Tufts University

Fletcher School of Law and Diplomacy

Seminar on

Practical Knowledge

EIB B233

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Syllabus: Overview, Requirements and
Daily Assignments

Classroom: Isobe Room

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Note:

A computer assignment is due at
Noon of the day **before** each class.

THIS IS A BASIC COURSE REQUIREMENT.

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Overview

This seminar examines the development of knowledge embodied in artifacts (including physical objects, protocols, and organizations) intended to transform "existing conditions into preferred ones."[1] We are particularly interested in knowledge "inclusively" produced by the many and for the many. Thus, we care more about how ready-to-wear footwear is designed, produced, and sold, than in customizing handcrafted boots for buyers who don't think about the price. Likewise, general tools and techniques commonly used to produce a variety of artifacts are of greater interest than specialized tools. Thus, we are interested in how consumer goods, not just shoes, are designed, produced, and marketed.

By traditional intellectual standards, studying practical knowledge may seem undignified and uninspiring. The ancient Greeks venerated contemplation, music and the other arts, abstract truths, and mathematical reasoning. Merchants and craftsmen (including, presumably, builders of large hollow horses) occupied the bottom rung of Plato's idealized society; their knowledge and toil was but a means towards the realization of the good life by a small enlightened class. Modern society has raised science into the pantheon of the wisdom we venerate. Engineers, physicians, lawyers, entrepreneurs, managers, and accountants earn high incomes; but, many dismiss their knowledge as a mere application of deeper scientific ideas or simply unfounded superstition. Similarly, in higher education: the first European universities started by offering practical medical and legal training and the University of Pennsylvania emerged from Benjamin Franklin's 1749 proposal for an Academy to teach "those Things that are likely to be most useful." But now, some in the upper reaches of the Academy deride professional education as verging on the teaching of trades that must be kept in its subordinate place.

Yet, developing practical knowledge affirms an essence of our humanity. We are human because we create, not just because we think abstract thoughts. Beavers build dams, prairie dogs excavate underground towns, and crows craft toys. But, a relentless preoccupation with the development of artifacts that stimulate our senses and minds far beyond any natural physiological need sets our species apart. The artifacts embody knowledge created through the exercise of faculties that mark us as human: to imagine, to reason, to have faith and to control our anxieties, to communicate and collaborate with remote strangers, and to "truck, barter, and exchange" as Adam Smith put it. According to a recent book by evolutionary biologist, Joe Henrich, humans are not particularly physically impressive or even smart. Rather, our capacity for purposive cooperation has made humans a uniquely successful species.[2]

Synthesizing complex techniques and tools that we use to make the things we want is also uniquely human. At best, other species craft rudimentary implements by taking apart natural objects, such as twigs, whereas human civilization has been propelled by inventing sophisticated and roundabout ways to create what we desire. Our cave dwelling ancestors, unlike their simian progenitors, learned to kindle fires. The Neolithic or the First Agricultural Revolution started relieving us from the vagaries of nomadic hunting about 10,000 years ago through inventions such as irrigation, selective breeding of cereal grasses, and harvester's sickles.

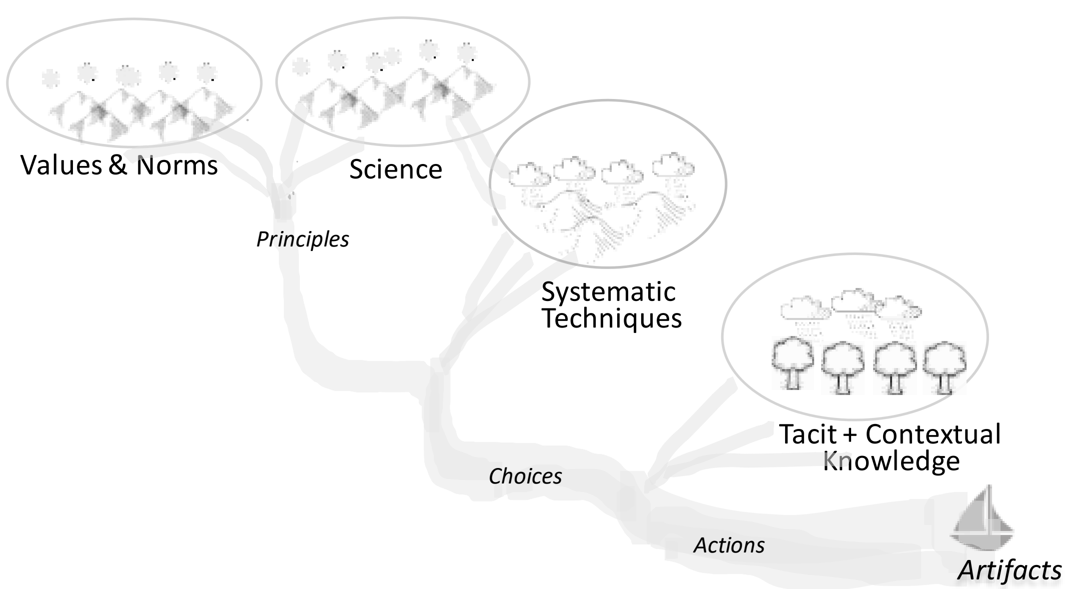
The Second Agricultural Revolution that started in Britain in the mid-17th century featured the development of crop rotation, breeding of livestock, land drainage and reclamation, and plows that could be easily pulled and controlled. The Industrial Revolution that started after about 1760, mechanized textile production through power looms and cotton gins, increased the efficiency of steam engines 5 to 10-fold, and slashed the cost of producing iron by using coke instead of charcoal in larger blast furnaces. And, whereas mobile phones and laptop computers may be the more celebrated manifestations of the Digital Revolution, specialized techniques and tools that many of us never see, such as computer-aided circuit design and numerically-controlled semiconductor fabrication, have made the visible consumer artifacts affordable and miraculously versatile.

The human capacity and impulse to jointly create practical knowledge and artifacts has enjoyed a momentous expansion over the last hundred years so. A highly *inclusive*, or to put it colloquially, massively *multiplayer*, game now provides unprecedented scope for individuals with diverse skills, capabilities and backgrounds to exercise their imagination and initiative. Before, the development of artifacts relied on exceptionally talented (but often not well-born) individuals. Similarly, where inventors once produced novelties principally for powerful or wealthy patrons, contemporary innovation relies on widespread consumption of affordable artifacts. Widely inclusive consumption in other words plays as important a role as widely inclusive production in multiplayer innovation.

Wide inclusivity has itself been supported by new techniques and tools. These include protocols that help organizations choose goals and objectives, produce plausible conjectures for attaining these goals, evaluate and refine the conjectures, codify and communicate selected ideas, motivate contributors and partition their tasks. The multiplayer game does not exclude unplanned discoveries and epiphanies. But, like farming after the agricultural revolutions, the inclusive development of new combinations ("ideas having sex" in Matt Ridley's memorable phrase) relies more on careful, selective breeding than on accidental or anonymous encounters. Silicon Valley has not only produced path breaking technological advances; companies like Intel have also instituted pioneering goal setting systems to coordinate and control employees dispersed across diverse locations and functions.

Scientific discoveries have provided a crucial starting point for many technologies – the transistor principle for producing semiconductors or genetics for high yielding crops. And the increased output of scientific discoveries has provided more starting points. But, technology doesn't just gush out of scientific geysers. Just as much of the water that a river carries into the ocean does not originate in headstreams, science does not provide all the important knowledge embodied in artifacts. The watersheds of practical knowledge (See Figure 1) include: values and norms, that along with science, provide the guiding principles; systematic techniques (as might be found in a text book in engineering or surgery) that harness the principles to produce choices; and, context specific tacit knowledge that turn choices into actions that culminate in new artifacts. To rephrase Schumpeter: apply as much electromagnetic theory as you please, you will never get a maglev train thereby. Similarly, the social sciences may offer general directions and signposts but cannot by themselves supply the organizational techniques that undergird inclusive innovation. Just applying cutting edge economics, sociology, or psychology could not have produced Intel's goal setting system.

Figure 1: Watersheds of Knowledge



That the sciences cannot by themselves provide all the knowledge embedded in artifacts is an intrinsic feature of science, not a defect. In his seminal *The Scope and Method of Political Economy* (1890) John Neville Keynes (father of John Maynard) argued against confusing the science of economics from ethical concerns about economic ends. Keynes also distinguished economic science from systematic techniques for attaining desired ends. Arguably, the distinctions help produce more and better science: if you want to find the glacial headstreams of a river stay away from the tributaries in the plains. But the purposive development of artifacts requires choices of ends and the application of techniques: if you want to control pollution and keep ship channels safe downstream you need to know more than where rivers originate. Moreover, methods designed for scientific discovery are always best for choosing ends and applying techniques. An inflexible adherence to methods demanded by specialized scientific communities can in fact undermine the development of artifacts.

Goals. We emphasize systematic techniques – the "mid-level" watershed in the diagram above; we will treat the normative and scientific watersheds "above" and the tacit knowledge watershed "below" mainly as complementary sources of knowledge. And, because even this mid-level watershed covers a forbiddingly vast territory, we will prioritize:

• Techniques that facilitate inclusive, multiplayer development over techniques that individuals may want to learn for their personal improvement such as time management. (We will however review techniques for individual use to illuminate the distinctive features of collectively used techniques.)

• Techniques used to perform tasks commonly encountered in many specialized domains (See Table 1) although the techniques themselves however may be domain specific.

• The main features and tradeoffs of alternative techniques rather than deep mastery in practices that experts have deemed as "best."

Table 1: Common Tasks and Examples of Systematic Techniques reviewed in seminar

Tasks commonly encountered	Examples of Techniques
Goal and problem specification	Objective and Key Results; Journey Maps
Ordering and Screening Choices	Strategic Planning
Conjecture	Positive Deviance; Root Cause Analysis;
Codification	Checklists; Best Practice Programs;
Communication	Pyramid Principle; Social Media Marketing
Testing and Evaluation	Randomized Control Trials; Rapid Prototyping;
Partitioning and Grouping Tasks	Organizational Templates; Project Management;
Aligning Incentives	Incentive Wages; Theory Y

We aim to touch hearts as well as minds: to show that striving to satisfy others' wants is a noble enterprise. Success may bring great material rewards, exhilaration and possibly a place in history, but innovators also face the possibility of ruinous loss, frustration and obscurity. To proceed on such a perilous path requires a love for adventure, and to continue when things go wrong demands courage. Thrift and bourgeois virtues of temperance and prudence celebrated by Max Weber and Deirdre McCloskey as the foundation of modern capitalism have their place — when joined to against-the-odds audacity.

Our mind-and-heart objectives limit the utility of studying well-codified "book" knowledge because many of the practices we are interested in have a fuzzy. Yet, whereas we can often best acquire individual skills (such as making a sales call, or performing an appendectomy) through hands-on practice, this is less feasible in tasks performed by large, geographically dispersed groups. Even projects undertaken by student teams over the course of an academic term cannot replicate the distinctive experience of protracted, widely inclusive development.

Therefore, we will rely on an indirect, case-method style approach. And because we are not interested mastering practices experts have designated as best, we will survey several popular techniques. Similarly, we will study the dynamics of multiplayer development by examining case histories of noteworthy artifacts (including new technologies, products, protocols, and organizations.) The case histories will also bring out the emotional challenges of doing something new to a greater degree than our survey of techniques.

The next sections and a concluding appendix review the:

¶ Age-old characteristics and challenges of developing and using practical knowledge.

¶ Distinctive features of contemporary multiplayer development.

¶ Tasks and techniques we survey in the first module of the seminar.

¶ Noteworthy artifacts whose evolution we examine in the second module.

¶ Contrasts between practical and scientific knowledge.

Age-Old Characteristics and Challenges

Adaptive Persistence

Like the molecules that store and carry genetic information, the knowledge embodied in man-made artifacts has multifarious forms. Even a simple analgesic like ibuprofen, for instance, incorporates knowledge that serves a variety of functions – technical design (how many milligrams of active ingredient, binding agents, coatings etc.), sourcing of ingredients, manufacturing and quality control, logistics, packaging, and advertising. And, as with genetic information, the multifaceted knowledge embodied in artifacts evolves through an extended process, in which the accretion of small changes can have transformational consequences. But, there is a crucial difference between biological evolution and the development of artifacts. Although artifacts do not spring full-blown from the mind of an omniscient creator, the extended development of the multifarious knowledge they embody requires a willful adaptive persistence absent in biological evolution.

In nature, mutations occur randomly without any purpose or end. And, as the political scientist and philosopher Jon Elster notes, the subsequent process of selection occurs in a simple deterministic way — the evolutionary 'machine' accepts a mutation if it endows the first organism in which it occurs with a superior reproductive capacity. Natural selection thus has an "impatient, myopic, or opportunistic" character. It cannot learn from mistakes because it has "no memory of the past," and no forethought – it does not forgo favorable mutations now to realize better ones later, as it has "no ability to act in terms of the future."[3] And nature does not permit willful imitation: house cats cannot follow the hunting habits of tigers.

Humans, in contrast, can choose the options we accept or reject just in our minds. We don't expose every possibility that we might think of to a competitive battle for survival outside our minds and imaginations. We often reflexively seek to emulate maestros. We also can summarily dismiss seemingly favorable options – or even accept unfavorable options – "in order to gain access to even more favorable ones later on."[4] And, if we encounter unanticipated setbacks, we can examine what went wrong and adjust our course without changing our overall direction. We can thus adapt while persisting.

The development of fixed-wing aircraft provides a striking example of adaptive persistence. Sir George Cayley first enunciated the underlying premise – that propelling a rigid surface through the resistance of air could produce an upward force ("lift") that would offset the downward pull of gravity – in 1809. All "airplane designers have this concept at the back of their minds" now, writes Walter Vincenti (former chair of Stanford's aeronautical engineering department), but Cayley's concept was "revolutionary at the time" because it "freed designers from the previous impractical notion of flapping wings."[5] Yet, it took nearly a century before the principle produced the first controlled flight of a powered, heavier-than-air aircraft on December 17, 1903, when the Wright Flyer took wing – for all of 200 feet. In the interim, resourceful and courageous inventors had experimented with gliders, steam engines, gasoline engines, propellers, automobile chains, and rudders. One intrepid pioneer, Otto Lilienthal, who had made the first well-documented, repeated, gliding flights, broke his neck and died in 1896 after his glider stalled. Finally, the Wright Brothers built on these prior efforts, improved on wing materials and designs, and pioneered the "three-axis" system to control flight.

Venturesome Leaps

Developers of artifacts require more than just forethought, however. Like myopic natural selection, forward-looking human choices can also lead to dead ends. It's obvious now that Cayley's principle was sound and that the many failures that preceded the Wright Flyer reflected limitations of wing, airframe, propeller, and control designs. But efforts to develop fixed-wing airplanes, like alchemy, could have been a fantasy. Or, even if technically feasible, fixed-wing aircraft could have lost out to rigid airships, popularly known as "Zeppelins," (summarized in the Box 'The Rise and Fall of Zeppelins'). Similarly, the synthesis of ibuprofen followed the screening of more than 600 compounds over more than ten years; this effort could, like attempts to cure the common cold, have been futile.

The Rise and Fall of Zeppelins

Count Ferdinand von Zeppelin first formulated his idea for rigid airships in 1874. Over the next 20 years he developed the technical details, which he patented in 1895. After several failures and some fatal accidents, airships built by the Count's eponymous Zeppelin Company were put into commercial service in 1910 by Deutsche Luftschiffahrts-AG (DELAG). DELAG, founded in 1909 by Count Zeppelin, thus became the world's first revenue-generating airline. And, by the onset of the First World War, DELAG had carried over 10,000 passengers in over 1500 flights.

Following the war, the Treaty of Versailles then prohibited Germany from building large airships. After the restrictions were lifted in 1926, the Zeppelin Company started building the LZ 127 Graf Zeppelin. Work was completed in 1928 and the Graf (again operated by DELAG) began providing regular transatlantic commercial service in 1930. It was joined in 1936 by the larger LZ 129 Hindenburg. Unfortunately, in 1937, the Hindenburg caught fire in New Jersey after a transatlantic flight, killing 35 of the 97 people on board. The Graf Zeppelin was retired a month later. Thus ended the role of airships in providing commercially viable long-haul air transport that they, not fixed-winged airplanes, had pioneered.

But just as success isn't a forgone conclusion, neither is failure. Invariably, protracted development poses, to borrow from economist Frank Knight, unmeasurable and unquantifiable risk. Skeptics who bet against new technologies – producers of buggy whips, oil lamps, and sailing schooners, for instance – can be swept away.[6]

Therefore, those who persist – as well as those who do not – have to make choices that, to borrow from the 19th century existentialist Søren Kierkegaard, involve a 'leap of faith.'[7] Moreover, those who first make the leaps also have to recruit others – visionaries rarely undertake the protracted development of artifacts on their own. Moreover, to persuade potentially skeptical supporters, pioneers' own convictions must be exceptionally strong.

Consumers also cannot escape venturesome leaps. One simple reason is that different individuals have different tastes and preferences. A best-selling book may not delight all subsequent readers and patrons drawn to a three-star restaurant may leave disappointed. More subtly, consumers also often have to invest in knowledge and infrastructure that unexpected social or technological developments can render worthless. For instance, the inability of Sony's pioneering Betamax video format to withstand the challenge of VHS harmed consumers who had accumulated libraries of Betamax videotapes, just as it did Sony. However, avoiding new technologies isn't safe either: buyers who stuck with sailing ships, like the shipyards who produced them, also lost out. Similarly, while experimental drugs can have dangerous long-term side effects, rejecting new diagnostic techniques (to detect colon cancer for instance) can be life-threatening.

Pragmatic Combinations

Pragmatist philosophers such as Charles Sanders Peirce, William James, and John Dewey, argue that the significance of ideas lies in their practical utility – "cash value," as James puts it. Where Plato privileged truth that "lies in the abstract and exists more clearly in our minds than in the natural world," the pragmatist credo avers it is more important to ask what works rather than what is true. (And according to Dewey, even the most thorough and careful inquiry could at best produce "warrantable assertions" – provisional, more-or-less reliable claims, supported by a reasonable warrant.)

Developers of practical knowledge are obviously more pragmatic in favoring the useful over the ultimately true. They also 'pragmatically' combine, as we will see next, 'rationalist' generalization with context-specific 'empiricism' and progressivity with conservatism.

Rationalist generalization + Context-specific Empiricism. Pragmatism also conjoins, according to James, the opposing dispositions of rationalists and empiricists. Rationalists, in James's classification, are "monists," "devoted to abstract and eternal principles." They "start from wholes and universals and make much of the unity of things." Their truth lies (as in Plato) more clearly in the mind than in the natural world. Empiricists in contrast are "devoted to facts in all the crude variety" (see Box 'Rationalists v Empiricists); they seek, like the fox in Isaiah Berlin's later essay, to know many things rather than the hedgehog who knows one big thing. James's sympathies clearly tilt towards "pluralistic" empiricism.

Rationalists v Empiricists

The empiricists' world of "concrete personal experiences," William James observed, "is multitudinous beyond imagination, tangled, muddy, painful, and perplexed." In contrast, the rationalists' world is "simple, clean and noble. The contradictions of real life are absent from it. Its architecture is classic. Principles of reason trace its outlines, logical necessities cement its parts. Purity and dignity are what it most expresses." But this latter world is just a "sanctuary in which the rationalist fancy may take refuge from the intolerably confused and gothic character which mere facts present. It is no EXPLANATION of our concrete universe, it is another thing altogether, a substitute for it, a remedy, a way of escape."

But crucially, James favors including the abstractions of rationalism when they have practical utility. James' own pioneering work in the then emerging field of psychology was not light on abstractions. Similarly, developers and users of artifacts have to pay close attention to both contextual facts in "all their crude variety" without discarding abstractions that can provide a foundation for practical designs. The overhead bins of modern airplanes must be designed to accommodate roller carry-on bags and ibuprofen containers must be childproofed. Similarly, organizing the production of these artifacts requires knowledge of the quirks and capacities of specific manufacturing plants and suppliers. At the same time, developers of airplanes and drugs rely heavily on the abstractions of fluid mechanics and biochemistry.

Progressivity + Conservatism. Pragmatism also balances tendencies that propel and restrain change. Nineteenth and early 20th century pragmatists implicitly or explicitly embraced efforts to progress: ultimate truths might never be discovered but advances in knowledge that improved the human condition were always at hand. John Dewey devoted his life to radically reforming education while James suggested unusual measures to increase one's productive working hours by curtailing sleep. Later 20th century "neo-pragmatist" philosopher Richard Rorty promoted *Social Hope* (for a "global, cosmopolitan, egalitarian, classless, casteless society" as he put it in the preface).

Yet in James's telling, pragmatic considerations require respecting existing ideas. James's pragmatist will seek out new ideas only to the degree that old ideas cannot deliver the goods, and, even then, will favor modifying or extending what exists rather than starting from scratch.

A similar combination characterizes the development of artifacts. A progressive conviction that things can be made better, that dogged enterprise can overcome problems, nourishes the faith necessary to persist through setbacks. Yet, the existing stock of tangible and intangible capital, and social and psychological conservatism, favors retaining what is already known and used to whatever degree is possible.

Anxieties of Choice

The combination of grand "monistic" leaps and myriad context-specific decisions creates a tangle of choices. For instance, the development of a solar-powered airplane requires, in addition to the core bet on solar-power, choices about several other attributes and functions, such as the range (short haul vs. long haul), target market (cargo, hobbyist, or passenger), scale of production, financing, marketing, and after sales service. Choices about properties and functions in turn require further choices about criteria and process: for instance, choosing a target range and market for the airplane raises questions about goals and purpose: why develop a new plane in the first place?

Simple trial-and-error is not a panacea because long-term consequences cannot be reliably predicted from short term outcomes: a new treatment that provides immediate relief can eventually produce worse side-effects than the disease.

Additionally, the immediately apparent options are not the only ones potentially available. The developer of a solar-powered airplane, for instance, has to choose whether to pick from known battery options or search for new battery technologies. To complicate matters, choices cannot be made one-at-a-time. The target market for a solar-powered aircraft for instance has implications for production and battery-technology choices.

Evaluating the long-term consequences of all possible combinations of known and unknown options is therefore impossible. If such evaluations were possible, problems of real choice would not even arise. Like hydrogen combining with oxygen to produce water, we would simply do the foreordained. But human choices, according to Kierkegaard, create existentialist anxieties: Abraham's decision to obey God's command to sacrifice his son produced *Fear and Trembling*. If so, confronting overwhelming combinations of options should, like large leaps of religious faith, create unrelenting anxiety.

Efforts to avoid this anxiety can lead to reactive "satisficing": pick the first option that alleviates the problem at hand — and only when the problem becomes intolerable. Up to a point, such satisficing is the inevitable result, as Herbert Simon pointed out, of the "boundedness" of our rationality — our ignorance of all the options that might exist and of their consequences. It is also pragmatic in respecting what's known to work: "if it ain't broke, don't fix it." But, making satisficing the default emasculates our capacity for foresight, for making choices before we must, and for imagining options that do not naturally appear in front of us.

Multiplayer Development and Use

As mentioned, the development and use of artifacts has become highly inclusive over the course of the last 100 or so years. Although many revolutionary products were invented between 1850 and 1900, new artifacts were usually developed by a handful of inventors who largely did it all themselves. Alexander Graham Bell invented the telephone with one assistant. Automobile pioneers were one- or two-man shows — Karl Benz and Gottlieb Daimler in Germany, Armand Peugeot in France, and the Duryea brothers of Springfield, Massachusetts. But small outfits couldn't develop products for mass consumption. Early automobiles were expensive contraptions that couldn't be used for day-to-day transportation because they broke down frequently and lacked a supporting network of service stations and paved roads. One or two brilliant inventors couldn't solve these problems on their own.

Innovation then became a more broad-based, "multiplayer" game starting in the "roaring" 1920s and continuing through the present (for convenience, I call this the 'late-modern' period). The division and specialization of labor that dramatically increased production efficiency in the early 20th century has now, albeit more quietly, transformed the development of virtually all artifacts. The Internet for instance, does not have a solitary Alexander Graham Bell. Innumerable entrepreneurs, financiers, executives of large companies, members of standard-setting institutions, researchers at universities and commercial and state-sponsored laboratories, programmers who have written and tested untold millions of lines of code, and even investment bankers and politicians – not just a few visionaries or researchers – have turned the Internet into a revolutionary medium of communication and commerce. Steve Jobs, often portrayed as a brilliant solitary inventor, relied on the contributions of tens of thousands of individuals working at Apple and its network of suppliers. And, systematically harnessing the creativity and enterprise of the many has resulted in more, better, and affordable innovations.

The broadening of venturesome consumption has provided a crucial complement to inclusive development. Unlike rich hobbyists who bought early automobiles, millions of the not-so-well-to-do line up to buy expensive new gadgets. And, larger demand pays for the greater specialization of development: In innovation, as in Adam Smith's 18th century pin factories, "the division of labor is limited by the extent of the market." The venturesomeness of contemporary consumers also includes resourceful effort. Complex, feature-rich artifacts – iPads and iPods included – usually don't "just work" out of the box. Producers cannot afford to provide individualized training and instead rely on the resourcefulness of consumers to learn about the quirks and nonobvious attributes of their artifacts. Similarly, consumers modify products standardized for low low-cost mass production to suit their individual needs. And, some leading-edge consumers participate in the process of development by providing valuable suggestions and feedback to developers.*

Advances in science and technology have helped the specialization and broadening of innovative effort. Improved scientific understanding of disease mechanisms have helped teams of researchers in pharmaceutical companies establish assembly lines to systematically screen molecules for their potential therapeutic effects and new print on demand and computer simulation technologies help product design groups rapidly test many physical or virtual prototypes. Waves of technology – radio, television, webpages, search engines and now social media have helped create and sustain mass marketing to consumers.

New organizations and organizational forms have played a crucial complementary role. As business historians have documented, the design and production of goods such as automobiles moved from the workshops of entrepreneurs to functionally specialized organizations to multi-divisional entities with centralized corporate staff (such as General Motors). In medicine, large multi-specialty practices such as the Mayo Clinic and the Cleveland Clinic (which, like university medical centers, include research laboratories) played pivotal roles in the development and dissemination of treatments such as cardiac surgery. New professional services firms such as Arthur D. Little and McKinsey & Company advanced new technical and organizational ideas. And, mass discounters (such as Wal-Mart), multinational

* Venturesome consumption has not widened uniformly across all fields. Notably as I have argued (Bhidé 2016) long-standing traditions and contemporary rules have held back medical advances by limiting the role of consumers.

advertising agencies (such as McCann Erickson) and now e-tailers (such as Amazon) whet and fed appetites for venturesome consumption.

In addition to enabling completely new artifacts such as smartphones and hip replacements, inclusive development has also transformed traditional manufacturing, as the case of running shoes shows. Shoemaking was one of the first industries in the United States to specialize and automate production, and by the early 20th century affordable shoes made in large factories had made owning multiple pairs commonplace. Goodyear introduced “Keds” with vulcanized, treaded soles in 1892 but did not market them as an athletic shoe till 1917. Adolf Dassler began making specialized running shoes in 1920 for competitive runners: Jesse Owens won his Olympic gold medals wearing Dassler shoes.[8]

Eventually, in 1960, New Balance Inc. introduced what is thought to be the first mass-produced running shoe, the Trackster. The Trackster was also the first shoe to be offered in varying widths, increasing its appeal to consumers. Then, after Nike pioneered waffle-soled shoes in 1972, and the Brooks Manufacturing Company introduced shoes to control pronation, one product innovation quickly followed another: shoes with proprietary cushioning systems (starting with Nike’s Air shoes) and pumps (pioneered by Reebok) as well as minimalist, ultralight shoes weighing less than 3 ounces. High-profile advertising campaigns and endorsement contracts secured the shoe companies global recognition for their brands and billions of dollars in revenues while outsourcing to factories in low-wage locations kept production costs in check. To achieve all this required shoe companies to secure expertise that once had no place even in “industrialized” shoemaking: of bio and software engineers, material technologists and scientists, and artists (to design new shoes); of lawyers to negotiate endorsement contracts with sports agents; of advertising agencies to produce commercials and purchase TV spots; and, of supply chain professionals to manage outsourcing.

Inclusive development has not made individual enterprise superfluous; audacious visionaries and entrepreneurs continue to make pathbreaking contributions. And, the benefits of wide inclusivity are not automatic. Many hands don’t always make lighter work. As Frederick Brooks wrote in his celebrated book on software development, "The Mythical Man-Month: Essays on Software Engineering": "When a task cannot be partitioned because of sequential constraints, the application of more effort has no effect on the schedule. The bearing of a child takes nine months, no matter how many women are assigned." In fact, ‘Brooks's Law’ suggests that increasing the size of software teams may actually delay development.

Likewise, many heads may be better than one, but too many cooks can spoil the broth. The collective effort of individuals with different expertise and perspectives can produce more elegant solutions as well as clumsy compromises – the proverbial camel crafted by a committee formed to design a horse. Multiplayer innovation also often requires justifying choices to individuals who weren’t involved in making them. For instance, where self-financed entrepreneurs can act on their hunches, raising outside funds requires them to justify their ventures to arm’s length investors. Similarly, within large corporations, advocates of new proposals face scrutiny from direct bosses and staff specialists; even CEOs with nearly absolute internal power must justify their choices to their boards of directors and stock analysts. And, where visionaries may be able to transmit their convictions to a small cadre of supporters, the difficulty of persuading remote financiers, technical specialists, and consumers may preclude great leaps of faith.

The difficulty of transmitting local information (as Hayek pointed out) – and even more so of hunches – makes effective centralized adjudication and coordination of decentralized initiatives impossible. A Food and Drug Administration (F.D.A.) panel may or may not effectively evaluate the effectiveness of new drugs that have undergone extensive trials but such panels cannot screen all early ideas for new drugs. But purely atomistic, independent initiatives cannot deliver the (innovative) goods either. Hayek’s celebration of the price system’s capacity to align decentralized choices notwithstanding, prices cannot play the same role in coordinating developers and users of modern artifacts as they might the simpler problem of coordinating producers and consumers of preindustrial commodities.*

The challenge of making many heads better than one has spurred the development of numerous, and often versatile, techniques. But versatility has limits and techniques often don't specify where they won't work. Some may even comprise persuasively marketed but comprehensively worthless nostrums. Deciding on a technique can thus worsen age-old problems of overwhelming choice discussed earlier. Yet, the tangle of techniques, both effective and worthless, is constantly increasing.

Common Tasks and Techniques (Module I)

Evaluating all available techniques is obviously beyond our scope. Instead, we will survey a selection of some of the more popular techniques that range from precise step-by-step procedures to general frameworks. And, to organize the survey we use the following categorization of tasks commonly encountered in the inclusive development of many artifacts.

• *Goal and problem specification* (choosing "ends"). Any purposive development requires choosing goals. Multiplayer development of artifacts for wide use significantly expands the range and complexity of goal specification. The overall value of an artifact as well as targets for its costs and technical attributes must be chosen to maximize its appeal to users who may have different tastes and preferences, for example. Similarly, goals and targets have to be established for the many functions involved in developing, producing, and marketing the artifact. In addition, multiplayer development is often undertaken by organizations that produce several artifacts and whose effectiveness depends on the quality of goals set at several levels: goals for the organization as a whole, for its subunits and, for its individual employees.

Although top-level goal-setting has not been systematized, several techniques have been developed for setting lower-level goals or include such goal setting as an important part of the technique. For instance, Human Centered Design protocols use ethnographic procedures to choose target attributes for new products, and as mentioned Intel's goal setting systems establish objectives for organizations and employees.

• *Ordering and Screening Choices*. Making general (Berlin's "hedgehog"-like) decisions before specific ("fox"-like) decisions reduces problems of overwhelming choice: Making general choices first can help limit the specific options evaluated or created to ones that are consistent with the general choices. Likewise, deciding on ends before means helps restrict the consideration of means to ones that are consistent with the ends. Screening choices for congruence with exogenous circumstances (i.e., those beyond the direct control of the decision-maker) provides similar advantages by quickly eliminating alternatives that don't fit the available resources and constraints.

Military planners pioneered doctrines and techniques – and established staff – for ordering and screening choices. Now such doctrines, techniques and staff have become a mainstay of strategic planning large business and non-profit organizations.

• *Conjecture* (generating ideas and hypotheses for "means"). Traditionally, the invention of new means was believed to result from an ineffable process of individual creativity which could not be systematized (although periodically individuals like John Stuart Mill would try). Now, organizations seek to harness the expertise of large teams using a variety of techniques to organize collective innovative effort, leaving less to unplanned epiphanies. These include, as already mentioned, assembly line style drug development; Human Centered Design protocols that seek to reduce cognitive barriers to creativity and the tendency of groups to avoid unconventional ideas; and, most recently, machine learning. At the same, time some experts and writers have sought to reemphasize the role of "intuitive" (rather than structured) problem solving.

* It is worth noting that the solitary example that Hayek (1945) provides of the coordinative role of price signals pertains to the production and consumption of tin.

• *Codification.* Precisely codified ends and means are less likely to be misunderstood when transmitted across organizational boundaries, cultures, distance, and time. Compliance is easier to monitor. And, codification can contribute to the cohesion and feeling of solidarity in large and far-flung organizations and communities. Nearly all structured techniques to develop or share solutions or specify desired outcomes therefore entail some codification. However, excessive codification can be dysfunctional. Decision-makers therefore must choose how much to codify (the options here can range from a few key items to "everything possible") and how to do so (with options ranging from with complete precision or through broad principles).

• *Communication.* Knowledge of ends and means, however well codified, may not be well used if it is not persuasively and clearly communicated. Even knowledge that is embedded in physical objects requires effective communication – consumers must be persuaded to buy the objects and instructed in their use. Effective communication also requires comprehensible and convincing exposition. Techniques to make communication effective are age old, going back to at least the Greek rules of rhetoric. Now we have a profusion of techniques that cover a variety of circumstances and technologies, ranging from person-to-person communications, written reports, presentations, recorded videos and podcasts, and social media.

• *Testing and Evaluation* can have many purposes such as choosing the base technology of an artifact, modifying its features, and troubleshooting. Tests and evaluations may also serve to screen or grade the inputs used and outputs produced in the ongoing production of an artifact. For instance, a bank may want to screen job and loan applicants and control the completeness of loan and collateral documentation. The range of techniques used for these multifarious ends is also correspondingly wide and can include instruments such as balanced scorecards, learning assessments, randomized control trials, A/B testing, credit scoring, reference checks, and structured interviews.

• *Partitioning and Grouping*: An extensive division of labor in an inclusive multiplayer game requires numerous choices about the partitioning of tasks: who does what, when and how do people doing different things interact? The division of labor also requires choices of grouping: who works in the same location, has the same boss, and responsibility for a common outcome? What's done within the group and what is outsourced? Does the group have an exclusive claim on the time and effort of its individual members or does it share with other groups? How do different groups coordinate plans and resolve differences?

As mentioned, several organizational models have emerged that provide useful templates for making these choices. These include M-form or multidivisional organizations that originated with large industrial companies); multinational and multi-practice law, consulting and accounting firms; multi-specialty clinics and Health Maintenance Organizations (as substitutes for solo medical practices); and, networked organizations (that rely heavily on "outsourcing" and sub-contracting). Sophisticated Project Management tools and protocols are also now widely used for partitioning and grouping especially in activities such as enterprise software development where tasks are often outsourced to specialized suppliers and independent contractors.

• *Aligning Incentives.* The shift from "putting out" production to Henry Ford's assembly line prompted a shift from piece-work payment to hourly efficiency wages paid for tasks specified by time-and-motion experts. The subsequent shift to collaborative "knowledge work" on and off the factory floor has spurred an ongoing search for combinations of incentives to promote teamwork without discouraging individual initiative.

Note that this categorization is just a simple "walking stick"[9] to help us find our way through a tangle of alternatives, not a "mutually exclusive and collectively exhaustive" taxonomy. For instance, goal specification tasks can intersect with testing and evaluation and with codification in several ways. If goals are precisely codified, they can serve as metrics for testing and evaluation. However, amorphous or difficult-to-measure targets may have to be mapped into "proxy" measures for the purpose of testing or evaluation. Similarly, communication tasks cannot be fully separated from codification tasks. And, like Swiss-Army knives, techniques often span multiple tasks. Human Centered Design protocols are intended to help specify nonobvious goals for new products, develop creative conjectures for how these goals might be met, and rapidly test these conjectures.

Nonetheless, this rudimentary categorization and survey offers benefits comparable to those of a nature lover's river map and guide. It won't include every stream, brook, access road, campsite, and bridge that would be found in a detailed satellite map or the hourly forecasts and storm warnings broadcast by the National Weather Service. Yet even the less-than-complete—and partially out-of-date information—provides a useful starting point for a canoeing or fishing trip: how to get there, what to carry, boating skills required and so on. Similarly, our survey seeks to provide a general introduction and overview – which, if nothing else, can protect us against charlatans and experts who oversell their favored nostrums. Familiarity with alternatives can also help us decide whether and when to learn more about a particular technique.

Noteworthy Artifacts (Module II)

The case histories that we examine in the second module of the seminar describe the evolution of noteworthy, many even transformational, technologies, products, protocols, and organizations. They include frozen foods, which changed what the developed world eats; shipping containers, which enabled the globalization of trade; personal computers, which led the democratization of computing; mammography which helped reduce breast cancer deaths in the United States by 25%; tests and treatments that rolled back the HIV-AIDS pandemic; and, the evolution of Handelsbanken into one of Europe's largest banks, and of McKinsey and Company into a leading international consultancy.

The cases complement our preceding survey of tasks and techniques in the following way: The cases are much more detailed and comprehensive, but (unlike the material on techniques) they do not provide explicit prescriptions or precepts. Rather, any prescriptions and precepts must be inferred. But, just taking in the myriad facts contained in individual case histories is not enough. Drawing useful inferences requires filtering and organizing the facts. Our categorization of common tasks and review of popular techniques survey can help us do this.

Reciprocally, inferences from the specific cases can help fill gaps left by the more generic techniques. For instance, the heuristic of what Peters and Waterman (1982) called "loose-tight" controls can guide organizations seeking a middle ground between comprehensive top-down planning and uncoordinated individual initiative. Studying specific cases can help us develop more concrete heuristics for what warrants tighter or looser oversight and control even if the cases themselves do not make such heuristics explicit. Similarly, the cases can get us to think about "sweet spots" for the applicability of techniques. For instance, the frozen food case suggests that using Human Centered Design techniques could have accelerated market acceptance, by helping producers more quickly understand the true consumer benefits. But the techniques would have done little in the early days of containerized shipping when institutional and political resistance, rather than poorly understood user needs, was the main barrier.

(How studying specific cases improves the utility of generalized techniques and vice versa is comparable to the symbiotic benefits of reading great novels as well as studying writing conventions. Aspiring writers may learn more about plot and character development from great novels than from studying the conventions of writing; but, knowing the conventions increases what aspiring writers learn by guiding their attention to how a great novel develops plot and character or deviates from standard techniques.)

Studying specific cases has benefits beyond the better use and selection of techniques. As mentioned, effective artifacts embody multiple choices that are well aligned with each other and with exogenous, contextual factors. But it is impossible for developers of transformational artifacts to anticipate the right constellation of choices. Rather, important additions and substitutions become necessary as the initial designs fail to perform. These can take decades.

Developers who adapt or extend landmark advances don't have to "reinvent the wheel" but differences in goals or circumstances also often make exact copying infeasible. After humiliating military defeats in the mid-19th century, Japanese officials made an all-out effort to learn from the West. In 1872, the Iwakura Mission traveled around the world, touring factories and studying legal systems and social customs.

French experts were hired to help draft a new legal code, British experts provided advice on industry and Americans on agriculture and education. Prussia provided a model for the army. Diplomats started to dress in coat and tails instead of kimonos, the Emperor could be seen wearing military uniforms and the Empress in Victorian gowns. But the Westernization wasn't blind. Unlike Turkey after Ataturk, Japan did not adopt the Roman script. A new "*bunmei kaika*" ("civilization and enlightenment") policy did not grant Japanese women the personal freedoms that members of the Iwakura mission had been surprised to find women enjoyed in the United States.[10] And, a new wardrobe did not alter the Emperor's divine status.

Understanding the structural and functional logic of a transformational advance facilitates adaptation to different goals and circumstances: Knowing *how* the elements of an existing artifact work together and align with exogenous circumstances provides useful hints about what might need to be changed. And, because the logic of an intricate architecture is rarely self-evident, a historical account of its evolution can tell us much of the why's and the wherefores of its elements.

Finally, the case histories with real, flesh-and-blood protagonists highlight the ineffable roles of persistence, chance, leaps of faith and inspirational leadership – and the occasional ruthlessness. The path to lifesaving medical advances is often littered with deadly experiments innovators perform on animals and barely informed human subjects. Moreover, while the cases demonstrate the value of inclusive effort, they also show individuals continuing to make vital creative contributions and bearing risks they cannot cast off in in some fictive anonymous market. And, by going beyond dry technique, the case histories just might inspire some participants in the seminar to seek pioneering challenges.

Appendix: Contrasts with Scientific Knowledge

Interdependent but distinct

Scientific (or "propositional") knowledge that help us understand nature and practical (or "prescriptive") knowledge embodied in man-made artifacts often complement each other. Thus, the discovery of nuclear magnetic resonance prompted the development of industrial spectroscopes used to analyze the composition of chemicals. In some instances, scientific understanding that came after the development of artifacts have helped improve the artifacts: thermodynamics improved the efficiency of steam engines, for instance.[11] Bacteriology and virology have improved the development of vaccines (which Jenner had pioneered in Britain before scientists had shown how bacteria and viruses cause disease).

Conversely, new artifacts can advance science. Recounting Henderson's quip that "until 1850, the steam engine did more for science than science did for the steam engine" physicist Malcolm Longair writes that James Watt's 1765 invention of a condenser, made in the course of repairing a steam engine, "led to the underpinning of the whole of thermodynamics."[12] Similarly the invention of electron microscopes brought to scientists' attention naturally occurring phenomena they could not otherwise observe and new instruments such as spectrometers enabled the testing of scientific theories.

The development of scientific knowledge also has several features in common with the development of practical knowledge embodied in artifacts. Unlike biological evolution, both kinds are propelled by human striving, and not just by chance. Both seek to build on existing knowledge and learn from mistakes. Both can require extended persistence – the discovery of the structure of the DNA and of evidence of the existence of Higgs boson ("God") particles no less than the development of fixed-wing aircraft and ibuprofen. Unlike the Platonic pursuit of purely abstract truths that transcend experience, both value observable phenomena that reach our minds through our senses. And both advance through the accretion of decentralized yet coordinated contributions of many individuals and groups.

Yet, the development of practical prescriptive knowledge and its nature also deviates significantly from the development and nature of scientific propositions. Vincenti argues eloquently in *What Engineers Know* that "technology, though it may apply science, is not the same as or entirely applied science." Rather, it is "an autonomous body of knowledge, identifiably different from the scientific knowledge with which it interacts." (See Box 'Vincenti: What Engineers Know').

Vincenti: What Engineers Know

"Modern engineers are seen as taking over their knowledge from scientists and, by some occasionally dramatic but probably intellectually uninteresting process, using this knowledge to fashion material artifacts. From this point of view, studying the epistemology of science should automatically subsume the knowledge content of engineering. Engineers know from experience that this view is untrue... my career as a research engineer and teacher has been spent producing and organizing knowledge that scientists for the most part do not address."

Similarly, a plausible argument can be made that the medical knowledge used by physicians is not the same as applied biology or biochemistry, organizational design isn't applied psychology or sociology, and good lending practices require much more that the application of micro-economic models. Moreover, as we will see, the kind of scientific propositions and methods favored by scientific communities strongly influence the coordination of their development by scientists dispersed across multiple locations.

Differences in Accountability

Many differences between propositional scientific knowledge and prescriptive knowledge embodied in artifacts can be traced to differences in whose wants developers must satisfy. Scientific knowledge is typically produced by and for other scientists; as mentioned, it may also have value in artifacts used by non-scientists, but that is not a necessary purpose. For many decades, the existence of the Higgs field was regarded as the central problem in particle physics although this had no obvious practical consequence.

Even when scientific research is prompted by practical problems – research in what Stokes called "Pasteur's quadrant"[13] – the process is generally insulated from the development of artifacts based on the research. The hunt for the pathogen causing AIDs had practical urgency: it would provide the basis for a diagnostic test. But the scientific hunt for the pathogen could be insulated from the design of test kits, whereas the design of the test kits had to consider practical issues of large-scale production, distribution, storage, usability, regulation and so on. And, "worth" of the results can transcend their direct utility. A scientific discovery that does not provide a direct or obvious way to solve the practical problem invoked to secure funding may nonetheless be celebrated as a valuable advance. Linus Pauling and his colleagues demonstrated in 1949 that sickle-cell disease occurs as a result of an abnormality in the hemoglobin molecule. Although the disease remains incurable, this discovery has been judged a milestone in the history of molecular biology.

Crucially, the specialized communities that produce – and are the main consumers of – scientific research themselves judge its worth. The communities specify questions that merit investigation, the range of hypotheses advanced, and the kind of reasoning and evidence they consider legitimate. Particle physicists established standards for the evidence that establish the existence of the Higgs field. Fellow virologists evaluated the research produced by virologists at the Pasteur Institute in France and the National Cancer Institutes in the U.S. identifying a retrovirus now known as HIV-1 as the cause of AIDS. Even when scientists seek outside funding for scientific research that has an explicit practical end, funding agencies turn to the scientist's peers to evaluate the research proposal.

In contrast, users who developers do not control have an important say in assessing artifacts. Visionaries may develop products far ahead of anyone's articulated wants, but ultimately their success requires buyers to open their wallets. Ongoing feedback from users can prompt changes, sometimes quite radical, in the design of products. Hollywood studios even test audience reactions to alternative movie endings. This does not mean that users always know best – patients continued to demand blood-letting from their sometimes-reluctant physicians through the mid-18th century. But, for good or for ill, users have an influential voice.

The production of knowledge by and for scientific communities provides two advantages in coordinating its development. It reduces the differences in knowledge and predisposition that can make it difficult for developers of artifacts to anticipate users' needs and to communicate the benefits of their offerings. And, it allows scientific communities to adopt norms that facilitate coordination that producers of practical knowledge could not follow even if they had this autonomy.[14]

Differences in Hypotheses and Tests

Modern scientific communities have chosen to privilege, as Thomas Kuhn termed it, a core set of "paradigmatic" ideas their members take for granted and which (much more than any external utility) bound the hypotheses they consider worthy of research. The paradigmatic ideas –in conjunction with the norm of citing and building on prior research – align the efforts of competing individuals and groups who are also expected to make novel and creative contributions. This is not to suggest that paradigms require scientists to eternally march along the same narrow path. As Kuhn pointed out, the accumulation of anomalies can precipitate a revolutionary collapse of paradigms. And, scientists can drift away from the questions framed by their community's paradigm. But, in either case, paradigms typically continue to align scientists' assumptions and hypotheses, either because a new paradigm follows a revolutionary collapse or scientists who drift away from the mainstream, branch out into a new community with a new paradigm that coexists rather than competes with the old.

Although the paradigms of different scientific communities lead them to research different kinds of questions, they will generally tend to favor hypotheses that are:

• *Precisely and concisely codified* —Newton' second law of motion, $F = ma$, and Einstein's law of mass-energy equivalence, $e = mc^2$ provide ideal examples;

• *Universal and timeless* — propositions are treated as scientific to the extent they abstract away from specific circumstances of place and time and place. Even in common usage, the more general a proposition, the more "scientific" it is regarded to be.[15] ;

• *Objectively verifiable* —through dispositive tests that satisfy fellow scientists.

Like the paradigmatic research questions that mark the territories of individual scientific communities, the general preferences also promote cohesion of scientific effort. For instance, precise codification and standardized verification allow scientists to communicate with each other efficiently and to rely on each other's work. Preferences for codification, universality, and verifiability, also reinforce each other. For instance, scientists cannot verify imprecisely formulated hypotheses. Similarly, scientists tend to avoid events that occur in a particular time and place because many plausible but unverifiable 'just-so stories' can be told about the causes.

The degree to which different scientific communities require precise codification, universality, and objective verification varies (See Box 'Variations in Hypotheses and Tests'). But that aspiration, widespread in science, is not a common feature of practical domains as we will now see.

Variations in Scientific Hypotheses and Tests

Not all scientific knowledge is concise – as anyone who has had to memorize the periodic table will testify – and cell biologists, ecologists, and zoologists treat detailed descriptions as contributions. But scientific communities that start with sprawling collections of facts strive for concise propositions. Science advances with "general statements of steadily increasing explanatory power" according to zoologist Peter Medawar, that "annihilate" the need to know particular facts. "Biology before Darwin was almost all facts, " writes Medawar but now is "over the hump." (Molecular biologist James Watson who dismissed naturalist colleagues at Harvard who engaged in classification as "stamp collectors" apparently did share the zoologist, and fellow Nobel Laureate, Medawar's assessment).

Similarly, paleontologists do research and inconclusively argue about the one-off extinction of dinosaurs. But even in these instances, scientists reject evidence that lies in the eye of a particular beholder and they strive to develop more conclusive tests. As the evolutionary biologist Jonathan Losos puts it, for the first century of its existence, his field was thought to be similar to history: "You can't go back in time and see what happened, so you just have to try to figure it out." Now researchers "replay the tape" using microorganisms to test hypotheses in their laboratories.

Unlike scientists who are evaluated mainly by their fellows, developers of artifacts that have to satisfy "outside" users cannot expect to rely just on precisely codified generalizations. As mentioned, knowledge embodied in artifacts comprises a complex tangle. Precise scientific principles, for instance about fluid flow and biochemistry, may represent an important, sometimes even foundational component. But, artifacts also require a wide range of contextual knowledge which cannot be fully codified. Some is indeed precisely specified – in engineering drawings, circuit diagrams, and project plans for instance. In other cases, however, complete codification is infeasible – as in the 'tacit' knowledge pilots need to fly airplanes. And, even if feasible, complete codification may be dysfunctional. For instance, it may be better to let employees learn by doing, and to leave them the flexibility to adapt to changing circumstances, than to precisely specify (a la Henry Ford) how they should perform assigned tasks.

Generalizability of practical knowledge involves similar constraints and trade-offs. All airplanes must be designed to conform to universal laws of nature, but, there is value to adapting designs to intended use (e.g. long-haul versus short-hop, or cargo versus passenger). Yet, customizing individual planes can make them unaffordable. How many models and options to offer is therefore a matter of pragmatic choice. Moreover, given the practical difficulty of getting something to work, developers will often first tune their artifacts for specific circumstances and for specific users and then look for ways to generalize their designs for broader applications.

Unlike scientists, developers of practical knowledge also cannot realistically even aim to produce timeless ideas. The utility of a design or technique depends on its fit with circumstances of time and place – the prevailing Zeitgeist. Moreover, the extent of use itself can affect utility. For instance, the capacity of standardized credit scoring to predict loan defaults deteriorated when its increased use by lenders taught borrowers how to game their scores. Conversely, learning or network effects can increase utility. For instance, the popularity of a surgical technique can accelerate its improvement, and wide adoption of a programming language such as Java can make it a valuable standard. In contrast, increased acceptance of a scientific hypothesis does not affect its correspondence to the nature: whatever reality is "out there" remains unchanged.

Practical knowledge comprising complex combinations in turn encourage pragmatic tests that that journal referees would dismiss as flawed or inconclusive (because, they had "selected on the dependent variable" or "confounded correlation with cause"). Rather, the tests reflect the experimenter's personal beliefs (See Box 'Upping the Dose') rather than those of a research community.

Upping the Dose

As recorded in the public television documentary *Emperor of All Maladies*, Dr. Stephen Rosenberg began exploring immunotherapy treatments for cancer in the 1970s after observing a miraculous remission in one of his patients. His approach was to extract proteins from immune cells grown in a laboratory culture and then inject these proteins into patients to boost their immune systems. Clinical trials of the extracted proteins (called "interleukin") began in 1982, but showed no signs of working on the first 66 patients. Dr. Rosenberg then gave, in 1984, a much higher dose of interleukin to the 67th patient, a Navy officer named Linda Taylor who went into complete remission and remained in good health for decades thereafter. High dosage became the norm for all subsequent interleukin treatments.

This story illustrates two common patterns of artifactual development discussed in the main text. First, the trial was a joint test of the general idea of immunotherapy, a specific manifestation, namely interleukin, and the dosage of interleukin. Second, Dr. Rosenberg's decision to persist after 66 failures reflected his strong convictions and possibly incentives to protect his personal "investment" in immunological therapies.

Pragmatic testing reflects broader and more consequentialist ends than scientific testing. For instance, whereas scientists seek verification of a hypothesis (to the satisfaction of their fellow researchers), developers of artifacts can experiment in order to decide whether to embark on a development project; choose a technological platform; troubleshoot and cure defects in a prototype; modify an artifact that that works under conditions A to work under conditions B or C (where it now fails). The tests used are correspondingly more diverse. For example, a developer may test an idea through thought experiments, examination of the underlying reasoning through a dialectical dialogue, and exploratory conversations with potential users. If, based on idiosyncratic evidentiary standards, the developer decides to continue, she may then follow up with mathematical simulations, physical prototypes, in vivo and in vitro lab tests, customer surveys, focus group interviews, alpha and beta tests, and unpublicized product launches in test markets.

Pragmatic tests similarly take more cognizance of the circumstances of place and time than experiments designed to verify universal and timeless scientific propositions. Developers seek to incorporate, to the degree possible, all the important external factors expected to affect the performance of their artifacts under conditions in which the artifact will be used, rather than "control" for these factors. Thus, engineers will try to test the shapes of airplane wings or automobiles in wind tunnels designed to replicate actual rather than idealized flying or driving conditions.

But, pragmatic testing that reflects personal predispositions and contextual factors also undermines the role that decisive results of tests based on a community standard can play in coordinating scientific research: others may not trust the results of a pragmatic test without personal knowledge of the expertise and predispositions of the person performing the test and firsthand examination of the test design. Yet, wide inclusivity, which limits the scope for unilateral personal action, requires such trust.

Differences in quality and membership standards

Scientific communities face strong incentives to require strict internal conformance to their norms. Researchers require funds provided by governments, foundations, and philanthropists who, as mentioned, cannot independently assess the quality of the research. Rather, the outside funding agencies rely on certification provided by journals, whose referees and editors enforce rigorous adherence to the research community's standards for parsimony, precision, and testing. Similarly, not tolerating mistakes also helps scientific communities and publications avoid externally damaging perceptions of favoritism. Therefore, if referees raise credible objections, scientific papers aren't accepted for publication in the expectation that the problems will be addressed in later iterations. And, increased competition between communities for outside resources and standing has likely spurred a tightening of criteria for hypotheses and evidence and reduced the scope for deviant or idiosyncratic inquiry. It also increases the confidence within the community in each other's work without requiring any knowledge of individual producers.

Along with – and possibly because of – stricter criteria, scientific communities have increased qualifications for membership. Bodies such as the Royal Society once included well-born gentleman-scholars – and even the Delft tradesman, Antonie van Leeuwenhoek, now considered the Father of Microbiology. But today, individuals who do not have PhDs and jobs at universities or recognized research institutions have been almost completely marginalized. Concurrently, the number of research communities, and the compartmentalized specialization of its members, has also grown. Thus, while the broadening of opportunities for higher education and the public funding of scientific research has made entering scientific communities more meritocratic and open to the not so-well-born, credentialed specialization has limited membership of specialized communities to individuals who have the same knowledge, training and life-experiences.

In contrast, developers of many artifacts face less rigorous standards than those imposed by gatekeepers of scientific research because users consider mainly their own costs and benefits (rather than enforce a group norm). Thus, users of new artifacts are often willing to tolerate obvious limitations in the expectation that they will be fixed. In some cases, the expectation can even lead to acquisitions of buggy "first generation" products that make users temporarily worse off. Users' tolerance for imperfections in artifacts isn't blind however and depends on first hand examination of the artifact and the reputation and persuasiveness of individual producer.

And, membership criteria for joining the multiplayer innovation game are more flexible. The increased division and specialization of labor in the development of practical knowledge has, as in the sciences, raised standards for the qualifications required of many specialists. However, there are important differences. Artifact development has continued to provide entrepreneurial opportunities for college dropouts like Bill Gates, Steve Jobs, and Mark Zuckerberg (who would now be excluded from scientific communities), and the companies they have founded (Microsoft, Apple, and Facebook) recruit many selftaught hackers. Moxie Marlinspike, whose encryption programs have been embedded in applications used by billions, barely finished high school before finding a job in Silicon Valley. But the greater diversity of backgrounds and training, as compared to scientific communities also increases the problems of coordination.

REQUIREMENTS AND GRADING

FINAL PAPER (Expected by noon, May 5, 2019 – and absolutely no later than two days before the deadline set by the registrar for submitting grades):

In lieu of a final exam, seminar participants will write a case history of a noteworthy artifact such as a medical treatment, software program, technique, or organization. The case history should include, to whatever degree information is available, a description and analysis of the:

- "Dynamics" and interactions of the common tasks we discuss in the seminar -- how one choice led to and affected another.
- Roles, background, motivations, and risks of key individuals and organizations.
- Competitive or regulatory problems and user resistance encountered and how they were overcome

I will provide extra credit for reflections on how your case-history:

- Compares with case-histories of other artifacts discussed in the seminar or you are otherwise familiar with.
- Suggests, reinforces or causes you to modify generalizations you found in the seminar readings or which were discussed in the seminar.
- Has influenced your own long-term goals and career choices.

You are strongly urged to pick an artifact from a list I will provide and make your choice as soon as possible. You will also be required to present your findings to other participants towards the end of the term and incorporate the feedback you receive in their final versions. And, as this is a capstone "incubator" course, papers may be turned into capstone projects.

Teams of up to three students may work on a single case history. (Under no circumstances, four or more).[*] And please limit your paper to 15 single-spaced pages. Attach exhibits or appendices as you see fit but note that I will not give additional credit for bulking up the paper.

PRE-CLASS SUBMISSIONS

Participants will be required to write up and submit (via an electronic Google form) one-paragraph responses to about 4-5 questions about the assigned readings by noon the day (i.e., on Mondays) before each class. I will compile the responses and share them with seminar participants by the end of that day. You are not required to read the compilations, but you may find it helpful to skim them. The assigned questions will typically be broad and open-ended.

If you have a problem logging on to the system (because the server is down, for instance) do not waste too much time trying to submit your response. Just send me an email telling me that you tried to submit your responses but couldn't; I will take you at your word.

I recognize that the day before class deadline may require you to plan your time with some care. But this deadline was suggested to me by a student who said that it would be of great help to those who mother tongue isn't English. I found the argument persuasive.

[*] I will grade the papers independent of team size: for example, two-person and three-person papers of the same quality will receive identical grades.

NORMS

No laptops open and of course all mobile devices turned off.

Do not enter the classroom after the scheduled start of the class. Tardiness disrupts discussions and devalues the effort of everyone else who does show up on time. You may not however be able to make it on time because of family emergencies, unexpected transportation breakdowns etc. If this happens, instead of showing up late please send me an email telling me why you couldn't make it. I won't count it as a "missed" class.

I will implement the tardiness policy under an honor system: if you tell me that you did not make it to class because you were delayed in a traffic accident or because you had to see a physician, I will take you at your word.

GRADING METRIC

Grading will be based on my assessment of papers and in-term contributions in the following manner:
I will divide the papers into two roughly equal buckets – a top half and a lower half. I will also identify papers that I regard as truly exceptional and those that fall well below the standard expected in a top-quality professional school. (I expect the truly exceptional papers will comprise less than half of all papers and hope there will be no papers of unacceptable quality.)

Participants who write a "top half" paper and have been regular and diligent contributors during the term will get an A. Those who write a truly exceptional paper but may not have been regular contributors can also get an A, unless their in-term contributions have been seriously deficient.

Those whose in-term contributions have been seriously deficient (or whose papers are of unacceptable quality) will get a B or possibly a failing grade depending on the extent of their shortfall.

Everyone else will get an A-.

Schedule

Class #	Date	Topic
Introductory Case History		
1	23-Jan	Evolution of medical knowledge
Module I: Common Tasks and Techniques		
2	30-Jan	Goal and Problem specification
3	6-Feb	Ordering and Harmonizing Choices ("Strategic Planning")
4	13-Feb	Conjecture (Human Centered Design)
5	20-Feb	Codification (Checklists, Best Practice Programs)
6	27-Feb	Communication
7	6-Mar	Testing and Evaluation
8	13-Mar	Partitioning and Grouping
9	27-Mar	Aligning Incentives
Module II: Noteworthy Artifacts		
10	3-Apr	Containers, Computers and Frozen Foods
11	10-Apr	HIV-Aids, CTs, CABG and Mammography
12	17-Apr	Handelsbanken
13	24-Apr	Wrap-up and Project Summaries

An electronic submission is due by noon on Monday before each class

Daily Assignments (not completed)

Introductory/Overview Case History

Evolution of Medical Knowledge

The history of medicine exemplifies efforts to develop knowledge that will "change the way things would naturally be," drawing upon – but not merely applying – knowledge of "the way things naturally are".

Readings:

• *The History of Medicine – A Very Short Introduction*
• Seminar Overview and Course Requirements (Syllabus)

Questions:

After completing the reading on the history of medicine, please answer the following questions:

1. Think of any three innovators (such as Hippocrates or Sydenham), or groups of innovators (such as the French hospitalists): What were their implicit or explicit goals? What were their key general or overall choices (of platforms, paradigms, etc.)?

2. Basing your response on one chapter of your choice: What was the relationship between the development of knowledge of "the way things naturally are" and the knowledge directly used to treat patients? Who were the leading developers of the former? How long were the lags between learning about the way things naturally are and the knowledge used to treat patients?

3. Again, focusing on any one chapter of your choice: In what ways did the state influence the development of medical knowledge?

4. What differences do you see in how practical knowledge is developed in medicine and in non-medical artifacts and practices?

Please enter your responses – just one paragraph per question – in the Google form below. (It would be prudent to type out your responses in a Word document and then cut-and-paste into the Google form at https://goo.gl/cNrlbU).

Module 1: Common Tasks and Techniques

Goal and problem specification (Choosing Ends)

~~Choosing ends first – and persevering with that choice – helps make choices of means consistent with each other and across time. But making the choices wisely – including choosing to defer the choice – poses a variety of difficulties that we will examine in this session~~.

Readings/Podcasts
• Technology of Foolishness (James March)
• Obliquity (John Kay podcast)
• Goals Gone Wild (Bazerman et. al) (SKIM)
• Establishing Design Requirements (SKIM) (Vincenti)
• Indeterminate Goodness of the Economy (Bhidé) (through the section, the Problem of Work)

Optional
• The Balanced Scorecard (Norton Kaplan HBR)
• In search of a better stretch target (Davies et. al)

Questions (to be answered at https://goo.gl/wvrSKW)

1. To what degree is the specification development process outlined in Vincenti's "Establishing Design Requirements" reading applicable outside airplane design?[*]

2. James March (Technology of Foolishness) raises the issue of choosing ends when you don't know what you will want in the future. What practical solutions do you see to this problem?

3. What kinds of goals or targets are best pursued obliquely (as John Kay puts it) and which ones directly?

4. The Bazerman and Bhidé readings raise the issue of the level of aggregation (or "subsidiarity") in choosing ends i.e. which ones should be chosen by individuals, which by employers, and which by societies and governments. What criteria can you think of for choosing this level? And, what procedure would you suggest for making this choice?

5. Other observations from and reactions to the readings.

[*] In later sessions, we will also compare this process with the problem framing steps used in six-sigma, reengineering, human centered design and checklist techniques.

Ordering and Harmonizing Choices (Strategic Planning)

Readings;
• *Competition and Business Strategy in Historical Perspective* (Ghemawat)
• *Gaining Advantage over competitors* (McKinsey Quarterly compilation)
• *What is Disruptive Innovation?* (Christenson, Raynor and McDonald)
• *Clay Christensen's theories are great for entrepreneurs, but not executives* (Bhidé and Ghemawat)

Optional reading on other management paradigms
(BUT READ AT LEAST ONE ON PROGRESS FUNCTIONS OR OPERATIONS RESEARCH):
• *Bad Work Practices and Good Management Practices* (Williams)
• *Scientific Management, Systematic Management*. (Nelson)
• *Operations Research vis-à-vis Management* (Thomas)
• *History of Progress Functions.* (Dutton)

Questions: (to be answered at https://goo.gl/xnK5nd)

1. What ideas in the readings did you find to be most in conflict? Most complementary?

2. What similarities and differences did you see in the development and diffusion of the paradigms? (you don't have to discuss all the paradigms)

3. Why haven't Progress Functions (as discussed by Dutton) or Operations Research (as discussed by Thomas) caught on to the same degree as Porter's Five Forces, Christenson's Disruptive Technologies, and Discounted cash flows?

4. What questions do the readings raise in your mind that we should discuss in class?

5. Other optional observations.

Conjecture

Readings
• Six sigma: Summary (Wikipedia)
• *Six Sigma: what it is and how to use it* (Plotkin)
• *Process management and the future of six sigma* (SKIM) Hammer
• *How strategists really think* (Analogical reasoning) (Gavetti and Rivkin)
• *Blink* Wikipedia summary and Richard Posner review of *Blink*
• *What is your intuition?* (Pattern recognition and mental simulations)
• *Positive Deviant* (David Dorsey. Fast Company)
• *Six Secrets to True Originality* (SKIM) Grant
• *Design Thinking and Innovative Problem solving* (Datar and Bowler)
• *Design Thinking Interview* Catherine Courage

Questions (to be answered at https://goo.gl/dEvkvX)

1. What kind of problem or problems are design thinking techniques best suited to solve?

2. What kind of problem or problems are design thinking techniques least suited to solve?

Codification

Readings/Podcasts:

Checklists (compiled into single pdf):
• *Perspectives in quality*: designing the WHO Surgical Safety Checklist
• Atul Gawande's *Checklist for Surgery Success*
• Atul Gawande interviewed by HBR's Katherine Bell
• Justin Fox Blogpost on Gawande book
• *Ten Steps to Preventing Infection in Hospitals*
• Wall Street Journal *Interview with Dr. Peter Pronovost*
• Wall Street Journal *Review of The Checklist Manifesto*
Best Practices
• *Xerox creates knowledge sharing culture* (Powers)
• *Creative Benchmarking* (HBR) Iacobucci and Nordhielm
• *Building a best practice sharing program* (HBR) Johnson
• *Beyond Best Practice* (SMR) Gratton and Ghoshal
• *If only we knew what we know* (CMR) O'Dell Grayson
Precision and Completeness of Codification:
• *Getting it Right the Second Time* Szulanski and Winter HBR
• *Organizational Learning* (Levitt and March.)
• *Judgement Deficit* (Bhide) or podcast at https://hbr.org/2010/09/the-big-idea-the-judgment-deficit

Optional Readings

• *Formulaic Transparency* (Bhide) SKIM. This is a more detailed and context specific version of *Judgment Deficit*

Questions: (to be answered at https://goo.gl/dQ4Sl2)

1. What do you see as the strengths and limitations of checklists – what kinds of problems and tasks are they best and least suited for? Do you agree with Philip Howard's critique (in his review of Atul Gawande's book)?

2. What alternatives can you think of that can replace or reduce the need for checklists and other forms of the codification (covered in the previous readings)?

3. What tradeoffs do you see in precise or unambiguous codification (as in airline and surgical checklists)?

4. What tradeoffs do you see in complete or comprehensive codification (as suggested for instance in the Szulanski and Winter article)?

Communication

Readings, podcasts and videos:

Persuasion and Media Theory:
• Rhetoric Bragg et. al podcast posted at http://www.bbc.co.uk/programmes/p004y263
Harnessing the Science of Persuasion -- Cialdini's article based on his book Influence: The Psychology of Persuasion)
• Guardian podcast interpreting Marshall McLuhan's "medium is the message" claim (McLuhan's theories left much room for interpretation, as fans of Woody Allen know).

Visual representation of data and arguments:
• *Gene Zelazny: Make Your Presentations Compelling* -- interview with author of Say It With Charts and its sequel Say It With Presentations and Zelazny remarks
•*Tufte reader's guide* – based on of Edward Tufte's Visual Display of Quantitative Information
• PowerPoint Debate -- compilation of observations by Parks, Tufte and Zelazny
• Minto Pyramid Presentation (slideshare download)

Written Communications:
• *How to Structure What You Write* (Bierck, on Minto's Pyramid Principle) HBR
• How to write a Memo or Report (Williams, also based on Pyramid Principle) HBR
• Vonnegut on Style and Shapes of Stories (Maria Popova based on Vonnegut's presentation and essay included in How to Use the Power of the Printed Word anthology)

Making Presentations and Speeches
• *The Knockout Presentation* – HBR
• *For Presidential Hopefuls, Simple language resonates* (Boston Globe article)
• 20 Simple Steps to the Perfect Persuasive Message (blog post)
• Nancy Duarte's 5 rules for presentations and a TedX East talk (video)
• Steve Job's presentations launching the iPod and iPhone (video)

Questions (to be answered at https://goo.gl/1N6XQ1)

1. What were the sharpest or most striking "general" differences (of differences "in principle") did you find in the assigned readings and videos? When would you follow one or the other principle?

2. What were the most striking "specific" lessons that you are likely to use in the future?

3. Which article or presentations did you find to be most effective in communicating their message? Who were the least effective? (List names; paragraph not necessary)

4. Which side do you support on the PowerPoint debate and why?

5. What lessons did you derive from the Steve Jobs presentations? What general and specific choices (e.g. about content, structure, delivery, visual aids, etc.) did Steve Jobs make? To what degree do his presentations confirm, extend, or challenge the other material you read or saw?

Testing and Evaluation

Readings

- *Management Half-truth and Nonsense: How to Practice Evidence-Based Management*
- *The Truth Wears Off* (Jonah Lehrer)
- *FDA and Clinical Drug Trials: A Short History* (FDA-Junod)
- Assessing the Gold Standard — Lessons from the History of RCTs (Bothwell et. al)
- *Pros and Cons of Standardized Testing* (Columbia)
- *The Problem with Evidence-Based Policies* (Hausmann)
- *The A/B Test: Inside the Technology That's Changing the Rules of Business* (Christian)
- *Why I don't Test Wine Blindly* (Altman)
- *The Development of Discounted Cash Flow Techniques in U.S. Industry* (Dulman)
- *Mammography Case-Study*
- *The Air-Propeller Tests of W. F. Durand and E. P. Lesley* (Vincenti) SKIM
- *Making Economics More Useful* (Bhidé) (Section 1) SKIM

Optional:

- *No-Nonsense Guide to Measuring Productivity* (Chew HBR)
- *Excessive Ambitions* (Elster) SKIM
- *Learning and Quality Control* (Miranti)
- *Online Controlled Experiments and A/B tests* (Kohavi and Longbotham)
- *Controlled Experiments on the Web* (Kohavi et al)
- Plato's *Allegory of the cave*

Questions: (to be answered at https://goo.gl/UDGplM)

1. What lessons do the examples of propeller testing and the No Nonsense Guide to Productivity measurement suggest that could be useful outside the field of aircraft design and productivity measurement?

2. To what degree could A/B testing address the problems raised by Hausmann of randomized control trials? What are some other alternatives to RCTs?

3. What changes would you suggest to the FDA's drug testing rules?

4. How persuasive did you find Pfeffer and Sutton's critique of the "sorry state of the business idea marketplace?" How useful did you find the solutions they offer? How does their approach to evidence-based management complement or conflict with the "balanced scorecard" approach?

5. When is standardized and blind testing most and least useful?

Partitioning and Grouping

Readings/Podcasts

• *Reengineering Work* (Hammer)
• *The Use of Knowledge in Society* (Hayek) (Focus particularly on Sections I-V)

Questions (to be answered at https://goo.gl/6j9Opn):

1. What kind of problem or problems is are reengineering techniques best suited to solve?

2. What kind of problem or problems is reengineering least suited to solve?

3. What does Hayek's article suggest about reengineering techniques?

4. Other observations from and reactions to the readings.

In many instances, answers or solutions are known to some but not all the members of a community or organization. Or, different individuals know about solutions to part of the problem but not the whole. These situations raise questions about how practical knowledge is to be shared and pooled.

Best practices/learning from success.

Role of prices in sharing across distance
Use of Knowledge in Society (Hayek). (Focus on Sections VI through the end)

NUMMI "case study":
• Podcast posted at at http://www.thisamericanlife.org/radio-archives/episode/403/nummi?act=1#play
• If you prefer to read a transcript instead of listen – the podcast is long -- it is at: http://www.thisamericanlife.org/radio-archives/episode/403/transcript

Optional Readings

• *Positive Deviance Guide* (Tufts University)

Questions (to be answered at https://goo.gl/c52rhH)

1. What similarities and differences do you see in the "best practice" and "positive deviance" techniques?

2. What lessons can you infer from NUMMI case for applying or adapting problem solving techniques or templates?

3. To what degree does the price system (per Hayek's argument) complement or substitute for other mechanisms for knowledge sharing?

4. Any other additional general observations?

Aligning Incentives

Readings;
• *Keeping the Best: Essential Retention Strategies* HBR (QUICK SKIM)
• Miscellaneous incentivization readings (QUICK SKIM)
• Daniel Pink videos
• *Did Henry Ford Pay Efficiency Wages* (Raff and Summers)
• *A Theory of Human Motivation* (Maslow)
• *A Historical View of Theory Y* (Carson)
• *Nature of Man* (Jensen and Meckling) FOCUS on the section The Psychological model of Human Behavior that starts on p. 14

Questions (to be answered at https://goo.gl/Emb5vv):

1. What "new takeaways" from the readings (or videos) on employee retention and motivation could you or an organization you are familiar with have fruitfully applied, and in what specific situations?

You don't need to describe the specific situations where the takeaways could have been applied in your write up, but please be prepared to describe them in class.

Also, the "new takeaways" don't have to be ideas that you had literally never thought about or which are completely non-obvious; they can be things that that you had not given serious thought to and ideas that are obvious once pointed out. Also, the takeaways need not be explicit in the readings but merely prompted by the readings.

2. The practical utility of which propositions do you have the most doubts about?

3. What relationship do you seen between an "efficiency wage" (Ford), "hierarchy of needs" (Maslow), and Theory Y (McGregor)? How relevant and useful are these ideas today?

4. Other optional observations.

Module 2: Noteworthy Artifacts

Containers, Computers and Frozen Foods

(There is a lot to read. Please focus on the story: the plot, the characters, and organizations rather than the author's take or analysis and skim as indicated).

• "*External Economies and Economic Progress: The Case of the Microcomputer Industry*" (Langlois).
• "*Not Only Microsoft: The Maturing of the Personal Computer Software Industry, 1982-1995*" (Campbell-Kelly) (QUICK SKIM)
• Levinson interview with Dan Wang
• "*Container Shipping and the Decline of New York, 1955-1975*" (Levinson) 49-80
• "*The Economies and Conveniences of Modern-Day Living: Frozen Foods and • Mass Marketing, 1945-1965*" (Shane).
• "*Lighting the Path to Profit: GE's Control of the Electric Lamp Industry, 1892-1941*" (Reich. (LIGHT SKIM).
•*From Novelty to Utility: George Westinghouse and the Business of Innovation during the Age of Edison* (Usselman. (LIGHT SKIM)

Questions (to be answered at https://goo.gl/CGO0JT)

Think about the similarities and contracts between all the cases but for the purposes of the pre-class write up focus on just ONE of the following artifacts: Microprocessors (Personal computers), Shipping Containers, and Frozen food

1. What did you find to be the most notable features in the evolution of the artifact, especially in terms of who did what when and why? And how do these features compare with those of the other artifacts you read about?

2. How does the evolution of the artifact fit – or not fit – the propositions in the "strategy" readings?

3. What questions do the readings raise in your mind?

4. Other optional observations.

HIV-Aids, CTs and CABG

Readings and recordings:

~~(There is a lot to read. Please focus on the story: the plot, the characters, and organizations rather than the author's take or analysis and skim as indicated)~~.

•

Questions ~~(to be answered at https://goo.gl/CGO0JT)~~

~~Think about the similarities and contracts between all the cases but for the purposes of the pre-class write up focus on just ONE of the following artifacts: Microprocessors (Personal computers), Shipping Containers, and Frozen food~~

~~1. What did you find to be the most notable features in the evolution of the artifact, especially in terms of who did what when and why? And how do these features compare with those of the other artifacts you read about?~~

~~2. How does the evolution of the artifact fit – or not fit – the propositions in the "strategy" readings?~~

3. What questions do the readings raise in your mind?

4. Other optional observations.

Handelsbanken

Readings
• Handelsbanken.: 2002 (A), HBS No. 115-018.
• Section on "Longevity and Growth" in Chapter on "Missing Attributes" in *Origin and Evolution of New Businesses*, Bhidé 1999.

Study Questions (for you to think about)

1. What makes Handelsbanken different from other large banks and what tradeoffs does its distinctiveness entail?
2. To what degree does Handelsbanken face the "generic" spurs and constraints to growth (described in the "Missing Attributes" chapter)? What additional spurs and constraint arise because of banking -- and Handelsbanken's distinctiveness distinctive approach?
3. What risks and opportunities does a bank in general -- and Handelsbanken in particular -- face in entering the Baltic and UK markets? How, if at all, would you change Handelsbanken's model in Sweden to the Baltics?
4. How do you weigh the risks and opportunities in the Baltics and UK vis-à-vis growth in Norway, Denmark and Finland where Handelsbanken already has a presence?

Questions to be answered at https://goo.gl/yN5Fkj

As Par Boman, I would recommend Handelsbanken make a serious commitment to growth in (check all that apply):

[] Norway and/or Denmark and/or Finland
[] The Baltic Countries
[] The UK
[] None of the Above
[] Other (please specify)

Because:
[Enter your top reason]
[Enter reason 2]
[Enter reason 3]

Optional Additional comments []

Wrap-Up and Project Review

Notes to Overview

[1] Simon (1996)
[2] John Kay's review (downloaded on August 21, 2018 from https://www.johnkay.com/2018/08/10/the-secret-of-our-success-a-review/) succinctly summarizes Henrich's argument.
[3] Elster (1993) p.51.
[4] Elster (1993) p.71
[5] Vincenti p 208
[6] *Contra* Schumpeter's "gales of creative destruction" imagery however, the alternative technologies can take decades to gather force.
[7] And possibly the existential anxiety that Kierkegaard said attends such leaps.
[8] https://runningtortoiseandhare.wordpress.com/running-shoes/history-of-running-shoes/
[9] To borrow a term from Roethlisberger (1977)
[10] Ethan Segal, "Meiji and Taishō Japan: An Introductory Essay" downloaded on August 26 2018 from https://www.colorado.edu/cas/tea/becoming-modern/1-meiji.html
[11] Scientific knowledge can also help control dysfunctional practices – for instance, ignorance that Vitamin C rather than all sour tasting substances prevent scurvy is said to have led to its resurgence when the British Navy substituted lime juice for lemon juice in sailor's diets (Barron 2009).
[12] Longair, Malcolm S. 2003. P. 223. *Theoretical Concepts in Physics: An Alternative View of Theoretical Reasoning in Physics.* Cambridge: Cambridge University Press
[13] Stokes, Donald E. 1997. *Pasteur's Quadrant: Basic Science and Technological Innovation.* Washington, D.C.: The Brookings Institution
[14] Scholarly communities in the humanities who have as much autonomy as scientific communities to choose their norms have apparently not favored consensus enhancing norms. This may derive from a tradition of contention that preceded the Scientific Revolution. In the sciences, the founding figures, Shapin's account suggests, explicitly rejected norms of irreconcilable contention.
[15] See for instance Hayek's distinction between scientific and specific knowledge.