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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Practical Knowledge

Overview

This seminar examines the development of knowledge embodied in artifacts (including physical objects, organizations and practices) intended to transform "existing conditions into preferred ones."[1] We are particularly interested in knowledge produced by the many and for the many: thus, we are more interested in standardized techniques developed for the average tennis player than in coaching customized for a prodigy.

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. And, while engineers, physicians, lawyers, entrepreneurs, managers, and accountants can secure higher incomes, many continue to regard their knowledge and its development as subordinate – a mere application of more profound scientific ideas at best, or simply unfounded superstition. Similarly, although Western universities started by offering practical medical and legal training, some in the upper reaches of the Academy now deride professional schools as verging on the teaching of trades that have no place in institutions of higher learning.

The disdain cuts against the essence of our humanity. We are human because we create, not just because we think. 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.

Moreover, we now have unprecedented scope to exercise these faculties, and not just because the exponential growth of scientific knowledge provides more raw material for new artifacts; innovation has also become more "inclusive" and systematized: Even lone geniuses and solitary inventors participate in a massively multiplayer game with more or less well-ordered rules of engagement. Organizations, communities, and networks help nearly everyone, including factory workers, to exercise their creativity and initiative. And, where novel artifacts were once produced principally for powerful or wealthy patrons, contemporary innovation aims at and relies on widespread "venturesome consumption."

The inclusive, systematic pursuit of practical ends has a distinctive character. Practical knowledge developed by and for the many isn't simply or mechanically derived from scientific knowledge or by the application of scientific methods. Rather, as we will see, practical knowledge is more multifarious in its content, in the contributions it integrates, and in the processes of its development than scientific knowledge. It therefore warrants study in its own terms.

Goals. In contrast to most courses in the natural or social sciences, we are less interested in *propositions* (about what must or will naturally happen) and more in *prescription* (to figure out and secure what we want). And, like its subject matter, the seminar has a practical purpose: to improve your capacity to develop and apply practical knowledge.

There are also subtle differences in the focus and structure of this seminar and in much of professional education that also seeks to provide instrumentally useful instruction. First, professional schools emphasize mastery in a practice they (or some standard setting body) has deemed as "best" – or best for some broad category of applications – without providing much training in what we might call skillful, discriminating use of alternative techniques. But professionals cannot rely just on mastery of specific tools (which often

become outdated). They also have to choose the most suitable tool from an evolving tool kit and jigger the tool they select to the particular problem at hand and to their own capacities.

In contrast, we focus on the general issue of choosing and adapting tools rather than deep knowledge of a particular set of tools - although we do this inductively by comparing several specific and currently popular techniques, discussing questions such as: What is the "sweet spot" of the technique or practice and to what degree is it applicable outside that sweet spot? Is a complete formula provided or instead some general pointers? What kind of tacit knowledge is stipulated or assumed? How clearly or completely is the technique or practice laid out? And, how persuasive is the argument for using it?

Second, professional schools – and students – seem to prefer easily transferrable techniques (that can be well-codified or acquired by hands-on practice) for individual use. This preference likely tilts against techniques (such as "balanced scorecards") to facilitate action jointly undertaken by widely dispersed individuals; although, as mentioned, these techniques are a defining feature of the now highly inclusive pursuit of practical ends, they have a fuzzier character and cannot be acquired through individual practice (or even small group projects). We examine tools for individual use mainly to illuminate the distinctive features of collectively used tools.

Third, professional schools that emphasize mastery of existing techniques do not provide an analogue to the "scientific method" that guides the development of new scientific knowledge.[2] In contrast, the development of new practical knowledge is of great concern to us. The wide range of domains we cover, however, makes "hands-on" practice in the development of such knowledge infeasible; therefore, we rely on the case-discussion approach of studying the evolution of specific protocols, transformational products (such as shipping containers), and exemplary organizations.

Discovering what naturally happens or naturally is – facts (such as of atomic structure), physical laws (as of planetary motion) – and axiomatic inferences – in geometry or micro-economics – fall outside our scope, except to the degree that we can harness such knowledge and inferences to develop and use artifacts.

The next section of this overview advances propositions about the distinctive characteristics of practical knowledge that underpin the seminar. Section 2 discusses contrasts with the development of scientific knowledge that will help illuminate these distinctive features. (Please bear in mind that I offer broad-brush hypotheses about the distinctive features and contrasts – even if they seem stated as firm conclusions). Section 3 offers a framework for working through the tangle of choices and options that developers and users of practical knowledge typically face. Section 4 provides a summary of the two seminar modules.

1. Distinctive characteristics

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]

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 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

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.

more than decade-long effort that, after screening more than 600 compounds, culminated in the synthesis of ibuprofen, could, like efforts to cure the common cold, have been futile.

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 don't – 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. And, 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 artifact-specific knowledge and infrastructure that unpredictable 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. But 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. Developers of practical knowledge are obviously more pragmatic.

More subtly the development of practical knowledge has a 'pragmatic' character in combining '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 "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);

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."

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' sympathies clearly tilt towards "pluralistic" empiricism.

But crucially, James favors including the "monistic" 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 have to be designed to accommodate roller carry-on bags and ibuprofen containers have to 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 in fact 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.

Tangle of Choices

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 further 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, produce existentialist anxieties. If so, confronting an overwhelming number of possible combinations should create unrelenting anxiety, possibly exceeding

the *Fear and Trembling* produced, according to Kierkegaard, by a single big leap of religious faith (as when Abraham accepts God's command to sacrifice his son).

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 have to, and for imagining options that do not naturally appear in front of us.

New techniques and scientific knowledge can reduce but not eliminate anxieties of choice. For instance, rational drug discovery procedures that harness improved scientific understanding of disease mechanisms have helped narrow the number the molecules researchers have to screen for their potential therapeutic effects. Print on demand technologies and computer simulations have reduced the cost and increased the effectiveness of testing physical or virtual prototypes. And, more reliable evaluations – or at least the expectation of more reliability – reduce the anxiety of choice and ameliorate the problem of over-cautious satisficing.

But tests are never foolproof. Drugs that show great promise in laboratory tests can turn out to be ineffective, or even dangerous in humans. Consumer products (such as New Coke) that sell well in test markets can fail full-scale launches. Notwithstanding great advances in biomedical engineering and materials technologies, no one can really know when an artificial hip will need to be replaced. Moreover, the proliferation of evaluation technologies creates a sort of, "*Quis custodiet ipsos custodes?*" puzzle: who evaluates a new evaluation technique? How do we know whether – and under what circumstances – it is better than its older alternative? At the same time, the utility of tests and other aids to decision making can decay as circumstances change; how does a user decide whether a test needs replacement?

Widened inclusivity

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 became a more broad-based, "multi-player" game in the 20th century. The Internet 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, harnessing the creativity and enterprise of the many rather than relying on a few genius inventors has resulted in more, better, and affordable innovations. 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 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.*

Similarly, new organizations and organizational forms have emerged to widen participation in knowledge development and venturesome consumption. As business historians have documented, the development of industrial designs and technologies moved from the garages 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) have 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 have advanced new technical and organizational ideas. And, mass discounters (such as Wal-Mart), multinational advertising agencies (such as McCann Erickson) and e-tailers (such as Amazon) whet and feed appetites for venturesome consumption.

But the benefits of 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 also 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. Massively multi-player innovation also often requires justifying choices to individuals who weren't involved in making them. For instance, where the self-financed entrepreneur can act on their hunches, raising outside funds requires entrepreneurs 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.†

Similarly, as we will now see, developing scientific propositions poses easier coordination problems that "paradigmatic" agreements that bind modern research communities can help solve. For example, the norms of scientific research favor well-codified, generalizations that can be easily transmitted to and evaluated by dispersed scientists. Indeed, unlike the developers of artifacts who may have a commercial

* 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.

† 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.

interest in keeping some of their knowledge secret, scientists are expected to and rewarded for full disclosure. Specialized scientific communities are more compact and self-governing. They evaluate each other's contributions – no external buyer needs to be "sold" – and align their efforts by agreeing on and enforcing paradigms that specify the kinds of problems members of the community will normally attack and the kinds of methods they will use.

2. Contrasts with Scientific Knowledge

Interdependent but distinct

Scientific (or "propositional") knowledge of how things naturally are 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 advances that came after the development of artifacts have helped improve the artifacts: thermodynamics improved the efficiency of steam engines, for instance.[8] Bacteriology and virology have improved the development of vaccines (which Jenner had pioneered in Britain before scientist had shown how germs cause disease).

Conversely, new artifacts can stimulate scientific research. 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."[9] 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 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 prioritize 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"[10] – 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.[11]

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 expected to make novel and creative contributions. This is not to suggest that paradigms force scientists to eternally march along the same 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, paradigmatic coordination typically remains, 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.

Scientific communities can also effectively share information by favoring well-codified, parsimonious hypotheses about 'universal', recurring phenomena that scientists can evaluate through tests the community considers decisive. These preferences, which allow terse, credible communication (for instance through journal articles) between scientists, reinforce each other. For instance, scientists cannot decisively test imprecisely formulated hypotheses. Similarly, scientists tend to avoid phenomena that occur in a particular time and place: such effects are difficult to replicate in controlled experiments and the causes are often overdetermined (in that many plausible but unverifiable 'just-so stories' can be told). Rather, propositions are treated as scientific to the extent they are expected to be universally true and even in common usage, the more general a proposition, the more "scientific" it is regarded to be.[12]

That said, paleontologists do research the one-off extinction of dinosaurs. Similarly, not all scientific propositions are parsimonious – as anyone who has had to memorize the periodic table will testify – and cell biologists, ecologists, and zoologists treat descriptions and categorization of complex phenomena as contributions.* But even in these instances, scientists expect objective evidence that does not lie in the eye of a particular beholder have a common understanding of the kind of evidence they will admit in support of a hypothesis or categorization.

In contrast, developers of artifacts that have to satisfy "outside" users cannot rely just on parsimonious, well-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.

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* Doing so does risk their standing in the eyes of researchers from other scientific communities however. For instance, the molecular biologist and Nobel Laurate James Watson dismissed naturalist colleagues at Harvard who engaged in classification as "stamp collectors." This preference for the highly parsimonious and abstract is apparently widespread in universities. As an alumnus told me, outside MIT's engineering departments, there is a clear pecking order. The mathematicians are at the top, physicists come next, then chemists, and then biologists.

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 multi-player 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 self-taught 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.

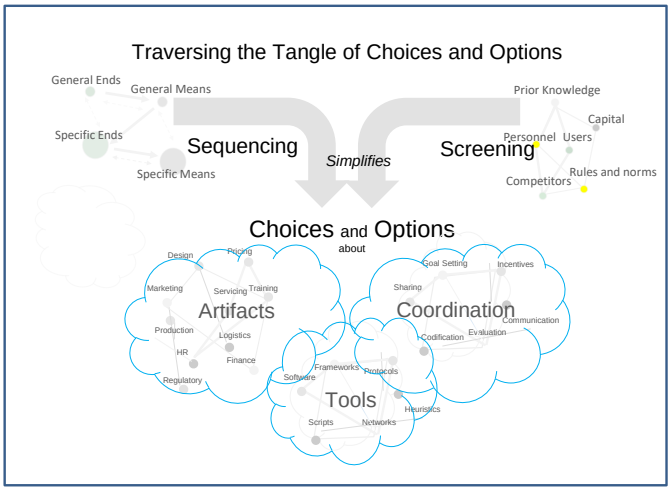
3. Coordinating Inclusive Development

Further Tools and Tangles

The limitations of paradigmatic scientific coordination have spurred the development of a plethora of general tools and techniques including heuristics, algorithms, collaborative software, step-by-step procedures, taxonomies, vocabularies, and organizational protocols. These artifacts represent an important component of contemporary practical knowledge: they help align goals and long-term directions (what we want to "persist" with and to what end), evaluate choices, plan and partition tasks, codify and communicate knowledge, persuade, and provide incentives for collaboration.

But the effective use of tools and techniques to improve the coordination of inclusive development, itself requires context-specific judgments. 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. But the heuristic does not specify what organizations should and should not control tightly. Other techniques that are more formulaic can lack precise indications about where they best work. Some may even comprise persuasively marketed but worthless nostrums. Therefore, like the more 'technical' evaluation techniques mentioned earlier, techniques to coordinate multi-player advances can potentially immobilize initiatives in a greater tangle of choices and options.

Fortunately, sequencing of choices and screening of options can provide a path through such tangles. Efforts to systematize this sequencing and screening have, under the label of "strategy formulation" become a mainstay of business education and practice, with a specialized vocabulary and several models and taxonomies (as we will see in one of the sessions of the seminar). For now, I will provide a simplified account (See Figure 'Traversing the Tangle of Choices and Options') highlighting their role in untangling and aligning choices.



Sequencing Choices

Strategic techniques typically order choices based on the following classification. First, choices may be distinguished by the degree of their generality. *General* choices pertain to selecting the overall goal or purpose of developing or using an artifact as well as the foundational strategies chosen to achieve that purpose. These choices (which we may associate with James's "rationalists" or Berlin's "hedgehogs") seek to anticipate and influence what will happen many periods into the future. For instance, the general choices made by a company in developing a smartphone may include decisions to target price sensitive customers (rather than customers looking for devices with the most advanced features) and to rely on a standard Android platform (instead of developing a proprietary architecture) to minimize costs. Developers and users also have to make more *specific* choices (that we may associate with James's "empiricists" and Berlin's "foxes") to implement general choices. For instance, launching a new phone requires establishing targets for the phone's cost and performance characteristics, selecting and negotiating with suppliers, and so on. These can be more tactical and reversible.

Choices (whether general or specific) can also be classified as pertaining to *ends* or *means*, as the smartphone example also illustrates. Thus, on the general side, aiming for a high share of price sensitive customers represents an "end" of an initiative to launch a smart phone and selecting an Android platform one of the "means." Similarly, on the specific-side, establishing a cost target for the bill of materials to be used in the phone constitutes an "end" choice, while selecting the suppliers for the materials represents a "means" choice.

A strategic approach (see Box 'McKinsey's General Outline') puts general choices ahead of specific choices and choices of ends before choices of means.

McKinsey's General Outline

James O. McKinsey, an accounting professor at the University of Chicago and founder of the eponymous James O. McKinsey & Company, developed an "integrated" or "top management" approach to consulting in the 1920s. The professor articulated his approach in his firm's General Outline, which was, according to Marvin Bower (who went on, in 1939, to found a successor firm, McKinsey & Company), "a checklist for making a strategic general survey of a business and a guide to [the firm's] thinking and problem-solving approach."

The Outline forced "a strategic approach in that it call[ed] for considering the industry outlook and the company's competitive position before considering anything specific to the organization. It also force[d] an orderly approach by requiring examination of the elements of managing in an undeviating sequence: goals, strategy, policies, organization structure, facilities, procedures, and personnel —in that order. To emphasize the sequential approach, [Professor McKinsey] would ask: 'Would you polish the brass on a sinking ship?'"

Prioritizing ends and general choices can help:

•Exclude inconsistent options. Making general choices first can help limit the specific options evaluated or created to ones that are consistent with the general choices. Similarly, choosing ends (general or specific) first helps restrict the consideration of means ones that are consistent with the ends.

•Facilitate deliberation and justification by providing a criterion for evaluating options that cannot otherwise be objectively ranked. For instance, when decision makers cannot quantify the consequences, they can discuss the merits of alternative means in terms of their fit with the chosen ends and of specific choices in terms of their fit with general choices.

•Control the problem of excessive satisficing by countering the temptation to choose from the most obvious options. If, for example, none of the existing choices of means appear likely to satisfy the prior choice of ends, this can spur the search for or creation of new options.[13]

Screening Options for Congruence

Options about choices can also be evaluated in terms of their congruence with exogenous circumstances (i.e., those beyond the direct control of the decision-maker). Classifications and techniques developed by business strategists to assess this "external" congruence have become rather sophisticated but for our purposes it may be sufficient to group the exogenous circumstances into two categories: resources available to the developer or user, including funds, personnel, social networks, reputations, and physical or epistemological tools; and constraints imposed by customers, bosses, financiers, competitors, regulators, lawmakers, and social norms – as well as the 'must have' wants and preferences of the decision-makers themselves.

Testing for the congruence of options with external resources and constraints provides the same kinds of advantages as evaluating the consistency of means and specific choices with ends and general choices. It eliminates the consideration of incongruent alternatives; allows the ranking of alternatives in terms of their expected 'fit'; and can stimulate the search for new options when the available choices fail the congruency tests.[14]

4. Seminar Modules

As mentioned at the outset, propositions about practical knowledge developed by and for the many and are highly provisional hypotheses. Likewise, the sequencing and screening framework outlined above provides a simple "walking stick"[15] for navigating through a tangle of choices and options. The propositions and framework have value only to the degree that they provide a starting point to help you develop, through an inductive process, heuristics and frameworks that best fit your world views, temperaments, and career plans.

For this, we rely mainly on individual reflection, sharpened and clarified by discussing a wide range of readings (and some podcasts and videos), organized in two modules.

1. Common tasks and techniques.

The module covers the following tasks that developers of practical knowledge in many domains have to undertake and some techniques now available for performing the tasks:

• *Goal and problem specification* (choosing "ends"). We examine approaches for selecting both the general or overall goals – the overarching aims or purpose of an organization – as well the definition of particular problems (such as specifying the desired flying characteristics for an airplane design). As mentioned, wisely chosen "general" ends can provide direction to choosing means that are consistent with each other and across time; they can also help coordinate and motivate "multiplayer" effort. But, there are relatively few techniques available for choosing overall ends. More techniques are available however for choosing more specific ends (e.g., selecting the performance characteristics for a new product).

• *Developing solutions* (creating the "means"). This covers not just making a choice between a given set of options – the domain of classic decision theory – but also deciding whether to look for more options, where and how to look, and how to craft solutions that effectively synthesize multifarious elements. Traditionally, solutions were thought to result from an ineffable process of individual creativity which could not be systematized (although periodically individuals like John Stuart Mill would try). As mentioned, the growth of organizations that seek to systematize development and harness advances in science and technology have prompted the development of techniques to coordinate innovative effort. At the same, time some experts and writers have sought to reemphasize the role of "intuitive" (rather than structured) problem solving.

• *Sharing and Pooling*. Frequently, solutions already exist but are known to only some members of a community or organization who could benefit. Effective sharing therefore increases the value of the solutions. Or different individuals may use partial or imperfect solutions that can be made more complete and robust by effective pooling.

To some degree, sharing and pooling within organizations and communities can occur naturally. But geographic dispersion of organizational subgroups and communities and organizational "silos" or boundaries can limit the interactions through which solutions are naturally shared. Therefore, large organizations (such as multinational companies, government agencies and international bodies like the WHO) have developed techniques such as checklists and best practice programs to share and pool information.

• *Codification.* Precisely specified 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, for reasons discussed in the section contrasting science and practical knowledge, excessive codification can be dysfunctional. Decision-makers therefore have to 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 have to 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 uses, as mentioned earlier, 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.

• *Aligning Intrinsic and Extrinsic 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 intrinsic and extrinsic incentives to promote teamwork without discouraging individual initiative.

• *Formulating Strategies.* As mentioned, sequencing and congruence testing protocols from the field of business strategy can help us navigate through tangles of choices and options encountered in developing practical knowledge in many other domains. In this session, however, we focus mainly on the strategy frameworks used in business. The readings include a review of the evolution of the strategy paradigm from James O. McKinsey's *General Outline* in the 1920s to the plethora of techniques in use today.

Note that this categorization of tasks and techniques is not collectively exhaustive or mutually exclusive. 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. Likewise, techniques often span multiple tasks. For instance, Human Centered design, listed above as a problem-solving technique, also encompasses problem framing and solution testing. Therefore, while discussing a particular task (or technique) we will as necessary take into account implications for other tasks.

2. Specialized templates, technologies and organizations.

We will examine two classic templates from the field of statecraft – Machiavelli's advice to *The Prince* on how to secure and consolidate autocratic powers (which dates back to the Renaissance) and Gene Sharp's contemporary manual *From Democracy to Dictatorship.*

The remainder of the module comprises case histories of the development of transformational products and technologies, such as shipping containers, personal computers, and MRIs, and of exemplary organizations such as McKinsey and Handelsbanken. The cases will illuminate features of the development of practical knowledge (discussed earlier in this document) that may not be fully brought out by studying general and specific techniques. These features include the protracted, evolutionary nature of development and the intertwined roles of persistence, chance, leaps of faith, inspirational leadership, multiplayer interactions, general principles, specific details, means, and ends.

Appreciating what transformational development requires by studying noteworthy cases could potentially influence both hearts and minds. Some participants in the seminar may be inspired to lead transformational developments, while a heightened appreciation of the risks and challenges may

encourage others to seek more supportive roles or pursue opportunities and careers that are less revolutionary.

REQUIREMENTS AND GRADING

FINAL PAPER (Expected by noon, May 11, 2018 – 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 paper on:

1) A commonly used (i.e. not just by or in a single organization) procedure or tool (or a set of such procedures) to perform a generic practical task. The paper will describe:

- How and why the procedure evolved AND how it was put into wide use
- Current strengths and limitations vis-à-vis alternatives
- The resources (including tacit knowledge, experience, and organizational capabilities) and conditions necessary for its effective use (i.e. where it works best and where it doesn't quite "fit")

OR

2) The evolution of a specific artifact (such as a medical treatment, software program, on-line training program, or organization). In this alternative, the paper should focus more on the historical narrative – how and why key elements of the artifact evolved as they did, the kind of competitive or user resistance faced and how they were overcome, how resources were secured etc. – and less on describing or analyzing the current strengths and weaknesses. Indeed, if the historical narrative is sufficiently detailed, I will accept a paper which does not at all discuss the current strengths and weaknesses (or has very little to say about them).

You are strongly urged to pick a topic from a list I will provide and select a topic (from or outside my list) 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 paper. (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 SUMISSIONS

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

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.

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
Generic Tasks and Techniques		
2	30-Jan	Goal and Problem specification
3	6-Feb	Evaluation and Testing
4	13-Feb	Codification
5	20-Feb	Human Centered Design
6	27-Feb	Pooling and Sharing
7	6-Mar	Communication
8	13-Mar	Integrated Problem-solving Processes
9	27-Mar	Aligning Incentives
10	3-Apr	Competitive Strategies and other Management Paradigms
Specialized Templates, Technologies and Organizations		
11	10-Apr	Advancing and Suppressing People Power
12	17-Apr	Handelsbanken
13	24-Apr	Containers, Computers and Frozen Foods

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

Daily Assignments

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).

1. Generic Techniques, Protocols and Templates

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.

Integrated problem solving processes

Efforts to systematize creative problem solving go back at least to Mill's Methods of induction. Advances in science technology and the growth of large organizations have accelerated these efforts, as we will see in this and the following session.[*]

Readings
• *Process management and the future of six sigma* (SKIM) Hammer
• *Six Sigma: what it is and how to use it* (Plotkin)
• Six sigma: Summary (Wikipedia)
• *Reengineering Work* (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)
• *The Use of Knowledge in Society* (Hayek) (Focus particularly on Sections I-V)
• *Six Secrets to True Originality* (SKIM) Grant

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

1. Pick any one technique (from Six Sigma, reengineering, analogical reasoning, and pattern recognition ("intuition") and mental simulations). What kind of problem or problems is this technique best suited to solve?

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

3. What does Hayek's article suggest about six-sigma and reengineering techniques?

4. Other observations from and reactions to the readings.

[*] Note that in several cases the problem-solving methods include issues of problem framing ("choosing ends") discussed in a previous section. In other instances, however, the readings do not make explicit the kinds of problems to be solved – or they take the choice and specification of problems as a given.

Human Centered Design

This is an "integrative" technique or process that includes problem framing and problem solving.

Readings
• *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?

Pooling and Sharing

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.

Readings/Podcasts

Best practices/learning from success.
• *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
• *Positive Deviant* (David Dorsey. Fast Company)

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?

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*

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

Practical knowledge is useless unless it is persuasively and clearly communicated. Even knowledge that is embedded in physical objects requires effective communication – people have to be persuaded to buy the objects and instructed in their use. Communication in turn itself involves techniques and thus, following the taxonomy laid out in the syllabus, choices of ends means, general principles and specifics.

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?

Evaluation and Testing (of inputs and outcomes)

As mentioned in the Overview the ends and means of testing and evaluation can span a wide range. And choices of means obviously presuppose choices of ends – although, pathologically, evaluations and tests can become an end onto themselves. Conversely choices of ends also have to be adapted to the available means – the high cost of reliable tests can often preclude comprehensive screening and thus the defects that have to be tolerated for instance. And both choices (of ends and means) are typically subject to constraints imposed by bosses, regulators, the law, and societal norms.

Readings

• *Management Half-truth and Nonsense: How to Practice Evidence-Based Management*
• *No-Nonsense Guide to Measuring Productivity* (Chew HBR)
• *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)
• *Excessive Ambitions* (Elster) SKIM
• *The Air-Propeller Tests of W. F. Durand and E. P. Lesley* (Vincenti) SKIM
• *Making Economics More Useful* (Bhidé) (Section 1) SKIM

Optional:

• *Learning and Quality Control* (Miranti)
• *Online Controlled Experiments and A/B tests* (Kohavi and Longbotham)
• *Controlled Experiments on the Web* (Kohavi et al)

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?

Aligning Intrinsic and Extrinsic 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.

2: Specialized Templates, Technologies and Organizations

Advancing and Suppressing People-Power

Readings;
• *From Dictatorship to Democracy* (Gene Sharp)
• *The Prince* (Machiavelli)
• *Hungary's U-Turn* (Kornai)
• Wikipedia summary of Alinsky's *Rules for Radicals*

Optional Reading
• Plato's *Allegory of the cave*

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

1. In light of the topics covered in the previous module, what are your observations on the Prince? (For instance, you could think about: the implicit or explicit "ends" of Machiavelli's advice; its "sweet spot," in terms of when and where it is most likely to be applicable; how it is codified; and how the author seeks to make his message clear and persuasive.

2. In light of the topics covered in the previous module, what are your observations on *From Dictatorship to Democracy*?

3. What lessons might Viktor Orban and his opponents draw from the two books and from *Rules for Radicals*?

4. (Optional) How does the Allegory of the Cave challenge or reinforce the message of the Prince and from *Dictatorship to Democracy*?

5. Other optional observations.

Competitive Strategies and other Management Paradigms

Readings;
Competitive Strategy
• *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)
• *The Development of Discounted Cash Flow Techniques in U.S. Industry* (Dulman)
• *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.

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 []

Containers, Computers and Frozen Foods (+other artifacts)

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).

• "*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.

Notes to Overview

[1] Simon (1996)

[2] For instance, medical schools and residencies provide hands-on instruction in how to perform bone-marrow transplants but not about the improvised experimentation that improves transplant procedures.

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] 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).

[9] Longair, Malcolm S. 2003. P. 223. *Theoretical Concepts in Physics: An Alternative View of Theoretical Reasoning in Physics.* Cambridge: Cambridge University Press

[10] Stokes, Donald E. 1997. *Pasteur's Quadrant: Basic Science and Technological Innovation.* Washington, D.C.: The Brookings Institution

[11] 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.

[12] See for instance Hayek's distinction between scientific and specific knowledge.

[13] To borrow a term from Roethlisberger (1977)

owever. Research on "emergent strategies" (and my own previous work on the evolution of fledgling businesses) suggests that general choices of purpose or strategy are often distilled or abstracted from the results of specific choices. For instance, an entrepreneur may act to seize an opportunity or solve a particular problem and that experience may lead her to make a broader decision about overall ends and means – "what business she is in" and her "business model." This is not shortsighted – the entrepreneur may simply not know enough at the outset.

Likewise, problems in finding feasible means may spur changes in previously chosen ends. For instance, after researchers failed to quickly find a cure or vaccine for AIDS, they turned their attention to treatments that would prolong and improve the quality of patients' lives. These revisionist possibilities do not, however, undermine the benefit of choosing ends before means or of making general choices before specific ones. Rather, they provide a way out if the normal sequence fails and inject some measure of optimizing into what might otherwise be a purely satisficing process.

[14] To borrow a term from Roethlisberger (1977)

tifacts may have to treat their resources and constraints as givens that their choices have to adapt to. Longer term however, decision-makers can alter their circumstances by, for instance, altering customers' preference, deepening relationships with financiers, or lobbying lawmakers and regulators. Indeed, many business strategists address their prescriptions to changing the competitive landscape in order to create durable advantages.

Moreover, as mentioned, artifacts – and competitive advantages – cannot be expected to last forever. Innovators develop radically improved technologies, competitors learn how to imitate, customers get bored, and lawmakers change the rules. And, even if circumstances do not change, success itself can make choices obsolete. For instance, in business as in war, the goal of defeating a formidable rival can fire up the troops. But once the enemy is defeated, a new rallying cry becomes necessary. Therefore, all choices, including the big ones of general means and ends, need to be periodically reassessed for internal consistency and external congruence.

[15] To borrow a term from Roethlisberger (1977)