the challenges here is finding materials that do not presuppose business experience to explain what businesses do, because most freshmen don't have much business experience.

We supplement the readings with a lot of in-class exercises. For example, consultants from Value Innovations Inc[15] have helped students turn value innovation abstractions[16] into a ten step process they can follow and use, with an in-class exercise where they move it from theory to practice. We have partnered with Value Innovation on multiple dimensions, helping them with a book on innovation and multiple proposals, including a successful NSF award to develop a commercial innovation teaching toolkit.

[15] www.valueinnovaitons.com

[16] W. Chan Kim, Ren'ee Mauborgne, "Blue Ocean Strategy"

Along with innovation comes the issue of intellectual property. Typically, schools offer a business law course or two, but with innovation there is a need to teach students how to protect their ideas. It is important for students to understand what intellectual property consists of, and we recognize that all the innovation we teach in the B.I. will come to naught if we negligently exclude comprehensive knowledge on how to write a patent, litigate intellectual property, and settle or formulate licensing processes.

Clearly the basic principles of business law are therefore essential, and so this is exactly what we do; we first teach the principles of court systems, torts, licensing and a little criminal law, as well as corporations, LLCs, C and S corps, and we also introduce intellectual property in the context of formulating business architectures to suit one form of business enterprise compared to another. After the mid-term examination, the students write a patent, write its claims, and then hypothesize various litigation processes and innovative means to prevent litigation. Students also explore how to pursue licensing agreements with adversaries to effectively make them partners. While we do not teach students how to be their own lawyers, we do prepare them to seamlessly interact with lawyers when necessary, and how to have control over a lawyer instead of vice versa.

We also introduce students to typical business budgets, with a focus on how resources should be spent on R&D. We run scenarios where R&D is low and high, and in their exams we require them to empirically formulate for hypothetical businesses the optimum R&D investment.

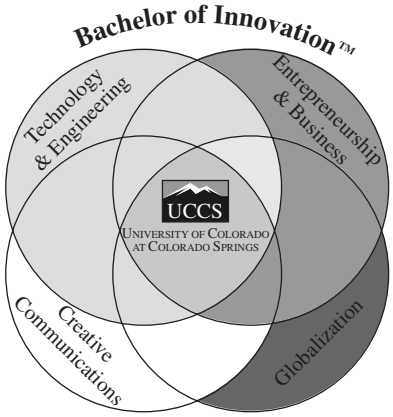
The remaining required course is a junior level technical writing course in an engineering program, but we put it in the sophomore year so more additional topics can be built on it. We also add a major component focused on team writing, proposal preparation, presentations and most importantly, persuading an audience to view their innovation from their point of view. We train them how to write proposals, such as a Small Business Innovation Research proposal. Additionally, we teach them to deliver an exuberant, animated, beautiful, and provocative monologue explaining why their idea, their innovation is the greatest thing to hit planet Earth since the wheel.

To teach argument and logic, we insist that hunting advocates advocate to a school board why guns should be banned, or ask conservatives to deliver a provocative speech explaining why we should teach Muslim-related courses at schools, or have liberal pacifists convince an audience that corporal punishment should be reinstated. We push students to deliver provocative speeches on issues they do not inherently believe in so that when it comes time to deliver their own innovative presentation, they consider it to be a "no-brainer."

The course is co-taught by B.I. Faculty that together have 2 PhDs, one JD in Law with years of intellectual property litigation, experience in three startup companies, and dozens of successful proposals that received more than $20 million in funding. Most importantly, these coaches have spent their lives successfully convincing investors, reviewers, funding agency and judges.

Beyond the innovation core, we structured the majority of the remaining electives to further support innovation, giving each student a secondary study area in which they know at least enough to partner effectively with others who are specialized in that area.

Each **Cross-discipline core** is a coherent collection of 15 credits from a key innovation supporting area other than the students major.[17] The goal is to provide experience and knowledge in a secondary area needed for innovation, providing enough skills and experience to enhance their ability to work



[17]In the first 2 years we required 21 credits in the cross disciplinary cores, but reduced it to 15 to better support the issues of transfer students from other schools/majors and to provide more electives for students to explore areas.

with others on an innovation team. Like cross training in sports, we don't expect students to master this area. Instead, it will strengthen and improve their abilities to work well with others in the secondary field. The initial cross-discipline cores are:

The Technology Core (for non-technology degrees) provides a broad coverage of engineering and technology using existing courses in engineering and computing.

The Business Core (for non-business degrees) provides a broad coverage of business topics based on the core business courses of accounting, marketing, management, and finance.

The Globalization Core (for any B.I. major) provides a selection of courses on international issues. It requires a foreign language at the second year level, and a collection of international business and policy courses. Students must demonstrate at least a three-month residence in a non-English speaking country, and one semester of study abroad will be facilitated and is strongly encouraged. While abroad, involvements in the Innovation team projects will be "virtual," but will be required.

The Creative Communication Core (for any B.I. major) will provide coverage of a variety of communication mechanisms including both traditional (e.g., oral communication) and non-traditional (e.g., visual arts) communication approaches.

When introducing a new degree we must also consider what will happen when graduates approach employers who are not yet familiar with the program. If the degrees were named by modifying the name of the major, rather than the family, e.g. like a BS in Electronic Innovations, the employers, and especially the human resource departments, might have a harder time understanding the capabilities of these students and what they have learned. Human resource offices in companies that advertise for students with, say, a Bachelor in Electrical Engineering, might dismiss them as unqualified without looking deeper. The B.I. designation allows the students, when they apply, to honestly say they have a "Bachelor in Electrical Engineering." Since the degrees are in general quite comparable to the BS degrees in their related areas, this naming allows companies to see it for what it is, a variation on the underlying background while still retaining the core of the major, which is generally the first consideration when hiring.

In the long term, innovation requires standards, and to ensure the B.I. is recognized as a high quality degree, we are seeking to service mark the name. Protecting an innovation through intellectual property protection, like trademarks, is part of the innovation process, and we use it as an example in our program. As we began advertising and marketing, the uniqueness of the name initially has students, parents and companies asking what it is all about, and the trademark helps assure that it will not be confused with programs from competitors.

Some might ask that if we are trying to transform education in a larger way and address a national need, why we would trademark the name and restrict its use. Our trademark does not mean that no one else can use it; it means we decide who can and cannot use it. Our goal is to ensure the name has a consistent meaning, that all such programs incorporate the core elements and significant learning by doing, and set the appropriate standards of quality. We have already begun discussions with other universities interested in starting their own B.I. programs.

4 PROCESS AND CHALLENGES

The barriers to our innovation were the long product cycles in academia, and the ultra-conservative and territorial model of universities, combined with the faculty's sense of superiority and resistance to change. So how did we successfully achieve the Bachelor of Innovation family of degrees? The answer, not surprisingly, was that we looked at the proven innovation processes we would be teaching, and adapted and applied them to the university.[18] In moving the overall B.I. program forward, here were our top dozen concerns and the steps we took, followed by some discussion on adaptability.

1. First, we had to find a place where the culture was partially willing to embrace change and innovation. Innovation needs the culture to grow, and changing academic culture is difficult. Unlike a corporation, where the CEO can champion change and exert some control, academics often resist change. Program leader Dr. Boult moved from the Ivy League where he had an endowed department chair at a top 40 university, to a young aggressive growth university (UCCS), which offered a core quality and talent in engineering and business, and with the potential for accepting change.
2. We began in "stealth mode" to avoid early derailment by detractors. We quietly laid the groundwork for the change, introducing key elements of the B.I. design as small changes, one-off

[18]T. E. Boult and J. Haefner "Beyond The Bachelor of Science", American Society for Eng. Education, 2007.

courses, and by seeking to prove some of the more controversial program elements, such as undergraduate students work on real projects for companies and work on proposals, so we could prove our students could do such work.

3. We designed a value innovation strategy by identifying elements of performance and the most important customers, and then analyzing their needs and designing to the new performance dimensions to deliver more value to each customer. Part of this included recognizing that different "key stakeholders" had different objectives, and so we developed story lines designed for each different customer segment and major personality types in those groups.
4. We gathered market data, asking hard questions about competitive (dis)advantages. Our market research introduced a new space of possible ideas to the broader community, who in turn put pressure on many otherwise uninterested people in the organization to take change seriously.
5. We formed an initial team that engaged key influencers and administrators in discussions on program elements and implementation issues to ensure high-level management engagement and buy in. We needed administrators to develop ideas on their own (although perhaps by being led somewhat) so they could take ownership of the ideas and champion the process. We expected to change our ideas along the way by integrating different viewpoints, also a key element of innovation.
6. We sought external validation and seed funding. We won grants from the National Collegiate Inventors and Innovators Alliance (NCIIA) and the National Science Foundation (NSF) Partner for Innovation Program. External validation speaks volumes to administrators and legislators, weakens the argument of detractors, and gave our team some room to operate.
7. We designed our innovation to initially co-exist with existing product lines and minimized the number of people impacted by implementing the change. We started in a bootstrap mode with Dr. Boult and Dr. Chamillard teaching more than necessary to get it going, and then after exceeding the revenue in our business plan we brought in new faculty with the necessary interdisciplinary background.
8. We anticipated roadblocks and developed strategies and partners to ensure we could get through or around them. We capitalized on strong external fiscal threats to catalyze open discussions and negotiated with stakeholders, initially asking for an idealized package, but settling on something that was still viable. We partnered with community members to push for change.
9. We didn't expect to get everyone onboard. Not everyone embraced the innovation process concepts; for example, the mathematics department, which had been in EAS for decades, decided this innovation initiative was not for them and moved their department from EAS to the College of Letter Arts and Science. The Department of Mechanical and Aerospace Engineering (MAE) felt the B.I. was not for them also. If we had tried to get everyone on the train, we'd still be back at the station.
10. We built on market data and the early successes to develop an exciting pitch backed with a detailed business/program plan. We used these to sell the B.I. in the many-stage campus and state approval processes. The pitch was targeted at intuitive individuals motivated by passion and ideas; the detailed 60-page plan addressed the data-driven mindset which seems to dominate academia.
11. We under-promised and over-delivered, marketing hard while aggressively managing growth and resources. The result is that our B.I. Family of degrees is a unique program focused on teaching innovation, and we have received awards from the American Society of Engineering Educators and Innovation India. We have a modern marketing plan, which our university initially opposed funding. We believed that marketing an innovation is critical, and our business plan justified the expense. With it we have attracted out of state and international students well above campus average. Our growth has been more than double the initial plan, with currently 130 students across five majors. Given the growth last year, we reduced our marketing to slow our growth rate. In the first two years, we had more partner companies and innovation team funding than we have had qualified students willing to work, so managing the growth to maintain quality given staffing levels has been important for us.
12. We don't expect the fight to stop when we got the approval. Once you begin to generate resources, expect administrators to want more of it and to provide less support. For example, while the college collects our student technology fees, the B.I. program had to buy its own computers.

http://www.icee.usm.edu/icee/conferences/asee2007/papers/2761_beyond_the_bachelor_of_science.pdf

Not everything along the way was clean and executed according to our plan. The details of the approval and implementation process for the B.I. in GDD provide a good example in adaptation for innovation. The initial vision for the GDD degree was as a joint venture between the College of Engineering and Applied Science (EAS) and the College of Letters, Arts, and Sciences (LAS). However, to mitigate the risk associated with the requirement for approval from both colleges for such a venture, Dr. Chamillard also forwarded an EAS-only proposal in parallel. Planning for and pursuing alternate paths is a valuable and necessary activity for any innovative endeavor. As it turned out, LAS rejected the proposal and campus-level feedback suggested that a GDD degree in EAS should be part of the B.I. family.

This B.I. in GDD approach had been discussed earlier but had not been pursued, as neither the B.I. or GDD groups wanted to risk being derailed because the other's radical vision was killed. With both programs through their first campus hurdles, the merger was swift and mutually beneficial, providing a market differentiation and competitive advantage for the GDD while providing for faster B.I. growth and a more diverse set of students in the innovation program.

It is important for the GDD majors to have the choice to form small independent game development companies in the area, as locally there is little of the more traditional employment in the game development industry. The Innovation Core and other components of the B.I. degree support that goal very well, and they also help students and parents see multiple potential career paths. The adaptation of GDD into B.I. strengthened both programs and the result is much better, even if moderately different from what either team originally envisioned.

As with many innovation efforts, successfully reaching our end goal required acuity to see a path, assiduity to diligently move forward despite adversaries and setbacks, and significant adaptability. It's an example that has a natural place in our curriculum, an example of not just talking about innovation, not just teaching it, but of us working actual process and how it is impacting the students whom we are teaching.

5 OBSERVATIONS, CONCLUSIONS, AND LESSONS LEARNED

Although many in academia see that the world is changing, and talk about it and write articles about the changes and innovation, and despite rapid external morphing in business and engineering, some of the very people who espouse these facts are reluctant to change themselves. Teaching the B.I., or more accurately coaching in the B.I. program, is not your average faculty interaction. When pitching the concept we knew this would take a special type of faculty: ones with experiences that span multiple dimensions of the innovation spectrum. Check out the faculty/authors bios at www.innovation.uccs.edu and you'll see what we mean. One cannot realistically support a program with a focus on learning by doing without faculty that are actively doing. You'll need real innovators in the classroom, and an attitude focused on innovation, not classic research or teaching. Don't expect too many established faculty to change, but make use of those who do.

The Bachelor of Innovation™ family of degrees represents a new direction for undergraduate education. Getting such a novel program through departments, campus, and eventually state approval was a non-trivial exercise, and along the way we faced and overcame multiple challenges by using innovation processes to drive the change process.

Does the B.I. work? Only time will tell for sure, but the first two and a half years have exceeded almost everyone's expectations. Our freshman classes for the B.I. are limited by space and resources, and our problem now is managing growth and quality. Our successes are compounding the interest.

In our first term we had one business plan get "defunded" at the first pitch half way though the term, but the team's second idea/pitch was good enough that we partnered them with a local company to win a $100,000 Navy Small Business Innovative Research (SBIR) contract. The freshman and sophomores produced about 80% of the project's deliverables, and the company has asked the B.I. to partner on other contracts.

In the second year, student teams have supported over $2M in successful grant/contract proposals, with multiple ongoing funded projects and teams supporting nearly a dozen companies. We have already seen multiple start-up companies emerge from the program, one that already has a product and beta customers, another winning $150,000 in an NSF SBIR. That is not bad for a "startup" program of mostly freshman and sophomores studying at a campus founded after the microchip, word processing, hypertext and the mouse had already been invented.

We define innovation as "transforming ideas in to impact," and with that definition, the B.I. clearly is an innovation. Its impact on campus has been significant, and its impact on local business is being felt and is growing. We seek broader impacts across the nation. Join us in the next innovation in education.

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The Real Disruptive Innovation in Education

by Brandon Busteed

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Story Highlights

- *Feeling supported in college helps grads in their careers*
- *Technology is significant, but human fundamentals matter too*
- *Effective mentoring is critical to a graduate's success*

Clayton Christensen, the Harvard Business School professor and author of *The Innovator's Dilemma*, is on record saying that as many as half of U.S. colleges and universities will go out of business in the next 15 years. His case for arguing this stems from extensive research on technology-driven "disruptive innovations" across many industries. In recent years, he has looked closely at the disruption caused by online courses in the education world, and his predictions have caused quite a stir.

In this case, I believe his prediction may come true, but not necessarily for the reasons he states. Most colleges and universities won't go out of business because they don't innovate fast enough with online courses. Instead, they will struggle because they aren't delivering on their fundamental value proposition and core mission.

Students Need Support -- and Experiential and Deep Learning

Gallup -- in partnership with Purdue University -- recently completed a representative study of college graduates, with more than 30,000 respondents. What we learned was that few college graduates experienced the most important elements *in* college that were linked to long-term success in their careers and lives *after* college.

In addition to studying traditional outcome measures such as employment and income, we were most

interested in understanding the extent to which graduates were engaged in their current work and thriving in their overall well-being, as described by five key elements: purpose, social, financial, community and physical. Engagement and well-being, one could argue, are much closer to quantifying the core mission of most institutions of higher education: to educate students so they have meaningful and productive careers, contribute to society and thrive in their overall lives.

We learned that if graduates felt "supported" during college -- by professors who cared, made them excited about learning and who encouraged them to pursue their goals and dreams -- their odds of being engaged in work more than doubled, as did their odds of being thriving in their well-being. This finding was true of graduates of all ages and years of graduation; in other words, it's a career- and life-trajectory game changer.

Appallingly, only 14% of all college graduates strongly agreed they received support in all three elements. And on one element that had a strong relationship to long-term success -- a mentor who encouraged them to pursue their goals and dreams -- only 22% of national graduates strongly agreed that they received this support during college.

Similarly, Gallup found that if graduates engaged in "experiential and deep learning" during college -- taking part in internships, being active in extracurricular activities and with organizations, and completing a long-term project -- their odds of being engaged at work doubled. Only 6% of college graduates experienced all three elements. And only 29% of graduates recalled taking part in a job or internship where they could apply what they were learning in the classroom.

Worst of all, a mere 3% of all college graduates experienced all six elements of support and experiential and deep learning during their college years. There's no need to worry whether online courses are disrupting higher education if it's never had the fundamentals for student success in place to begin with.

Investing in One-to-One Mentoring

Some colleges and universities *are* excelling on the measures Gallup studied. But it's not because they are private or public, small or large, selective or not selective. It's because they are making intentional efforts to provide these experiences for students -- and to improve outcomes for graduates.

Western Governors University (WGU) provides an illustration of how Christensen is both right and wrong about the impact of online learning. This accredited, online university has been hailed for its innovative use of technology to offer a scalable, affordable degree. Technology is certainly part of the story, but perhaps even more important and impressive is that WGU is excelling at the human-related fundamentals.

When Gallup surveyed WGU's graduates, we found that 68% strongly agreed they had a mentor who encouraged their goals and dreams. This is *more than three times higher* than the national average for all college graduates. WGU intentionally invests in one-to-one mentoring for each student from the time they enroll to the time they graduate. Being an online university doesn't prevent WGU from focusing on a core fundamental of human development like a mentorship. Technology itself may not be the disruption, unless institutions use it to enable crucial elements like this.

We may learn that the real disruptive innovation in education is the need for a human support system and deep learning experiences. Though colleges and universities might be threatened by disruption from online courses, they should have an advantage on fundamentals like mentoring, caring professors and deep and experiential learning. But institutions will only capitalize on these advantages if they intentionally invest in them. So far, most are not.

In a world entrenched in technology, we need to work harder to be more human -- and we need to be more human than ever before. Colleges and universities that make intentional efforts to embrace the fundamentals of human development will thrive. Online courses can help lower costs and increase efficiency and effectiveness in certain aspects of learning. But online learning will never reach its full potential -- much like higher education itself -- unless there is human-driven emotional engagement and deep experiential learning at its core.

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Colleges Must Mix Entrepreneurial Skills, Traditional Liberal Arts

Brad Bernthal 1/14/15 **Follow @BradBernthal**

The great challenge facing higher education is to prepare students to navigate a world of accelerating uncertainty and faster churn. Training students to re-invent themselves every few years, as is already required in the world today, is an objective that legacy approaches to higher education is not optimized for. I'm convinced, however, that the University of Colorado-Boulder is piloting the right solution. Now we have to scale it.

We must teach every student an entrepreneurial mindset. In addition to the traditional depth of a discipline (think: major or degree path), students need breadth. High functioning individuals today are not just domain experts, they are also cognitively proximate to people in other domains. An entrepreneurial mindset goes beyond the traditional liberal arts ideals of training critical thinkers who are engaged citizens. An entrepreneurial mindset focuses upon empowering students to act upon their convictions and mobilize teams. In particular, there are five principles to the entrepreneurial mindset:

1. Collaboration is central to innovation. No one goes it alone. Yet much of higher education targets the individual. Students need to be taught methodologies that allow them to manage team processes, communicate across disciplines, and be able to recognize good ideas from other domains. Collaboration methods such as design-centered thinking develop an individual's capacity to work with others.

2. Cultivate a network based perspective, rather than a hierarchical one. This is crucial in a world where an individual is likely to move across multiple organizations during a career. We need to teach students how to see themselves as actors in a network, more than cogs in a bureaucracy. Teaching students how to create a network, how information spillovers work, and how to provide value to others needs to be more front and center as part of a higher education experience.

3. Impart tools to embrace and navigate conditions of uncertainty and rapid change. Technology literacy as well as familiarity with lean startup practices are powerful tools to navigate uncertainty. High functioning individuals today must

understand technology enablers. Those that do not understand changes effectuated by technology feel threatened, not empowered. Further, high functioning individuals also must be able to test ideas in experimental ways. Practices like lean methodologies teach individuals how to run tests before going “all in” on a new direction.

4. Bias toward doing over planning. Classroom lectures, PowerPoint presentations, and academic papers still have important roles in teaching formal knowledge. But these tools should be complemented by an emphasis on experiential learning. Another way of saying this is that the formal learning of the classroom must be balanced by the acquisition of tacit knowledge (i.e., knowing in doing). Students need both in order to be effective A-level players. And especially as more and more formal learning can be done through on-line courses, I expect experiential education to increasingly differentiate in-person education that occurs on campus.

5. The community is part of the classroom. Over the past decade, CU-Boulder and Silicon Flatirons have created a high velocity of interaction between campus and community. Collapsing the barriers between town and gown is remarkably powerful. Active engagement within one’s relevant community yields opportunities and experiences that cannot be learned elsewhere.

[*Editor's note: Xconomy recently asked thought leaders in educating and developing entrepreneurs what changes they'd like to see the education system in this country make. You can see* ***answers to that and other questions here****.*]

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LET'S BRING THE POLYMATH — AND THE DABBLERS — BACK

I noticed recently that books with the phrase "The Last Man Who Knew Everything" all share in common that their subjects lived during the period close to the Scientific Revolution, roughly between 1550 to 1700. (The examples I own are about Athanasius Kircher, a Jesuit priest born in 1602; Thomas Young, who studied topics such as optics and philology and was born in 1773; and Philadelphia area professor Joseph Leidy, who was born in 1823.)

It's as if the Scientific Revolution — and the knowledge it spawned — killed the ability to Know Everything. Before then, it was not only possible to be a **generalist** or polymath (someone with a wide range of expertise) — but the weaving together of different disciplines was actually rather unexceptional. The Ancients discussed topics such as ethics, biology, and metaphysics alongside each other. The Babylonian Talmud discusses everything from astronomy and biology to morality and law, weaving them together into a single compendium.

So what changed? Scientific knowledge exploded in size, mainly due to the application of the scientific method to our surroundings. As that knowledge base and its domain experts grew exponentially, we began classifying and ordering all that we understood — from the classification taxonomy of Carl Linnaeus to manuals for categorizing mental disease. We made sense of our world by dividing information into manageable portions and distinct areas of proficiency.

But as people began to specialize, knowledge became fragmented. We chose to know more and more about less and less. We may have expanded what we as a society know — but it was at the price of no single individual being able to truly know it all.

Now, we obviously require specialized experts (as opposed to dilettantes) to solve specific problems; think about the field of medicine, for example. Yet the most exciting inventions occur at the boundaries of disciplines, among those who can bring different ideas from different fields together. As Robert Twigger noted, "Invention fights specialisation at every turn."

In fact, some of the most exciting advancements in computing right now come from the field of deep learning — which itself draws from multiple fields: neuroscience, cognitive psychology, machine learning, natural language/ linguistics, computer vision, mathematics — to make the next step of AI possible. Companies such as Facebook, Google, IBM, and Microsoft are all involved.

But frankly, this kind of interdisciplinary approach isn't happening more broadly in corporations, let alone in academia. There are institutional barriers (nearly all training, and data, lives in silos) as well as cognitive and biological ones. Even though the information storage capacity in our

brains is vast (multiple petabytes), we eventually bump up against what we can truly understand (what some call *The End of Insight*) — or we just can't hold all the relevant knowledge in our heads.

Still, we needn't despair. There are ways to foster a culture of interdisciplinarity in a fragmented world.

We Need to Focus on the Tools, Not the Fields

Several years ago, a team of scientists examined hundreds of millions of clicks on scientific papers in order to discern the "clickstream" — the path readers take from one page to the next.

This data revealed patterns of how people moved from one subject area to the next. For example, nursing connects medicine to the fields of psychology and education. Organic chemistry bridges physical chemistry and analytic chemistry; economics is tightly intertwined with sociology and law; and the field of music stands quite distinct.

Of course, these are oversimplifications. Music incorporates concepts from physics and psychology while economics draws heavily from mathematics. But it's one way to explore the interconnected nature of ideas, and it reminds us that we need to identify the tools necessary to bridge different domains and place them into a connected framework.

Let's take a simple analogy. What do the following things have in common: doing Sudoku, constructing crossword puzzles, conducting logistics for large companies, playing Super Mario Brothers?

Well, in content terms, not much. They appear to be a collection of tasks that are easy to understand but not master. And it turns out that they're all hard in a specific way: They're what are known in theoretical computer science as NP-complete problems. Knowing this means each of these problems can be converted into a version of the other — I can construct a Sudoku puzzle that, if solved, could potentially shed light on how Walmart should route its delivery trucks.

Simply put, there are fields that have a certain generalizability, and their organizing ideas and tools can be used to find relationships between disparate areas. The most basic example of such a field is mathematics. As Eugene Wigner stated in his 1960 paper *The Unreasonably Effectiveness of Mathematics in the Natural Sciences*, "The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve."

Mathematics is a gift, an unbelievably useful tool for understanding our surroundings.

We Need To Think in Terms of Modules and Protocols

Take the science of complexity. It's an attempt to abstract complex systems to their relevant interacting components, and then create a mathematical formalism that can explain the phenomenon being examined.

A complex system often has many interconnecting units that are themselves made up of many pieces. These larger units, which often have a certain degree of independence and internal sophistication, are known as **modules**. The property of modularity is a hallmark of many complex systems, from those in biology to programming. But an additional feature of these modular systems — often more abstract than the individual components — is how the pieces interact.

LEGO pieces can be combined in multiple ways. But what allows them to interact effectively is the shape and structure of the bricks — the bundle of properties that allow them to snap together easily. Similarly, multitudes of personal computers, massive servers, phones, and appliances can all connect to the Internet. What allows them to do this is the use of a common **protocol**, in this case the Internet Protocol (IP).

Whether referred to as protocols, standards, or interfaces, **modules** can vary, but can only interact — and be *interoperable* — if they use a common set of protocols.

Such modularity is not just a feature of physical systems. We need it for information, too. Think of the usefulness of websites like If This Then That ("Lincoln logs for your online life") allowing "ingredients" like email, photos, RSS feeds, notes, weather updates, calendars, activity, and now location to be connected into meaningful recipes.

IFTTT is important because information is most useful when modules can be connected. And the same is true with knowledge. Distinct fields act like modules: complex, intricate, and complete with their own terminology and jargon. These features act as hurdles to interaction, and we can only interconnect the domains by building a set of common protocols.

This is exactly what the tools of mathematics and complex systems are: protocols. Not only do such tools allow someone to work in multiple disciplines — making it possible, once again, to be a generalist — they demand that similarities between different domains be made explicit.

This suggests that learning how to code is not enough to change how we think. Yes, coding does provide a certain structure to one's thoughts. But there is a more important — and often ignored aspect — behind programming: through code, and the recognition that algorithmic similarity occurs over and over, we can see the *similarities* between different spheres of knowledge.

Far from being a tech-centric perspective, coding connects ideas across fields.

And We Need to Embrace the Machines

Charlie Munger, Warren Buffett's investing partner, refers to the mental models required to understand the world — and that can be plugged into different situations — as a "latticework of models". When suitably abstracted, these models can provide a powerful way of understanding

many phenomena that might on the surface seem unrelated. Though an expert is a good guide along the way, these models are the tools that allow us to jump from field to field.

And machines can help, acting as partners in generalism.

Some people are not happy with this idea. But we need to welcome the tools that will allow us to more effectively manage the rapid growth of knowledge and prevent the balkanization of fields. As knowledge grows, we must increasingly rely on computers. This is not a new insight; in 1945, Vannevar Bush wrote the seminal "As We May Think" essay in *The Atlantic* describing the need for a machine:

But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers — conclusions which he cannot find time to grasp, much less to remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial…

The difficulty seems to be… not so much that we publish unduly in view of the extent and variety of present day interests, but rather that publication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships.

The problem of hidden knowledge (also discussed in my book *The Half-Life of Facts*) continues to grow. And now we have the Internet, and search, and big data which both surface, and hide, knowledge. As a way of addressing this problem of growing knowledge, Bush proposed a "memex" device, a type of rudimentary web browser.

But we can go further than browsing. Computers can help us *generate* new knowledge. It could be in proving mathematical theorems. It could be in finding papers that, when combined, yield new discoveries. It could be in taking different people's annotations and finding unexpected connections between them. No matter what forms such discovery takes, though, it is clear that the crafts and tools of mathematics and computing will finally allow for the return of the generalist.

* * *

Where are all the generalists, anyway? They're not really thriving in academia; for the most part, they've gone elsewhere to find their place, and one of these places is business. In the realm of data science at least, the startup world is beating academics at their own game when we consider examples such as Google and Facebook or Bit.ly and Misfit Wearables.

Videogame companies are also promoting this stitching-together of fields. Maxis (a subsidiary of Electronics Arts), the company that makes SimCity, Spore, and the Sims, is full of people who bounce from topic to topic, incorporating information from seemingly unrelated fields. Want to know why the steepest incline of streets in the newest version of SimCity is a certain number of

degrees? It's because the developers took the time to examine the steepest inclines in the world and based their coding of this information on that knowledge.

More generally, the world of business and entrepreneurship actively encourages those who see connections between disciplines. One who can recognize a relationship between two disparate fields of ideas will more likely come up with the next, big, new thing. That's investment gold.

So how do we train people for this kind of thinking? The Girl Scouts once offered a fascinating merit badge: the Dabbler badge. This allowed a young scout who wanted to do a little bit of everything to not only generalize, but to be *recognized* for that achievement. Perhaps it's time for the academic and business equivalent of the Dabbler badge: a way to acknowledge and foster those dabbling in different ideas, all the way from gradeschool to late career.

Specialization is clearly on the rise. It's time for the generalist and the polymath to rise once again. Society needs to make a place for these Last Men and Women to Know Everything, and we need to go beyond the rhetoric of education reform to focus on the right tools that will make this happen.

Editor: Sonal Chokshi @smc90

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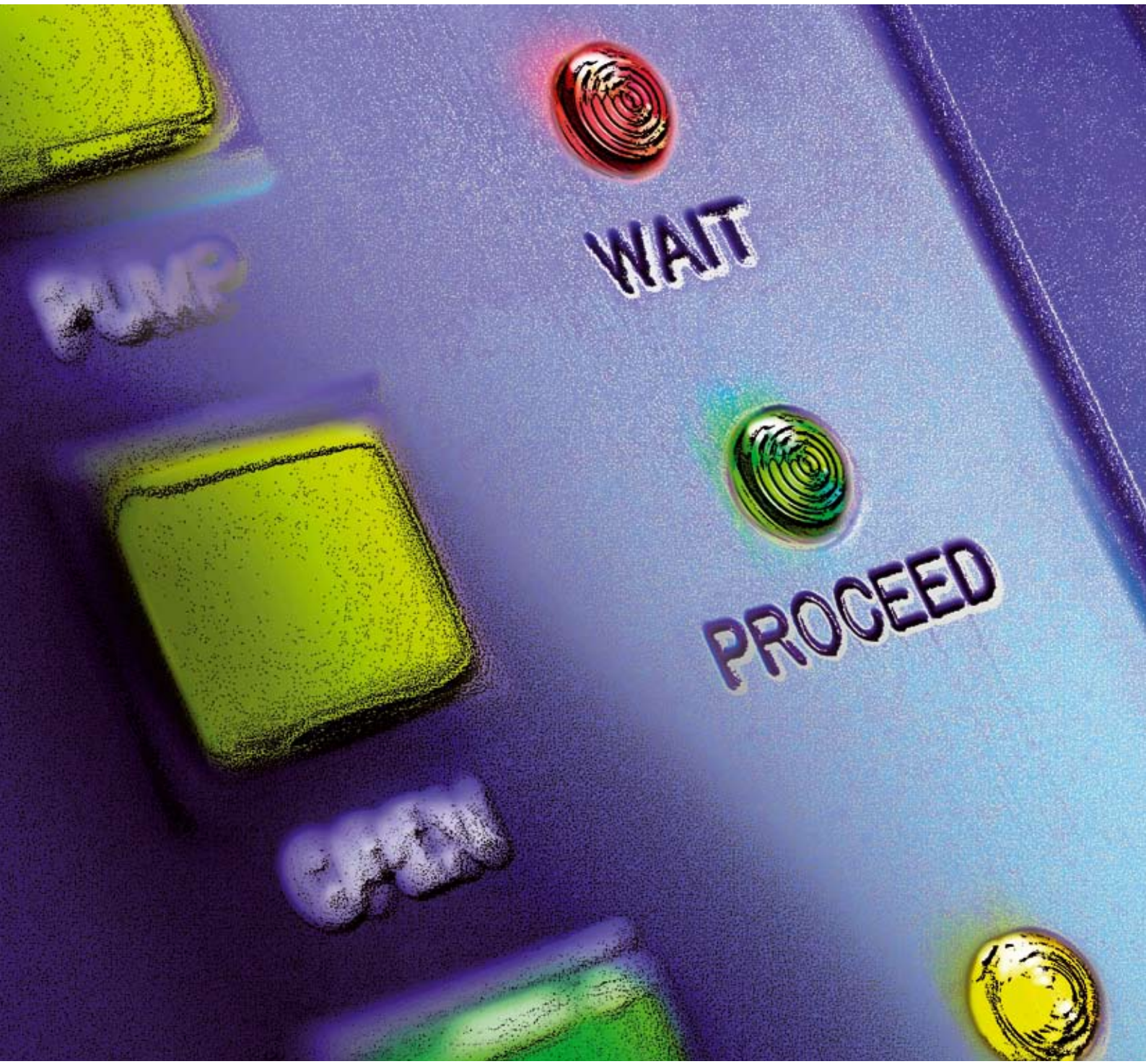
Succeeding through service innovation

A service perspective for education, research, business and government



A White Paper based on
- **Cambridge Service Science, Management and Engineering Symposium (July 2007)**
- **The consultation process (October – December 2007)**

Executive summary

Service systems[1] are dynamic configurations of *people, technologies, organisations* and *shared information* that create and deliver value to customers, providers and other *stakeholders*. They form a growing proportion of the world economy and are becoming central to the way businesses, governments, families and individuals work. Innovation, a term applied almost exclusively to technologies in the past, is increasingly used in relation to service systems.

Ideas of service are, of course, not new. However, the scale, complexity and interdependence of today's service systems have been driven to an unprecedented level, due to globalisation, demographic changes and technology developments. The rising significance of service and the accelerated rate of change mean that *service innovation* is now a major challenge to practitioners in business and government as well as to academics in education and research. A better understanding of service systems is required.

Many individual strands of knowledge and expertise relating to service systems already exist, but they often lie in unconnected silos. This no longer reflects the reality of interconnected economic activities which, for example, sees manufacturers of engineering products adopting service-oriented business models and health care providers learning lessons from modern manufacturing operations. Indeed, there are wide gaps in our knowledge and skills across silos.

In response, *Service Science*, *Management and Engineering (SSME)*, or in short *Service Science*, is emerging as a distinct field. Its vision is to discover the underlying logic of complex service systems and to establish a common language and shared frameworks for service innovation. To this end, an *interdisciplinary* approach should be adopted for research and education on service systems.

Developing Service Science is no easy task; it not only requires intensive collaboration across academic disciplines but also a doubling of R&D investment in service education and research by governments and businesses. All stakeholders must start to engage each other and make plans for service innovation.

For those responsible for creating a service innovation roadmap, this white paper provides a starting point to raise awareness. For those who have already developed such roadmaps, it serves as a benchmark for improvement. More specifically, drawing upon the expertise and experience of leading academics and senior practitioners, this document makes the following interrelated recommendations:

For education: Enable graduates from various disciplines to become *T-shaped professionals* or *adaptive innovators*; promote SSME education programmes and qualifications; develop a modular template-based SSME curriculum in higher education and extend to other levels of education; explore new teaching methods for SSME education.

For research: Develop an interdisciplinary and intercultural approach to service research; build bridges between disciplines through grand research challenges; establish *service system* and *value proposition* as foundational concepts; work with practitioners to create data sets to understand the nature and behaviour of service systems; create modelling and simulation tools for service systems.

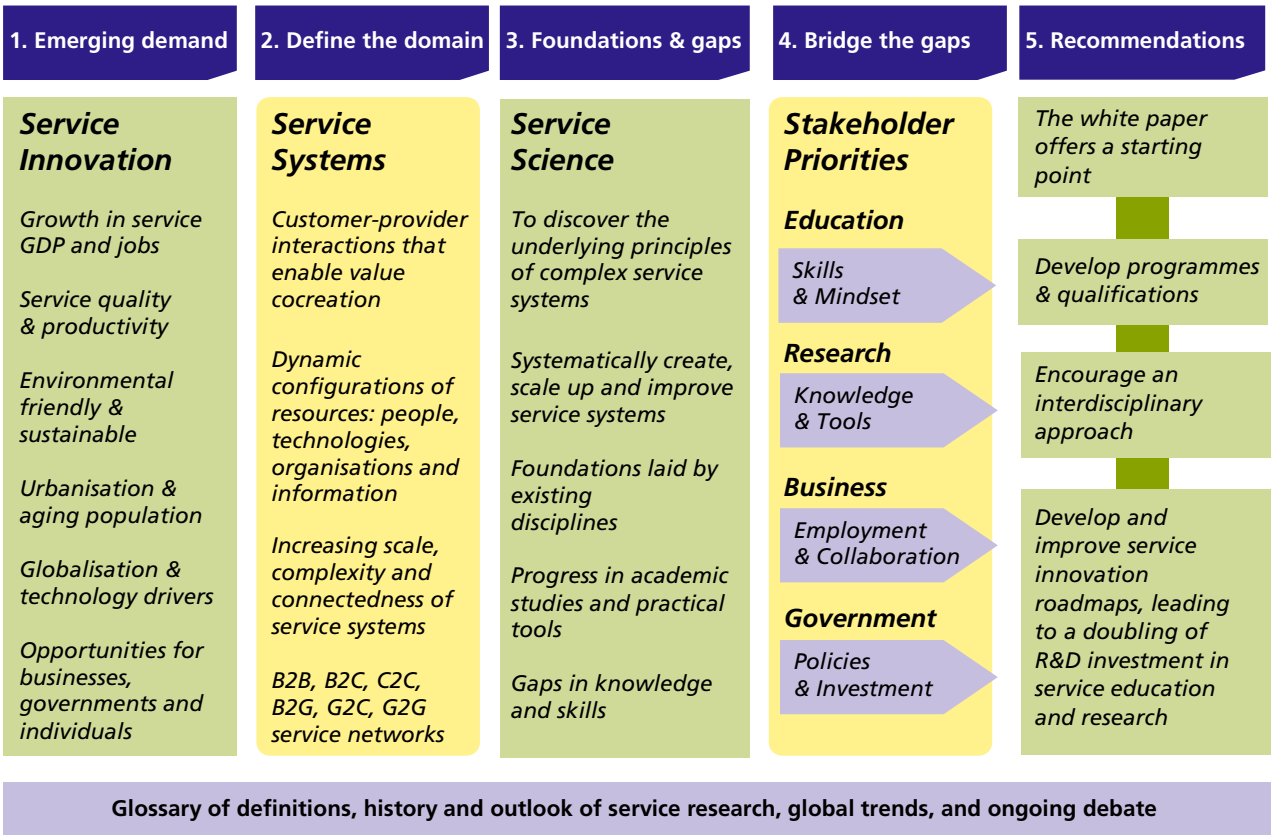
For business: Establish employment policies and career paths for T-shaped professionals; review existing approaches to service innovation and provide grand challenges for service systems research; provide funding for service systems research; develop appropriate organisational arrangements to enhance industry-academic collaboration; work with stakeholders to include sustainability measures.

For government: Promote service innovation and provide funding for SSME education and research; demonstrate the value of Service Science to government agencies; develop relevant measurements and reliable data on knowledge-intensive service activities; make public service systems more comprehensive and citizen-responsive; encourage public hearings, workshops and briefings with other stakeholders to develop service innovation roadmaps.

Service Science is still in its infancy; but we are confident that, by adopting these recommendations, we can accelerate its development and place ourselves in a better position to create and benefit from service innovation in the future.

[1] Words in italics are defined in the glossary.

Succeeding through service innovation: A framework for progress



1. Introduction

1.1 The demand for service innovation

Growth in service

The growth of service activity across industries is now widely recognised. However, is it really anything new? Service is as old as the division of labour and has been provided in various forms since record keeping began. Indeed writing records was a form of service! What has changed, however, is the scale and complexity of *service systems* –configurations of resources that create and deliver value to stakeholders through service activities.

Service systems are growing rapidly and have become an ever greater part of value creation in modern economies. We are paying proportionally more for services in the form of experience, advice, information, assurance, infrastructure and leasing, and proportionally less on growing, building and owning physical goods. And more than ever before, we are constrained by natural resources and have to achieve the triple targets of effectiveness, efficiency and sustainability. The rise in complexity is partly due to the expansion of our values in social, ecological and political dimensions.

Opportunities for service innovation

Thanks to the application of science, management and engineering to the improvement of agriculture and manufacturing, remarkable products, from disease resistant crops to automobiles and personal computers, can be produced flexibly and efficiently and are widely available. However, as product complexity and diversity increase, it can take more time and consume more resources to search for, obtain, install, maintain, upgrade and dispose of products than production itself. This offers great opportunities for *service innovation* – including both incremental improvements and radical changes to service systems.

Service innovation can impact customer-provider interactions and improve the experience of finding, obtaining, installing, maintaining, upgrading and disposing of products. Service innovation can enhance the capabilities of organisations to create value with stakeholders. Service innovation can deliver better self services, eliminating waiting and allowing 24/7 access via modern devices such as mobile phones, web browsers and kiosks.

Opportunities for service innovation can be extended well beyond the business world. Government programmes, for instance, have become increasingly complex and diverse, requiring innovative solutions to cope with the vast scale of the demand. For families and individuals, each generation aspires to a richer and more fulfilling life than their predecessors. Service innovation is required to improve the quality of life and help society deal with important issues such as aging populations.

Service innovation has also found its place in the virtual world. Information and communication technologies (ICT) and on-line spaces have enabled the creation of new service businesses such as Amazon and Google, not to mention the fast emergence of 'Web 2.0'. These new services in turn are changing our behaviour in decision making and in many other areas.

1.2 New skills and knowledge required

The rising demand for service innovation has huge implications for skills and the knowledge base that underpins them. People are needed who can understand and marshal diverse, and increasingly global, resources to create value. Quite often, these resources are accessed using advanced ICT and new globe-spanning business models. The people with such skills are known as *adaptive innovators* - those who identify and realise a continuous stream of innovation in service systems.

The need for science, management and engineering in relation to agricultural and manufactured products has not gone away. They are an integral part of service innovation and have a strong impact on the way that products behave and perform in larger service systems. For example, cutting-edge technologies such as biotechnology and nanotechnology can be applied to enhance consumer experience. But as the scope of innovation continues to move beyond products, we must prepare ourselves with skills and knowledge required for service innovation.

1.3 Service Science: an emerging field

The growth of service in modern economies has gradually driven scholars to service-related studies. Whilst research into service can be traced to as early as the 1940s, significant developments were not possible until the late 1970s when service research was broken free from product-centric concepts and theories (see Appendix I: History and future outlook of service research). The field of service research now covers a wide range of subjects, including *service economics, service marketing, service operations, service management, service engineering, service computing, service human resources management, service sourcing, service design,* and many others.

Despite these advances in the service field, however, there has been a growing perception that it is time to take stock and to explore the possibility of bringing coherence into the various strands of knowledge and experience. Without a clear understanding of the domain and how it relates to existing theories, knowledge will continue to be fragmented. Indeed, a more integrated approach is needed if real progress is to be made. In response, *Service Science, Management and Engineering (SSME)*, or in short *Service Science*, is emerging as a distinct field to look for a deeper level of knowledge integration[2].

1.4 Drawing the threads together: the white paper

Since 2004, IBM has been working with many other pioneers to call for a systematic approach to service research and education. The initiative was clearly driven by IBM's own substantial growth in services and its recognition of a potential future shortage of knowledge and skills required for service innovation. Over the past few years, this movement has led to dozens of SSME-related meetings in various countries.

The Cambridge symposium

In July 2007, IBM and Cambridge University's Institute for Manufacturing (IfM), in conjunction with BAE Systems, orchestrated an international symposium to help distil the key issues surrounding the nature of service and to identify guidelines for future development. The two-day meeting was attended by a group of leading academics and senior business leaders with a wide and deep knowledge of service research and practice – some 200 years experience in all. The symposium was also informed by 'correspondents', those who were unable to attend the meeting but made contributions through completed questionnaires and position statements or papers. In spite of the diverse backgrounds of this multidisciplinary group (see Appendix II: Contributor list), the event produced a remarkable commonality of view as to how we can move the field forward.

White paper development

An important outcome of the Cambridge symposium was a discussion document (IfM and IBM, 2007)[3]. To collect views from a wider group of stakeholders, the document was then put into a broad consultation process, involving over one hundred respondents from academic, business and governmental organisations all over the world (see Appendix III: Consultation respondents). Based on their comments, the discussion paper was further developed into this white paper.

Target audience and key messages

The paper is aimed at all those who have the responsibility to understand service innovation and improve their organisation's capacity to meet future demands. It describes the changing structures of the modern economy, demonstrates the growing significance of service activities, and examines the nature of service systems. It identifies knowledge and skill gaps in service innovation and proposes potential ways to address those gaps. It continues to invite discussion about service innovation - new ways that service systems can improve our economic and social well-being sustainably.

1.5 Key concepts

To establish a basis for an inclusive discussion, this document would like to create a shared view on the key concepts of Service Science: service system, value proposition, adaptive innovator, and Service Science, Management and Engineering (SSME) graduates. These concepts provide a service perspective on the traditional concepts: factory, trade, problem solver, and *Science, Technology, Engineering and Mathematics (STEM)* graduates.

The changing global landscape of business and society can be described, for the purpose of increasing service innovation, as a very large global service ecosystem. The ecosystem is populated by many species (types) of *service systems* (from individuals to complex businesses and government agencies) interacting via *value propositions* to exchange service for service (with value-cocreation as desired outcomes). Individuals fill roles in complex service systems. Complex service systems can fill roles in even more complex service systems. When problems arise, individuals may want to change, improve, or create new types of service systems. In this context, adaptive innovators will benefit from their knowledge of Service Science, Management and Engineering (SSME) or Service Science.

[2] Considering the integral role of design and the arts in customer experience, SSME could be logically extended to SSMED or SSMEA (Service Science, Management, Engineering and Design/Arts).

[3] IfM and IBM. (2007). Succeeding through Service Innovation: A Discussion Paper. Cambridge, United Kingdom: University of Cambridge Institute for Manufacturing. ISBN: 978-1-902546-59-8.

2. Clarifying the rationale and defining the domain

2.1 What is a service system?

A service system can be defined as a dynamic configuration of resources (people, technology, organisations and shared information) that creates and delivers value between the provider and the customer through service. In many cases, a service system is a complex system in that configurations of resources interact in a non-linear way. Primary interactions take place at the interface between the provider and the customer. However, with the advent of ICT, customer-to-customer and supplier-to-supplier interactions have also become prevalent. These complex interactions create a system whose behaviour is difficult to explain and predict.

2.2 Why are we interested in service systems?

A world of service systems

We live in a world where it is a daily experience to interact with various service systems such as banking, communications, transport and health care. We all suffer frustrations (or worse) when service quality is poor and we all pay more when productivity is low. Yet this business-to-consumer (B2C) or government-to-consumer (G2C) view of service systems is just the tip of the iceberg.

Indeed, service systems in business-to-business (B2B), business-to-government (B2G) and government-to-business (G2B) environment are invisible to most consumers and citizens, but are experiencing enormous change and growth. This is driven by global sourcing of organisational capabilities. It is also enabled by an increasing use of technologies to ensure the fulfilment of service level agreements between organisations.

The shift to service as an economic driver is clear. The 2007 report by the International Labour Organisation indicates that, for the first time in human history, worldwide service jobs (42%) outnumbered jobs in agriculture (36.1%) and manufacturing (21.9%)[4]. While developed economies are dominated by the service sector, developing countries also start to assess their role in the service economy (see Appendix IV: Service sector in global economy). If we take into account service activities in manufacturing, even the latest figures become an understatement.

However, the importance of service has not led to increased investment in service research and development. Indeed, despite the fact that the service sector accounts for over two thirds of GDP and jobs in many developed economies, investment in services represents less than one third of total R&D spending[5]. This mismatch hinders the progress we could make to address many challenges.

Critical questions for businesses

Businesses, competing in a global economy, are familiar with many of the service issues and challenges that need to be addressed. Service systems can be divided into 'front stage' and 'back stage'. The 'front stage' is about provider-customer interactions: how can customer satisfaction be ensured in the presence of multiple customer touch points and various channels of contact? The 'back stage' is about operational efficiency: how can productivity be improved through skilled employees, streamlined processes and robust relationships with partners and suppliers (*service networks)*? Service performance relies on both *front-stage* and *back-stage* components: how can the 'voice of the customer' (customer needs) and the 'voice of the process' (provider capability) be matched for the best overall performance?

Changes in the modern world have posed additional questions. Increasingly, service excellence implies the use of global resources: how can opportunities in global sourcing and constraints in regulatory compliance be balanced? Growing competition means service leadership never stands still: how can service innovation be stimulated, realised and sustained? Service growth requires the ability to rapidly create a definable, repeatable, scalable and unique market success: how can promising service offerings be scaled up with growth in both revenue and margin? More than anything else, businesses want to know: how can the enterprise work in a seamlessly integrated manner?

Service businesses are not the only ones concerned with these questions. Increasingly, manufacturers are also keen to understand the same issues as they embark on a *servicisation* journey (see Appendix V: Business challenges for service research).

Pressure in non-business areas

Perhaps somewhat less intuitively, organisations in non-business areas are under similar pressure to improve service systems. Government agencies feel the need to provide better service to the public. Commercial competition is replaced by demands for transparency, quality and efficiency. Similarly, non-profit organisations are also urged to improve quality, productivity and innovation. For households, there is a growing recognition of the need to

[4] Key Indicators of the Labour Market (KILM), 5th edition, 2007

[5] RTI international. (2005). Measuring Service-Sector Research and Development. RTI Project Number 08236.002.004.

seek better education, health care and financial planning. And environmental concerns are high on everyone's agenda.

2.3 What is the vision for Service Science?

Discovering the fundamentals
Challenges facing modern organisations are, to a large extent, due to our poor understanding of the nature and behaviour of service systems. Unlike the IT industry, there is no *Moore's Law* roadmap for the service domain to guide organisations on what investments to make in order to see predictable performance improvements.

The vision of Service Science, therefore, is to discover the underlying principles of complex service systems (and the value propositions that interconnect them). It should provide the structure and rigour for building a widely accepted and coherent body of knowledge to support ongoing innovation in service systems.

Key questions for Service Science
While it is important to acknowledge the differences between the many types of service systems, it is crucial to accept their variability and get on with the task of discovering the fundamentals. We still need specialists to deal with the complexity within individual areas but, to extract the full potential, we must develop our knowledge about: (1) how to invest in service systems to sustainably improve key performance indicators (e.g. revenue, margin, growth, customer satisfaction, productivity, innovation, quality of life, social responsibility, environmental sustainability, and regulatory compliance), and (2) how to develop new service offerings, together with creative value propositions and improved service systems.

These enquiries lead to the following questions:

- What are the architectures of service systems?
- How can service systems be understood in terms of a small number of building blocks that get combined to reflect the observed variety?
- How might architectures and building blocks help us understand the origins, lifecycles and sustainability of service systems?
- How can service systems be optimised to interact and co-create value?
- Why do interactions within and between service systems lead to particular outcomes?

Potential benefits of Service Science
Service Science is about integration, optimisation and sustainability. We have pieces of knowledge today, but they are not integrated into a unified whole. Service Science provides motivation, methods and skills for integration. Service Science has the potential to benefit individuals, businesses and society, drawing upon the integrated talents of a diverse community. Service Science will enable adaptive innovators to identify the seeds around which innovation can take root and grow.

2.4 Who are the stakeholders of Service Science?

Individuals and organisations dependent on complex service systems are all stakeholders of Service Science in that they need the knowledge and skills required for service innovation. Businesses that want to improve their service revenues and profit margins have a clear interest in Service Science. Organisations in non-profit sectors share similar concerns and aspirations as they seek to deliver unique service offerings sustainably. Governments, at both national and local levels, wishing to create a high-skilled workforce and develop infrastructures to improve their competitiveness would benefit from the insights provided by Service Science.

Clearly, knowledge workers across a wide range of disciplines are also stakeholders. The past twenty years have seen the establishment of disciplines such as service marketing, service operations, service management, service engineering, service design, service computing, and many others. Different strands of knowledge would contribute more value to practice if they were brought together to form an integrated theory. For individual disciplines, Service Science in turn provides a platform for critical examination of their relevance, assumptions, strengths and limitations.

2.5 Why now?

Global trends, such as demographic shift, self-service and web-based technologies, outsourcing and offshoring, are challenging us to create new ways of doing things (see Appendix VI: Global trends and service innovation). This requires a solid scientific foundation if we are to understand increasingly complex service systems. Service Science has the potential to be as important as the foundation provided by physics, chemistry, biology, cognitive science and computer science for agriculture and manufacturing. We must act now in order to create the next generation of innovation.

3. Recognising the foundations and identifying the gaps

3.1 What foundations have been laid by existing theories?

Resource clusters

The resources used to form service systems offer a useful starting point for the development of Service Science. They can be divided into four clusters:

(1) Whole businesses and organisations: Studied primarily by schools of management (marketing, operations management, operations research and management sciences, supply chain management, innovation management)

(2) Technology: Studied primarily by schools of science and engineering (industrial engineering, computer science, statistical control theory)

(3) People: Studied primarily by schools of social sciences and humanities (economics, cognitive science, political science, design, humanities and arts)

(4) Shared information: Studied primarily by schools of information (communications, management information systems, document engineering, process modelling, simulation)

Academic disciplines

Our knowledge of service systems benefits from the following disciplines, which study some or all of the four resource clusters:

- Architecture and designed systems (1,2,3,4)
- Behavioural sciences and education (3, 4)
- Cognitive science and psychology (1,2,3,4)
- Complex adaptive systems theory (1,2,3,4)
- Computer science and AI/web services (2,4)
- Computer supported cooperative work (1,2,3,4)
- Economics and law (1,3,4)
- Engineering economics and management (1, 2, 4)
- Experience design, theatre and arts (3)
- Financial and value engineering (1,2,3,4)
- Game theory and mechanism design (3,4)
- Human resource management (1,3)
- Industrial engineering (IE) and systems (1,2,3,4)
- Industrial and process automation (1,2,3,4)
- International trade (1)
- Knowledge management (1,2,3,4)
- Management of information systems (1,2,3,4)
- Management of technology & innovation (1,2,3,4)
- Marketing and customer knowledge (1,2,3,4)
- Mathematics and non-linear dynamics (1,2,3,4)
- Operations management (OM) (1,2,3,4)
- Operational research (OR) (1,2,3,4)
- Organisation theory and learning (1,2,3,4)
- Political science (1,3)
- Project management (1,2,3,4)
- Queuing theory (1,2,3,4)
- Simulation, modelling visualization (1,2,3,4)
- Sociology and anthropology (1,2,3,4)
- Software metrics and development (2)
- Statistical control theory (2,4)
- Strategy and finance (1,2,3,4)
- Supply chain management (1,2,4)
- System design and software architecture (2,4)
- Systems dynamics theory and design (1,2,3,4)
- Total quality management, lean, six sigma (1,2,3,4)

Progress in academic studies

Discovering fundamental building blocks of service systems and the way they can be combined to reflect the reality is already underway. Resource classification schemes are being developed, along with associated access rights, service level agreements, standards and protocols, safeguarding mechanisms, intellectual property and failure recovery methods. Multiple perspectives are being established on service systems (such as provider, customer, governance authority, competitor, partner, employee) to introduce systematic approaches to service innovation. Encouragingly, pioneering attempts are being made to develop a normative view on how service systems can be described and their behaviours explained, including the Customer Contact model, the Service Quality GAPS model, Service-Dominant Logic, Unified Theory of Service, Service as Leasing, and Work Systems Theory, to name but a few.

Development of practical tools

Meanwhile, tools, methods and data sets for practical use are also emerging (e.g. IBM's Component Business Modelling approach and toolkit). They provide starting points for practitioners to establish an overarching framework and outline the problem space at multiple levels. They are used to model not only businesses but also government agencies and the public sector. Tools and methods are also being developed to model industrial evolution, which has generated interest among historical economists and organisation theorists. The development of service-oriented architectures (SOA) for describing information technology 'services' that support work and business practices is on the rise and has gained widespread acceptance.

3.2 Where is the knowledge gap?

Challenges facing individual disciplines

Despite significant progress, we are far away from achieving the vision of Service Science. For one thing, there are still challenges within individual disciplines. For example, operations research and industrial engineering often model people waiting in queues, but the model fails to recognise people as emotional and psychological

beings that can learn and adapt over time. Computer science and information science often model information system architectures on the basis of well-understood environmental variations, but the design of governance mechanisms that allow information systems to respond proactively to strategy changes and predictable technological advances is less understood.

In a similar vein, economics and business strategy need to accommodate predictable innovations. Service management and operations need to create a better knowledge of service system scaling and lifecycle. Law and political science need to build a better comprehension of social innovation and the way that legislation can improve service system productivity. Complex systems engineering should provide more specific insights into the robustness of service systems.

More fundamental challenges

In addition to challenges within disciplines, there are more fundamental challenges in integrating various strands of knowledge. Specialisation remains important, but one shortcoming is that each discipline tends to focus on particular configurations of resources. And academics have well defined research agendas to deal with discipline-specific issues. The complexity of service systems, however, requires an integrated approach.

The key to understanding service systems is not just to examine one aspect of service but rather to consider service as a system of interacting parts. As service systems become more complex, our ability to understand them is hampered by the isolation of different disciplines. The hard work of creating an integrated theory that spans many disciplines has not been done.

Causes of the knowledge gap

The current situation stems from the tradition that academic institutions are structured along disciplines and sub-disciplines. Academic silos are created to encourage deeper understanding of a specialised subject (see Figure 1). The expectation from institutions and funding bodies is that academics conduct research and provide courses within their disciplines. Although often addressing similar matters, each discipline or department usually has a presumed set of interests, paradigms and methodologies. Over time, academics see interdisciplinary research as being highly risky and potentially career-damaging.

As a result, there is an imbalance in service research; studies tend to focus on either customers from a marketing perspective or providers from an operations perspective. This is reflected, and indeed reinforced, by top journals, which tend to be highly specialised. In operations management journals, for example, less than 20 per cent of the papers focus on service topics although the majority of the economy is service-based. Moreover, disciplines also tend to focus on specific sectors; marketing tends to be concerned with business-to-consumer and operations with business-to-business. Gradually, a gap has emerged between academic output and practical interest.

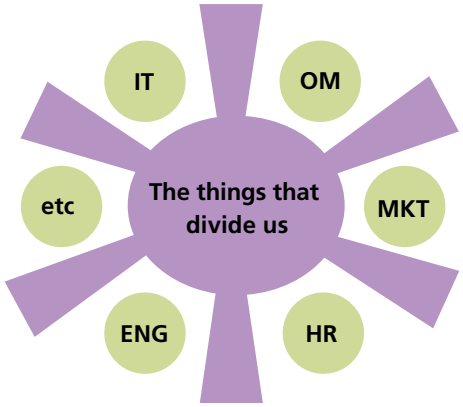


Figure 1 The gaps between academic disciplines

3.3 Where is the skill gap?

Similarly, the supply of people with the right skills is increasingly inadequate. The role of education in the 20th century was in a large part to prepare students for jobs. Universities have been rewarded for creating people with specialised knowledge. The increasing complexity of service systems, however, requires an extended role of education in the 21st century - universities must prepare people to be adaptive innovators.

Adaptive innovators are still deeply educated in their home disciplines. However, they also have the ability to think and act across multiple disciplines. They can build consensus across functional silos and work across inter-organisational boundaries. They can communicate with specialists who do not necessarily have the same background. They embrace a service mindset, which is supported by intellectual, psychological and social capital components. They are driven by an integrative 'service logic' rather than one of the competing logics associated with organisational functions and units. As the service economy continues to grow, adaptive innovators will be in high demand.

4. Working together to bridge the gaps

4.1 What are the possible approaches to addressing the gaps?

The gaps in knowledge and skills needed to deal with complex service systems indicate that we need to reassess our approach to research and education. Figure 2 shows three possible routes to address the gaps. To some people, Service Science is seen as a *multidisciplinary* 'superset' embracing all appropriate, but as yet not agreed, disciplines and functions. To others, Service Science is seen as a multidisciplinary 'subset' embracing select elements of the major disciplines and functions. Finally, Service Science can be seen as an *interdisciplinary* activity which attempts to create an appropriate set of new knowledge to bridge and integrate various areas based on *transdisciplinary* and *crossdisciplinary* collaboration.

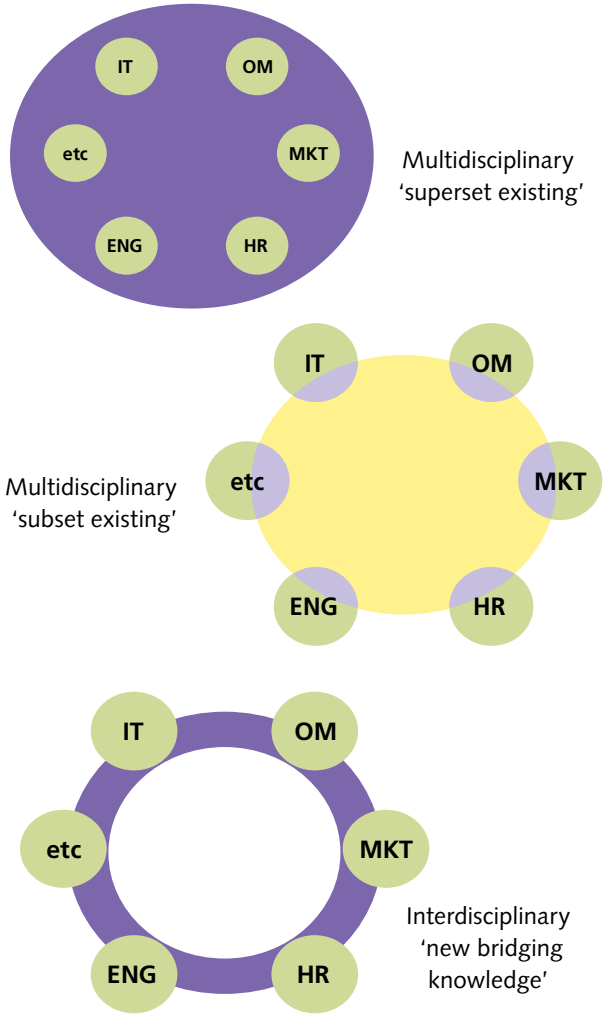


Figure 2 Three perspectives of Service Science

The interdisciplinary approach

In this document we advocate the interdisciplinary approach. Since many barriers to integration are well established, attempts to remove them would not only require considerable effort but deflect attention from purposeful bridging activities. Therefore, one way to overcome the barriers is to accept their existence and build bridges over them. This approach will lead to

> "curricula, training, and research programs that are designed to teach individuals to apply scientific, engineering, and management disciplines that integrate elements of computer science, operations research, industrial engineering, business strategy, management sciences, and social and legal sciences, in order to encourage innovation in how organisations create value for customers and stakeholders that could not be achieved through such disciplines working in isolation" (US Congress HR 2272, 2007).

From a practical perspective, the approach would help develop a rigorous methodology to invest in the improvement of service systems and the design of high-value service offerings. From an academic perspective, the approach would provide a rigorous foundation based on which research and education could be advanced more rapidly.

4.2 Where are the opportunities to address the knowledge gap?

Interdisciplinary activities are not new. They are in evidence in many universities and industries. Indeed, there is an established body of knowledge about how to undertake interdisciplinary work, which can be adapted to service research. Opportunities exist at all levels to address the barriers between disciplines.

Individual: Leaders in academia, business and government are well positioned to highlight the value of interdisciplinary work and to reduce the risks associated with moving outside a specialism or discipline. They can help articulate challenges in service innovation. The potential of service science to improve business as well as society will attract sophisticated and capable people to the field.

Structural: Interdisciplinary interactions happen at a project or activity level. Cross-functional teamwork on specific projects with common goals encourages mutual awareness and creates respect for other disciplines. A shared belief in customers-provider interactions can provide a useful starting point. Exemplary projects in the form of case studies can stimulate more cooperative behaviours with common purpose across disciplines

or functions. However, rigour and relevance in interdisciplinary research is still important in order to generate robust and reliable knowledge.

Business: Business challenges are often interdisciplinary and cross-functional. Business problems commonly require participants with different disciplinary backgrounds to learn enough about each other's perspective in order to achieve effective and productive work. Problems should be clearly expressed in the business context, which demonstrates that no single academic community has exclusive 'ownership' of the problems. Businesses can also supply hard data for academic research to reach robust and practical conclusions. Industrial structures focused on service are already emerging, through which businesses can encourage the development of business professionals and academic fellows in service, and the cultivation of a service ethos. Employment policies should start to include psychological and emotional qualities into the assessment of existing employees as well as the recruitment process.

Academia: Leading journals in the field of service research are extremely influential in setting the tone and agenda of academic research. They are uniquely placed to encourage interdisciplinary studies. Major specialised journals should be encouraged to initiate special issues on interdisciplinary topics. This is not straightforward; more work is needed to define precisely what constitutes 'good' interdisciplinary research. One of the tools that can be used is web-based communication. This could enable the required multidisciplinary social networks to form as needed and facilitate the shift from knowledge silos to webs of knowledge.

Funding and Incentives: Except in certain areas of physics and mathematics, little is known about the methods needed to create integrated yet parsimonious theories that span multiple areas. Besides discipline-specific studies, funding should also be provided to support interdisciplinary service research through mechanisms such as dual appointments and shared rewards. Funding bodies should introduce interdisciplinary requirements into the proposal assessment and therefore encourage interdisciplinary studies. Close partnerships between funding bodies and industry stakeholders can help academics to develop relevant research agenda. This will lead to the development of interdisciplinary tools, models and frameworks that reflect interactions between a firm's different departments and its external partners.

4.3 Where are the opportunities to address the skill gap?

Developing T-shaped professionals

Discipline-based education remains a vital role of modern universities. In order to close the skill gap, however, universities should also offer students the opportunity to gain qualifications in the interdisciplinary requirements of SSME. Such qualifications would equip graduates with the concepts and vocabulary to discuss the design and improvement of service systems with peers from other disciplines. Industry refers to these people as T-shaped professionals, who are deep problem solvers in their home discipline but also capable of interacting with and understanding specialists from a wide range of disciplines and functional areas.

Widely recognised SSME programmes would help ensure the availability of a large population of T-shaped professionals (from many home disciplines) with the ability to collaborate to create service innovations. SSME qualifications would indicate that these graduates could communicate with scientists, engineers, managers, designers, and many others involved in service systems. Graduates with SSME qualifications would be well prepared to 'hit the ground running', able to become immediately productive and make significant contributions when joining a service innovation project.

Support needed from business and government

Establishing SSME qualifications is a challenging task. Interdisciplinary course development requires significant effort to develop because different faculty members might find it hard to work together sustainably over time. Educational innovations are vulnerable because they are often reliant on the efforts of one or two people. Interdisciplinary programmes are even harder to organise, and more expensive to initiate and maintain, than conventional ones. Rapid progress in the design and delivery of these programmes would require support and resources from business and government.

5. Recommendations

In many ways, Service Science is in a similar position to the science, management and engineering of agriculture and manufacturing two centuries ago. Although better tools and information systems may exist today to develop Service Science, the problems facing service scientists are far more complex.

However, even though the service sector contributes over two thirds of GDP and employment in developed economies, investment in services accounts for less than one third of total R&D expenditure. To address this imbalance, we urge the development of service innovation roadmaps, leading to a doubling of service R&D investment, as well as specific government programmes to support service innovation.

The following recommendations are offered as a point of departure for a more inclusive conversation as various stakeholders start to formulate action plans for service innovation (see Appendix VII: Example of innovation roadmap).

5.1 Recommendations for education

1 ***Enable graduates from various disciplines to become T-shaped professionals, who are adaptive innovators with a service mindset and can make early contributions to the service-driven economy.***

All students and employees, who wish to, should have the opportunity to learn about Service Science and develop themselves into T-shaped professionals. This can be achieved by adding SSME qualifications to an existing deep home discipline of study. As adaptive innovators, they will have a good background in the fundamentals of service innovation. With a service mindset, they can work effectively in project teams across discipline and functional silos. As research creates a truly integrated theory of service systems, students of Service Science will become system thinkers prepared to succeed in a 21st century service-driven globally integrated economy.

2 ***Promote SSME education programmes and qualifications as a way of developing a service mindset, in conjunction with industry recognition and recruitment of SSME qualified graduates.***

SSME qualifications, which we see as critical to developing adaptive innovators with a mindset for service innovation, should include interactional skills across the main disciplines of Service Science. Interactional skills enable proficiency in the concepts and vocabulary for framing problems and discussing potential solutions across disciplines.

The main disciplines of Service Science include service economics, service marketing, service operations, service management, service quality (especially customer satisfaction), service strategy, service engineering, service human resource management (especially in a professional service firm), service computing, service supply chain (especially eSourcing), service design, service productivity, and service measurement.

Within the disciplinary areas, additional topics include service process analysis, SERVQUAL and TQM (including when to use and when not to use these methods), Lean and Six Sigma, servicisation, self service, integrating competing logics of different disciplines, managing the service experience over time, managing service failure and recovery, managing organisational change, and service provisioning (including interpersonal skills such as cross-functional teamwork and conflict resolution).

Many universities are piloting SSME-related courses, programmes and degrees, so a wealth of materials is being created. Much remains yet to done in order to establish standard curricula templates and associated quality standards.

3 ***Develop a modular template-based SSME curriculum in higher education, add new materials and refinements as research develops over time, and then extend to all levels of education.***

SSME qualifications should employ a template-based curriculum model and specify modules that can be switched in and out across different faculty and courses. Practical or industry capstone projects are essential for students to develop a service mindset and to acquire the ability to solve problems cross-functionally in real-time.

Capstone projects could help prepare students to become adaptive innovators with a balance of practical and theoretical knowledge of service systems. They also allow students to see service systems in action. The design and provisioning of such projects should ideally involve student teams with members from different areas, including business, engineering, social sciences and information science, and sometimes from different universities.

The design of Service Science laboratory space would enable small multidisciplinary project teams to work together with collaborators in remote locations. Service Science labs should focus on entrepreneurial projects.

Support should be given to tele-presence meetings and the design of remote collaborations. Projects should especially be encouraged to link service systems in the real world, those in virtual worlds and those in simulated worlds.

Along with the development of SSME curriculum at the university level, attention should also be given to primary and secondary education. Students should be encouraged to work in teams and explore ways to improve the service systems around them.

4 ***Explore new teaching methods for SSME related education.***

SSME qualifications should be accessible through a range of channels, including on-line eLearning and virtual worlds. They should offer access to cases, simulations, and lab activities in major sectors of the modern economy, including the public sectors (government and security, healthcare and education, environment and recreation), commercial sectors (retail and franchise, hospitality and entertainment), information sectors (financial and banking, consulting and professional, media and internet), and infrastructure sectors (transportation and communications, utilities and construction, manufacturing and mining).

5.2 Recommendations for research

1 ***Develop an inclusive interdisciplinary and intercultural approach to service research.***

Many of the pioneering service research journals and conferences have made this a stated priority. However, much more needs to be done to measure and reward efforts that increase the actual amount of interdisciplinary and intercultural work in this emerging field.

2 ***Build bridges between disciplines through grand research challenges.***

With good architecture, we would be able to reduce a complex problem to separable components. However, when decomposition is not fully effective or has enormous complexity associated with it, a deeper foundational understanding is often needed. Researchers from multiple disciplines should look for opportunities to bridge between disciplines, especially in the context of grand research challenges that span multiple disciplines.

3 ***Establish service system and value proposition as foundational concepts.***

Every science must clearly define its boundaries in terms of the entities that it studies and the relevant interactions between those entities. Service systems and value propositions represent a starting point for Service Science.

4 ***Work with practitioners to create data sets to better understand the nature and behaviour of service systems.***

Much real world data about service systems often has a proprietary nature and security concerns associated with it. The confidential feature of the data may require novel methods of archiving and releasing. Unlike many other subjects, service science researchers must focus their efforts on establishing appropriate legal, social, and economic conventions around data sharing for specific purposes.

5 ***Create modelling and simulations tools for service systems.***

Perhaps more than any other subjects, advancement in Service Science depends on models and simulations of alternative service systems designs. When data are not readily available, service practitioners need simulation tools to support their decision-making processes.

5.3 Recomendations for business

1 ***Establish employment policies and career paths for T-shaped professionals.***

Businesses should define career paths for T-shape professionals and indicate their preference for SSME qualifications in recruitment. This would demonstrate the demand for academic programmes and encourage the formation of interdisciplinary Service Science communities.

2 ***Review existing approaches to service innovation and provide grand challenges for service systems research.***

Understanding, modelling and measuring service activities that take place in business today is already underway; for example, activity-based costing and service-oriented architecture. Despite promising progress, surprisingly little is known about (a) how to make optimal investment for service innovation, (b) how to scale up margins as service revenues increase, (c) how to systematically reduce the complexity of service systems, and (d) how to devise measurement

systems that can be used internally and shared externally to protect privacy and preserve competitive advantage. These issues are potential grand challenges for multidisciplinary research teams to work on.

3 ***Provide funding for service systems research.***

Businesses should provide funding for service systems research, directly through many regional industry-academic-government collaboration forums, or indirectly via global organisations such as the Service Research and Innovation Initiative (SRII). A starting point is to establish benchmarks on the level of service research investment compared to other areas.

4 ***Develop appropriate organisational arrangements to enhance industry-academic collaboration.***

Businesses can also encourage employees to participate in SSME relevant conferences and to support academic SSME programmes with the latest projects and case studies. Tools, methods and data sets related to SSME are an ideal focus for business-academic collaborations to stimulate rapid progress.

5 ***Work with stakeholders to include sustainability measures and create actionable service innovation roadmaps.***

As sustainability becomes an increasingly urgent global concern, businesses should take the opportunity to expand the definition of stakeholder value to include new measures. More emphasis should be placed on the balance between efficiency, effectiveness and sustainability. Roadmaps for service innovation should include updated performance measures and adjust mechanisms of measurement.

5.4 Recommendations for government

1 ***Promote service innovation for all parts of the economy and provide funding for SSME education and research.***

Service innovation is still poorly understood considering its growing importance to the economy. Nevertheless, history has shown that focused research and development efforts can advance science and build a body of knowledge with long-term practical benefits. The separate discipline areas of service research have developed to a point that an integrated theory is within reach. National funding for university-based research in Service Science is critical and has far-reaching benefits for economy and society. Cataloguing existing funding opportunities and increasing the level of national funding in Service Science are important steps in advancing research and academic curricula.

2 ***Demonstrate the value of Service Science to government agencies, and thereby create methods, data sets, and tools to inform and challenge current education and research support.***

Improvements in government service systems, which employ over 20% of the populations in some nations, would lead to a ripple effect through the rest of the economy. As with business stakeholders, government agencies are well positioned to challenge existing education and research efforts.

3 ***Develop relevant measurements and reliable data on knowledge-intensive service activities across sectors to underpin leading practice for service innovation.***

Measuring service activities across sectors of the economy to better understand service quality, productivity, regulatory compliance, and sustainable innovation is an important starting point. More funding is needed for nationally directed data collection about multiple aspects of the service economy, including employment, skills and career paths, exports, investment, pricing, and IT-enabled activities, among others.

4 ***Make government service systems more comprehensive and citizen-responsive.***

Government service systems are especially in need of comprehensive review by engaging citizens concerned. A first step is to change the orientation of existing service systems from a provider-centric one to a citizen-centric one.

5 ***Encourage public hearings, workshops, briefings with other stakeholders to develop service innovation roadmaps.***

It is critical to carry out a review of service innovation roadmaps for collaborations between academia, industry and government. Priority should be given to investment, legislative and policy initiatives that can systematically support the growth of the knowledge economy (knowledge creation) and the service economy (knowledge application to create value).

6. Taking it forward

Over one hundred people have contributed their knowledge and experience to the issues discussed in this document. However, we are acutely aware that our journey to develop a Service Science is far from complete (see Appendix VIII: Ongoing debate). We see this white paper as just a step in an ongoing dialogue that will engage many more stakeholders who seek to improve service systems and to develop successful adaptive innovators.

This document will be widely distributed to universities, research institutions, business organisations, non-profit organisations, government departments and agencies. We will continue to challenge academics, researchers, practitioners and policy makers to perform or support the interdisciplinary work needed to lead to a breakthrough in Service Science and bring about the positive impact on business and society that more systematic and sustainable service innovations could achieve.

Adam Smith laid the foundations of modern economics with his exploration of division of labour (specialists) and its role in creating the wealth of nations. Our consensus is that today, to grow the wealth of nations sustainably, we must become far more systematic about service innovation in a world of increasing division of labour and specialization (Smith was right, in part). Nevertheless, the foundations of Service Science are based on the premise of the need for knowledge integration (adaptive innovators, SSME T-shaped professionals).

We know division of labour alone is not the answer to increasing value creation capacity of nations (or else we would still be using scribes for our record keeping and communications!). We need both specialization and integration to solve the complex coordination problems of applying new knowledge to improve service systems and that value propositions that interconnect them.

We continue to invite feedback on this important topic and comments on this document are welcome.
Please find further information at:

www.ifm.eng.cam.ac.uk/ssme
www.research.ibm.com/ssme

INNOVATION

DESIGN THINKING

BY TIM BROWN

FROM THE JUNE 2008 ISSUE

Thomas Edison created the electric lightbulb and then wrapped an entire industry around it. The lightbulb is most often thought of as his signature invention, but Edison understood that the bulb was little more than a parlor trick without a system of electric power generation and transmission to make it truly useful. So he created that, too.

Thus Edison's genius lay in his ability to conceive of a fully developed marketplace, not simply a discrete device. He was able to envision how people would want to use what he made, and he engineered toward that insight. He wasn't always prescient (he originally believed the phonograph would be used mainly as a business machine for recording and replaying dictation), but he invariably gave great consideration to users' needs and preferences.

Edison's approach was an early example of what is now called "design thinking"—a methodology that imbues the full spectrum of innovation activities with a human-centered design ethos. By this I mean that innovation is powered by a thorough understanding, through direct observation, of what people want and need in their lives and what they like or dislike about the way particular products are made, packaged, marketed, sold, and supported.

Many people believe that Edison's greatest invention was the modern R&D laboratory and methods of experimental investigation. Edison wasn't a narrowly specialized scientist but a broad generalist with a shrewd business sense. In his Menlo Park, New Jersey, laboratory he surrounded himself with gifted tinkerers, improvisers, and experimenters. Indeed, he broke the mold of the "lone genius inventor" by creating a team-based approach to innovation. Although Edison biographers write of the camaraderie enjoyed by this merry band, the process also featured endless rounds of trial and error—the "99% perspiration" in Edison's famous definition of genius. His approach was intended not to validate preconceived hypotheses but to help experimenters learn something new from each iterative stab. Innovation is hard work; Edison made it a profession that blended art, craft, science, business savvy, and an astute understanding of customers and markets.

Design thinking is a lineal descendant of that tradition. Put simply, it is a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity. Like Edison's painstaking innovation process, it often entails a great deal of perspiration.

I believe that design thinking has much to offer a business world in which most management ideas and best practices are freely available to be copied and exploited. Leaders now look to innovation as a principal source of differentiation and competitive advantage; they would do well to incorporate design thinking into all phases of the process.

Getting Beneath the Surface

Historically, design has been treated as a downstream step in the development process—the point where designers, who have played no earlier role in the substantive work of innovation, come along and put a beautiful wrapper around the idea. To be sure, this approach has stimulated market growth in many areas by making new products and technologies aesthetically attractive and therefore more desirable to consumers or by enhancing brand perception through smart, evocative advertising and communication strategies. During the latter half of the twentieth century design became an increasingly valuable competitive asset in, for example, the consumer electronics, automotive, and consumer packaged goods industries. But in most others it remained a late-stage add-on.

Now, however, rather than asking designers to make an already developed idea more attractive to consumers, companies are asking them to create ideas that better meet consumers' needs and desires. The former role is tactical, and results in limited value creation; the latter is strategic, and leads to dramatic new forms of value.

Moreover, as economies in the developed world shift from industrial manufacturing to knowledge work and service delivery, innovation's terrain is expanding. Its objectives are no longer just physical products; they are new sorts of processes, services, IT-powered interactions, entertainments, and ways of communicating and collaborating—exactly the kinds of human-centered activities in which design thinking can make a decisive difference. (See the sidebar "A Design Thinker's Personality Profile.")

Consider the large health care provider Kaiser Permanente, which sought to improve the overall quality of both patients' and medical practitioners' experiences. Businesses in the service sector can often make significant innovations on the front lines of service creation and delivery. By teaching design thinking techniques to nurses, doctors, and administrators, Kaiser hoped to inspire its practitioners to contribute new ideas. Over the course of several months Kaiser teams participated in workshops with the help of my firm, IDEO, and a group of Kaiser coaches. These workshops led to a portfolio of innovations, many of which are being rolled out across the company.

One of them—a project to reengineer nursing-staff shift changes at four Kaiser hospitals—perfectly illustrates both the broader nature of innovation "products" and the value of a holistic design approach. The core project team included a strategist (formerly a nurse), an organizational-development specialist, a technology expert, a process designer, a union representative, and designers from IDEO. This group worked with innovation teams of frontline practitioners in each of the four hospitals.

During the earliest phase of the project, the core team collaborated with nurses to identify a number of problems in the way shift changes occurred. Chief among these was the fact that nurses routinely spent the first 45 minutes of each shift at the nurses' station debriefing the departing shift about the status of patients. Their methods of information exchange were different in every hospital, ranging from recorded dictation to face-to-face conversations. And they compiled the information they needed to serve patients in a variety of ways—scrawling quick

notes on the back of any available scrap of paper, for example, or even on their scrubs. Despite a significant investment of time, the nurses often failed to learn some of the things that mattered most to patients, such as how they had fared during the previous shift, which family members were with them, and whether or not certain tests or therapies had been administered. For many patients, the team learned, each shift change felt like a hole in their care. Using the insights gleaned from observing these important times of transition, the innovation teams explored potential solutions through brainstorming and rapid prototyping. (Prototypes of a service innovation will of course not be physical, but they must be tangible. Because pictures help us understand what is learned through prototyping, we often videotape the performance of prototyped services, as we did at Kaiser.)

Prototyping doesn't have to be complex and expensive. In another health care project, IDEO helped a group of surgeons develop a new device for sinus surgery. As the surgeons described the ideal physical characteristics of the instrument, one of the designers grabbed a whiteboard marker, a film canister, and a clothespin and taped them together. "Do you mean like this?" he asked. With his rudimentary prototype in hand, the surgeons were able to be much more precise about what the ultimate design should accomplish.

The surgeons described a new device for sinus surgery. One designer grabbed a marker, a film canister, and a clothespin and taped them together. "Do you mean like this?" he asked.

Prototypes should command only as much time, effort, and investment as are needed to generate useful feedback and evolve an idea. The more "finished" a prototype seems, the less likely its creators will be to pay attention to and profit from feedback. The goal of prototyping isn't to finish. It is to learn about the strengths and weaknesses of the idea and to identify new directions that further prototypes might take.

The design that emerged for shift changes had nurses passing on information in front of the patient rather than at the nurses' station. In only a week the team built a working prototype that included new procedures and some simple software with which nurses could call up previous shift-change notes and add new ones. They could input patient information throughout a shift rather than scrambling at the end to pass it on. The software collated the data in a simple format customized for each nurse at the start of a shift. The result was both higher-quality knowledge transfer and reduced prep time, permitting much earlier and better-informed contact with patients.

As Kaiser measured the impact of this change over time, it learned that the mean interval between a nurse's arrival and first interaction with a patient had been more than halved, adding a huge amount of nursing time across the four hospitals. Perhaps just as important was the effect on the quality of the nurses' work experience. One nurse commented, "I'm an hour ahead, and I've only been here 45 minutes." Another said, "[This is the] first time I've ever made it out of here at the end of my shift."

Thus did a group of nurses significantly improve their patients' experience while also improving their own job satisfaction and productivity. By applying a human-centered design methodology,

they were able to create a relatively small process innovation that produced an outsize impact. The new shift changes are being rolled out across the Kaiser system, and the capacity to reliably record critical patient information is being integrated into an electronic medical records initiative at the company.

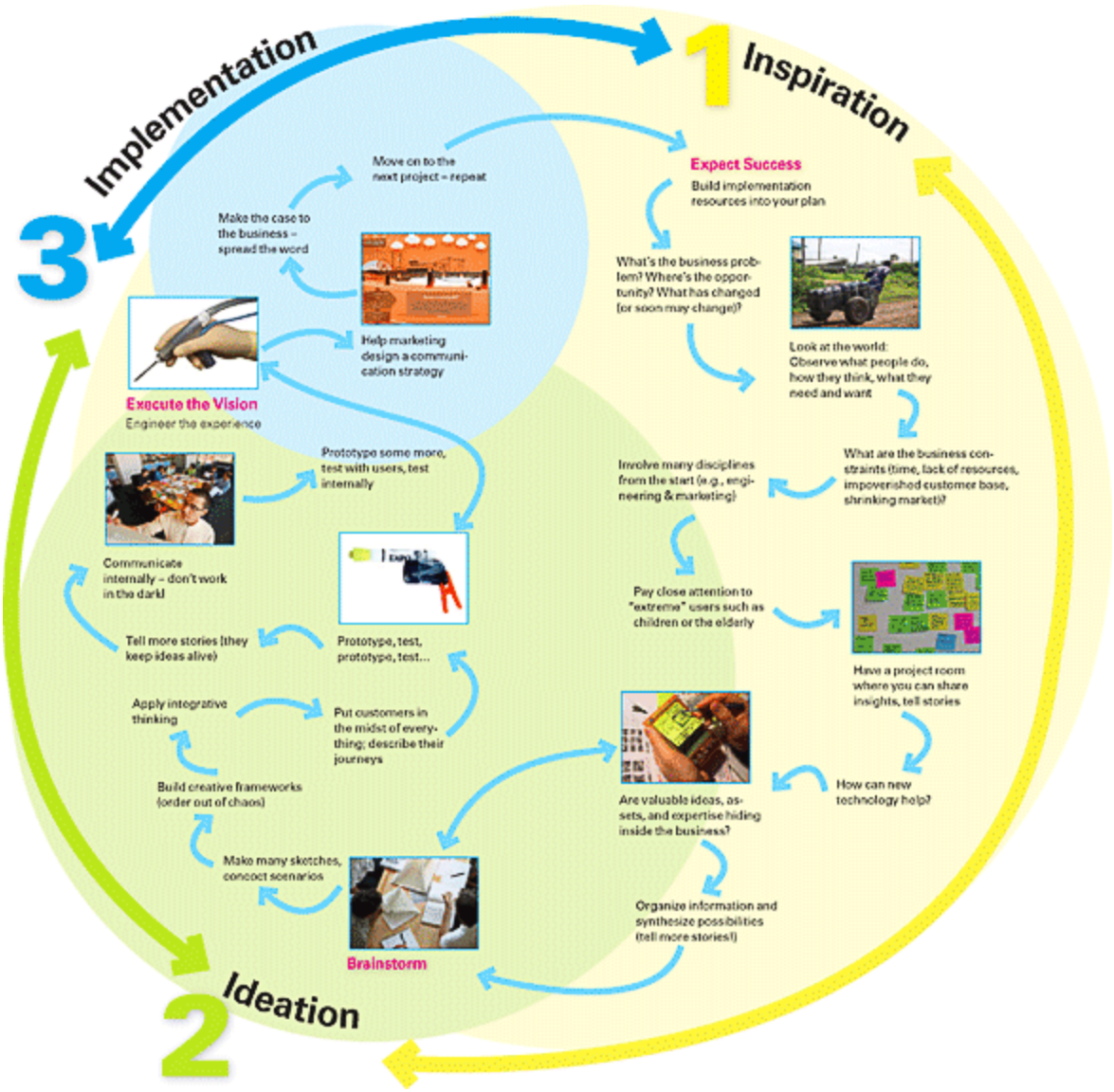
What might happen at Kaiser if every nurse, doctor, and administrator in every hospital felt empowered to tackle problems the way this group did? To find out, Kaiser has created the Garfield Innovation Center, which is run by Kaiser's original core team and acts as a consultancy to the entire organization. The center's mission is to pursue innovation that enhances the patient experience and, more broadly, to envision Kaiser's "hospital of the future." It is introducing tools for design thinking across the Kaiser system.

How Design Thinking Happens

The myth of creative genius is resilient: We believe that great ideas pop fully formed out of brilliant minds, in feats of imagination well beyond the abilities of mere mortals. But what the Kaiser nursing team accomplished was neither a sudden breakthrough nor the lightning strike of genius; it was the result of hard work augmented by a creative human-centered discovery process and followed by iterative cycles of prototyping, testing, and refinement.

The design process is best described metaphorically as a system of spaces rather than a predefined series of orderly steps. The spaces demarcate different sorts of related activities that together form the continuum of innovation. Design thinking can feel chaotic to those experiencing it for the first time. But over the life of a project participants come to see—as they did at Kaiser—that the process makes sense and achieves results, even though its architecture differs from the linear, milestone-based processes typical of other kinds of business activities.

Design projects must ultimately pass through three spaces (see the exhibit "Inspiration, Ideation, Implementation"). We label these "inspiration," for the circumstances (be they a problem, an opportunity, or both) that motivate the search for solutions; "ideation," for the process of generating, developing, and testing ideas that may lead to solutions; and "implementation," for the charting of a path to market. Projects will loop back through these spaces—particularly the first two—more than once as ideas are refined and new directions taken.



Inspiration, Ideation, Implementation

Sometimes the trigger for a project is leadership's recognition of a serious change in business fortunes. In 2004 Shimano, a Japanese manufacturer of bicycle components, faced flattening growth in its traditional high-end road-racing and mountain-bike segments in the United States. The company had always relied on technology innovations to drive its growth and naturally tried to predict where the next one might come from. This time Shimano thought a high-end casual bike that appealed to boomers would be an interesting area to explore. IDEO was invited to collaborate on the project.

During the inspiration phase, an interdisciplinary team of IDEO and Shimano people—designers, behavioral scientists, marketers, and engineers—worked to identify appropriate constraints for the project. The team began with a hunch that it should focus more broadly than on the high-end market, which might prove to be neither the only nor even the best source of new growth. So it

set out to learn why 90% of American adults don't ride bikes. Looking for new ways to think about the problem, the team members spent time with all kinds of consumers. They discovered that nearly everyone they met rode a bike as a child and had happy memories of doing so. They also discovered that many Americans are intimidated by cycling today—by the retail experience (including the young, Lycra-clad athletes who serve as sales staff in most independent bike stores); by the complexity and cost of the bikes, accessories, and specialized clothing; by the danger of cycling on roads not designed for bicycles; and by the demands of maintaining a technically sophisticated bike that is ridden infrequently.

This human-centered exploration—which took its insights from people outside Shimano's core customer base—led to the realization that a whole new category of bicycling might be able to reconnect American consumers to their experiences as children while also dealing with the root causes of their feelings of intimidation—thus revealing a large untapped market.

The design team, responsible for every aspect of what was envisioned as a holistic experience, came up with the concept of "Coasting." Coasting would aim to entice lapsed bikers into an activity that was simple, straightforward, and fun. Coasting bikes, built more for pleasure than for sport, would have no controls on the handlebars, no cables snaking along the frame. As on the earliest bikes many of us rode, the brakes would be applied by backpedaling. With the help of an onboard computer, a minimalist three gears would shift automatically as the bicycle gained speed or slowed. The bikes would feature comfortably padded seats, be easy to operate, and require relatively little maintenance.

Three major manufacturers—Trek, Raleigh, and Giant—developed new bikes incorporating innovative components from Shimano. But the design team didn't stop with the bike itself. In-store retailing strategies were created for independent bike dealers, in part to alleviate the discomfort that biking novices felt in stores designed to serve enthusiasts. The team developed a brand that identified Coasting as a way to enjoy life. ("Chill. Explore. Dawdle. Lollygag. First one there's a rotten egg.") And it designed a public relations campaign—in collaboration with local governments and cycling organizations—that identified safe places to ride.

Although many others became involved in the project when it reached the implementation phase, the application of design thinking in the earliest stages of innovation is what led to this complete solution. Indeed, the single thing one would have expected the design team to be responsible for—the look of the bikes—was intentionally deferred to later in the development process, when the team created a reference design to inspire the bike companies' own design teams. After a successful launch in 2007, seven more bicycle manufacturers signed up to produce Coasting bikes in 2008.

Taking a Systems View

Many of the world's most successful brands create breakthrough ideas that are inspired by a deep understanding of consumers' lives and use the principles of design to innovate and build value. Sometimes innovation has to account for vast differences in cultural and socioeconomic conditions. In such cases design thinking can suggest creative alternatives to the assumptions made in developed societies.

India's Aravind Eye Care System is probably the world's largest provider of eye care. From April 2006 to March 2007 Aravind served more than 2.3 million patients and performed more than 270,000 surgeries. Founded in 1976 by Dr. G. Venkataswamy, Aravind has as its mission nothing less than the eradication of needless blindness among India's population, including the rural poor, through the effective delivery of superior ophthalmic care. (One of the company's slogans is "Quality is for everyone.") From 11 beds in Dr. Venkataswamy's home, Aravind has grown to encompass five hospitals (three others are under Aravind management), a plant that manufactures ophthalmic products, a research foundation, and a training center.

Aravind's execution of its mission and model is in some respects reminiscent of Edison's holistic concept of electric power delivery. The challenge the company faces is logistic: how best to deliver eye care to populations far removed from the urban centers where Aravind's hospitals are located. Aravind calls itself an "eye care system" for a reason: Its business goes beyond ophthalmic care per se to transmit expert practice to populations that have historically lacked access. The company saw its network of hospitals as a beginning rather than an end.

Much of its innovative energy has focused on bringing both preventive care and diagnostic screening to the countryside. Since 1990 Aravind has held "eye camps" in India's rural areas, in an effort to register patients, administer eye exams, teach eye care, and identify people who may require surgery or advanced diagnostic services or who have conditions that warrant monitoring.

In 2006 and early 2007 Aravind eye camps screened more than 500,000 patients, of whom nearly 113,000 required surgery. Access to transportation is a common problem in rural areas, so the company provides buses that take patients needing further treatment to one of its urban facilities and then home again. Over the years it has bolstered its diagnostic capabilities in the field with telemedicine trucks, which enable doctors back at Aravind's hospitals to participate in care decisions. In recent years Aravind's analysis of its screening data has led to specialized eye camps for certain demographic groups, such as school-age children and industrial and government workers; the company also holds camps specifically to screen for eye diseases associated with diabetes. All these services are free for the roughly 60% of patients who cannot afford to pay.

In developing its system of care, Aravind has consistently exhibited many characteristics of design thinking. It has used as a creative springboard two constraints: the poverty and remoteness of its clientele and its own lack of access to expensive solutions. For example, a pair of intraocular lenses made in the West costs $200, which severely limited the number of patients Aravind could help. Rather than try to persuade suppliers to change the way they did things, Aravind built its own solution: a manufacturing plant in the basement of one of its hospitals. It eventually discovered that it could use relatively inexpensive technology to produce lenses for $4 a pair.

Throughout its history—defined by the constraints of poverty, ignorance, and an enormous unmet need—Aravind has built a systemic solution to a complex social and medical problem.

Getting Back to the Surface

I argued earlier that design thinking can lead to innovation that goes beyond aesthetics, but that doesn't mean that form and aesthetics are unimportant. Magazines like to publish photographs of the newest, coolest products for a reason: They are sexy and appeal to our emotions. Great design satisfies both our needs and our desires. Often the emotional connection to a product or an image is what engages us in the first place. Time and again we see successful products that were not necessarily the first to market but were the first to appeal to us emotionally *and* functionally. In other words, they do the job and we love them. The iPod was not the first MP3 player, but it was the first to be delightful. Target's products appeal emotionally through design and functionally through price—simultaneously.

This idea will grow ever more important in the future. As Daniel Pink writes in his book *A Whole New Mind*, "Abundance has satisfied, and even over-satisfied, the material needs of millions—boosting the significance of beauty and emotion and accelerating individuals' search for meaning." As more of our basic needs are met, we increasingly expect sophisticated experiences that are emotionally satisfying and meaningful. These experiences will not be simple products. They will be complex combinations of products, services, spaces, and information. They will be the ways we get educated, the ways we are entertained, the ways we stay healthy, the ways we share and communicate. Design thinking is a tool for imagining these experiences as well as giving them a desirable form.

One example of experiential innovation comes from a financial services company. In late 2005 Bank of America launched a new savings account service called "Keep the Change." IDEO, working with a team from the bank, helped identify a consumer behavior that many people will recognize: After paying cash for something, we put the coins we received in change into a jar at home. Once the jar is full, we take the coins to the bank and deposit them in a savings account. For many people, it's an easy way of saving. Bank of America's innovation was to build this behavior into a debit card account. Customers who use their debit cards to make purchases can now choose to have the total rounded up to the nearest dollar and the difference deposited in their savings accounts.

The success of this innovation lay in its appeal to an instinctive desire we have to put money aside in a painless and invisible way. Keep the Change creates an experience that feels natural because it models behavior that many of us already exhibit. To be sure, Bank of America sweetens the deal by matching 100% of the change saved in the first three months and 5% of annual totals (up to $250) thereafter. This encourages customers to try it out. But the real payoff is emotional: the gratification that comes with monthly statements showing customers they've saved money without even trying.

In less than a year the program attracted 2.5 million customers. It is credited with 700,000 new checking accounts and a million new savings accounts. Enrollment now totals more than 5 million people who together have saved more than $500 million. Keep the Change demonstrates that design thinking can identify an aspect of human behavior and then convert it into both a customer benefit and a business value.

Thomas Edison represents what many of us think of as a golden age of American innovation—a time when new ideas transformed every aspect of our lives. The need for transformation is, if

anything, greater now than ever before. No matter where we look, we see problems that can be solved only through innovation: unaffordable or unavailable health care, billions of people trying to live on just a few dollars a day, energy usage that outpaces the planet's ability to support it, education systems that fail many students, companies whose traditional markets are disrupted by new technologies or demographic shifts. These problems all have people at their heart. They require a human-centered, creative, iterative, and practical approach to finding the best ideas and ultimate solutions. Design thinking is just such an approach to innovation.

A version of this article appeared in the June 2008 issue of *Harvard Business Review*.

Tim Brown, @tceb62 is the CEO and president of IDEO, a global design and innovation and design firm. His book on how design thinking transforms organizations, Change By Design, was released in 2008. His designs have won numerous awards and been exhibited at the Museum of Modern Art in New York, the Axis Gallery in Tokyo, and the Design Museum in London.

the d.school
THE HASSO PLATTNER INSTITUTE OF DESIGN AT STANFORD

The scale and complexity of the challenges facing the world today are unprecedented. Solutions won't come from any single field, but from collaboration between innovators who can see beyond the way the world is to the way it could be. At the same time, students seek a new kind of education that fosters creative confidence and pushes them beyond the boundaries of traditional academic disciplines.

The Hasso Plattner Institute of Design at Stanford was founded in the School of Engineering in 2005 to prepare a generation of innovators to tackle these complex challenges. Known on campus as the d.school, the institute brings students and faculty from radically different backgrounds together to develop innovative, human-centered solutions to real-world challenges. The transformative experiences of students and faculty have fueled the d.school's explosive growth.

Design Thinking

d.school courses and curriculum are based on the *DESIGN THINKING* process. It draws on methods from engineering and design, and combines them with ideas from the arts, tools from the social sciences, and insights from the business world. The process provides a glue that brings teammates together around a common goal: make the lives of the people they're designing for better.

Design thinking is best learned by doing, and our classes immerse students in an experiential learning environment. Students cycle rapidly through a series of steps: observe, brainstorm, synthesize, prototype, and implement; repeating as necessary. We focus on the design process because we seek to equip our students with a methodology for producing reliably innovative results in any field. Our focus is on creating innova*TORS* rather than any particular innova*TION*.

T-Shaped Students

At the d.school, we help to create "T-shaped" students. They bring a deep set of skills, knowledge and approach to problem solving from their own field; we help them develop the breadth and creative confidence to collaborate with people from vastly different disciplines. This equips students to tackle the big, ambiguous challenges they'll encounter out in the world that can't be solved with a single approach.

The d.school does not grant degrees; instead it serves as a university-wide hub for innovation where students from enginering, the arts, medicine, education, law and the social sciences come to take classes together and work on projects. We currently serve over 650 students per year, and demand for our classes continues to outweigh availability.

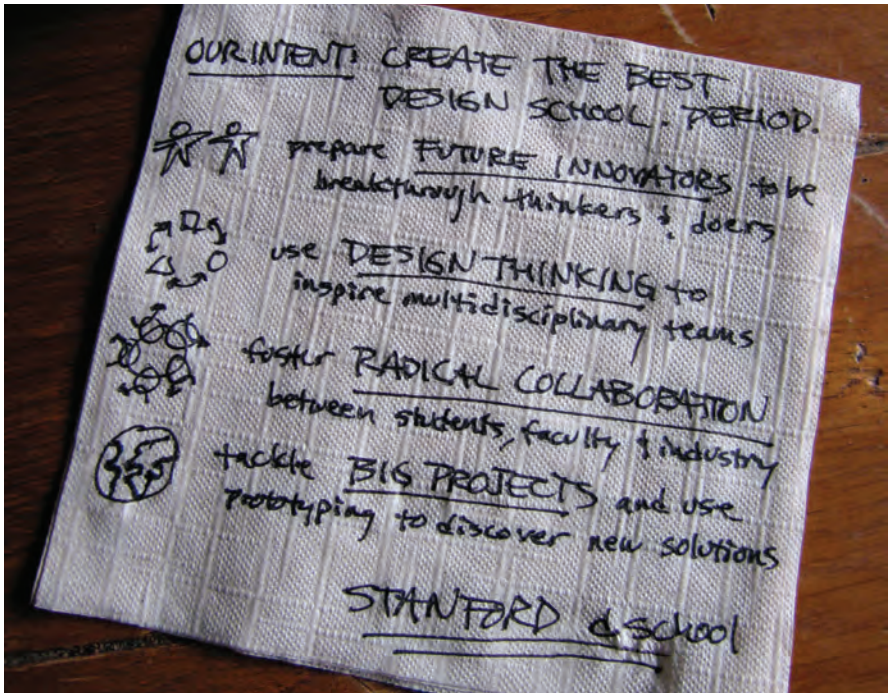
"When I get depressed or worried about something, I often wander over to the d.school...and just hang around for an hour or two. I come away feeling good about life and about the things that Stanford students can create and invent."
— Jim Plummer, Dean of the Stanford School of Engineering

Faculty

We have more than 70 members of our teaching teams drawn from across campus and industry. Every class at the d.school is taught by a team. Some are pioneering research faculty, some are influential practitioners in the field, all are bringing the full benefit of their knowledge to our students. For example, this year noted Stanford political scientist Joshua Cohen and Computer Science pioneer Terry Winograd will teach *Designing Liberation Technology*, exploring how cutting-edge technology can be used to spread development and democracy in Africa.

Partnerships

Our classes require real-world projects and partners to give students the kinds of constraints and environments that teach them to be the innovators of the future. Some of our recent partners include: Facebook, Procter & Gamble, SFMOMA, International Development Enterprises, Kaiser Permanente, Google, Henry Ford Learning Institute, Timbuk2, WalMart, JetBlue Airlines, Mozilla Foundation, and Electronic Arts.



Highlights

• **Entrepreneurial Design for Extreme Affordability** has developed a global reputation for producing innovative solutions to the problems facing people in the developing world; alumni are game-changing social entrepreneurs. Students have started five companies out of the class, including non-profit Embrace, which makes an infant warming device that costs less than 1% of a traditional incubator. This device is positioned to save the lives of 100,000 premature babies in the next three years.

• **k-12 Education:** The d.school's k-12 Lab is bringing design thinking to elementary and high school students around the world. The lab develops curriculum, offers regular teacher workshops, and helps schools as far away as India to create design challenges. The k-12 lab works to help students, teachers and schools foster creativity, and develop the youngest generation of innovators.

• **The Next Generation of Media:** One of the areas where design thinking is being applied is in media and journalism. John Keefe, the Executive Director of New York public radio station WNYC, partnered with our *Media+Design* class to come up with new ideas for a recently launched morning radio show. He now uses design thinking to help transform his organization: "The most effective way I've found to practice design thinking is by showing, not telling. Rather than explaining what it is, I practice it myself and communicate that by saying: 'I can get you results next week.' When I turn around a successful prototype so quickly, people ask: 'How did you do this?' That's when I explain that I'm using this thing called design thinking."

• **Classes, workshops and programs:** The d.school offers more than 30 classes, workshops and programs each year, such as: *Design Thinking Bootcamp, From Play to Innovation, Design for Sustainable Abundance, Improv + Design, No Teacher Left Behind, Personal and Interpersonal Dynamics*, and *Customer-Focused Innovation*, a joint executive education program with the Graduate School of Business at Stanford.

For Press Inquires, please contact Stern & Associates at debbe@debbestern.com

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Recreating Law School

By Brad Feld
October 3, 2013

I spend a lot of time hanging around CU Law School. I know it's a strange place to find a venture capitalist and entrepreneurs, but it happens to be the epicenter of entrepreneurial activity at CU Boulder. I wrote a chapter about this in my book Startup Communities: Building an Entrepreneurial Ecosystem in Your City explaining why and how CU Law has taken a different approach to the engagement of the of a university and the entrepreneurial community.

Step back and think about it a little. A surprising number of entrepreneurs have legal backgrounds. A legal education is a great grounding in systems thinking, which can be applied to many businesses, especially as their scale up dramatically. And, in a world that needs less lawyers and more entrepreneurs, repurposing some of the brightest non-technical graduate students to be entrepreneurs is a neat idea. See – that's not so strange.

Phil Weiser, the Dean of the CU Law School, is a good friend. Phil also totally groks entrepreneurship and is aggressively applying it to the vision, the curriculum, and the operations of CU Law. Following are some thoughts of his that recently appeared in an article in the ABA Journal titled Five initiatives that legal education needs.

Just like every other corner of the profession, legal education is grappling with a New Normal that was barely appreciated as recently as four or five years ago.

Even as law schools welcomed incoming classes this year, the mood has changed. And it's no secret why.

Applications are down nationally for the third year in a row. And larger law firms aresignificantly cutting back on their entry-level hiring. The American Bar Association is also starting to focus on changes to legal education, recently releasing a draft report (PDF) from the Task Force on the Future of Legal Education.

Change is happening, and that's a good thing.

The upside of today's New Normal is that law schools have the opportunity to develop a new generation of lawyers who are more purposeful than ever before about how to develop and navigate their careers. These graduates will be **legal entrepreneurs**. By that, I mean lawyers—whether working in government, nonprofits, law firms, consulting firms, or businesses—who take ownership of their career paths and develop the tool kit necessary to add value and succeed wherever they work. Developing legal entrepreneurs, however, requires a commitment to innovation and experimentation that until recently has not been traditionally associated with legal academia.

To underscore the range of emerging innovations needed in legal academia, consider the following five initiatives now taking place in legal education:

1. Build an entrepreneurial mindset. Training law students to **develop an entrepreneurial mindset** is foundational for the New Normal. The reality is that large law firms are employing fewer and fewer law graduates, and the early interview week model is not what it once was. As such, law schools need to reorient their students' thinking about their careers. An entrepreneurial mindset is a must in the New Normal, and law students need to heed LinkedIn co-founder Reid Hoffman's teachings in *The Start-up of You*. How law schools will transmit those lessons to a notoriously risk-averse group remains to beseen. But

the age of law school as a risk-free option for people who expect a job to be handed to them at the end is over.

2. Challenge employers on entry-level hiring. Challenging employers to think differently about entry-level hiring and summer jobs is a critical to adjusting to the New Normal. The marketplace for legal talent is incredibly traditional, and the resistance of employers to experiment is a formidable challenge to creating new opportunities for recent law school graduates. Most law students would welcome the chance to work at any number of successful law firms or in-house organizations in a temporary capacity over the summer or even upon graduation—even at lower rates than traditional summer associate or associate positions—because such jobs can offer valuable opportunities to build marketable skills and develop important networks, connections, and references. And such opportunities present firms with the chance to use the talents of these students or recent graduates. But a big impediment to developing such an opportunity is that firms often believe that they cannot provide them if they are not prepared to offer a long-term job when the student graduates. A number of law schools are taking this issue head on, such as the Cardozo New Resident Associate Mentor Program and, in Colorado, where both law schools (the University of Colorado and the University of Denver) are collaborating on a Legal Residency program that encourages law firms or other employers to hire a recent graduate for 12 to 18 months, offer a quality experience, and provide apprenticeship outside of the traditional associate track.

3. Compress law school education and couple with experience. Law schools can couple a 2.5 year degree with a quality experience. The opportunity to graduate in 2.5 years, which can be achieved through accelerated schedules that permit saving a semester, is increasingly appealing as tuition costs has risen greatly over the past decade. Law schools encouraging such paths can work with

partners like Cisco's general counsel Mark Chandler, who is welcoming paid interns for seven months at Cisco from June 1st after their second year until the following January, enabling students to graduate not only with less debt, but with more experience.

4. Provide multidisciplinary training. Law schools increasingly are providing their students with multidisciplinary training, including but not limited to key business skills. The New Normal means that "thinking like a lawyer" is not enough; we need lawyers who can "think like clients." For lawyers to understand their clients, they need to learn their businesses. This concept applies to those working in the public sector as well as the private sector; lawyers with domain knowledge of the fields they are practicing in are simply more likely to succeed than those without such knowledge. This means more nontraditional courses, more interdisciplinary courses, and more "boot camp"-type experiences.

5. Engage with the community. Law schools need to engage with their communities, get to know their success stories, and reverse-engineer them. The reality is that law firm hiring is not coming back, and a core challenge for law schools is to develop nontraditional opportunities—such as ones in business development, compliance, human resources, and public policy—for law school graduates with the right skill sets. The challenge is that developing such partnerships and opportunities is a long game. But the forces that shaped today's New Normal were a long time coming; the actions that will enable law schools to adapt will take time as well.

Experimentation, innovation, and the New Normal. In 2008, most law school deans were living in the Old Normal. Today, all law school deans know that they are in a New Normal. The reality is that the shaping of today's environment took place over a long period of time, even if we did realize it while it was happening.

As such, developing a new model will not happen overnight. But momentum is building. The broad outlines of the New Normal—the need for a more entrepreneurial mindset, more community engagement, more multidisciplinary training, and new (and nontraditional) employment pathways—are now taking shape through experiments all over the country. The exciting part of this emerging paradigm is that it is still very much a work in progress, and law schools have the opportunity to develop creative partnerships and innovations to support our students in a changing and challenging environment.