“By now we are all beginning to realize that one of the most intractable problems is that of defining problems (of knowing what distinguishes an observed condition from a desired condition) and of locating problems (finding where in the complex causal networks the trouble really lies). In turn, and equally intractable, is the problem of identifying the actions that might effectively narrow the gap between what-is and what-ought-to-be” (Rittel & Webber, 1973).

“How Wicked Problems Are Classified”

Problems are often classified in terms of how much is known about them, or by the degree of complexity involved:

<table>
<thead>
<tr>
<th>Problem Space Well-Defined</th>
<th>Problem Space Ill-Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Space Well-Defined</td>
<td><strong>Simple Problems</strong>: Dictate mostly exploitation and convergent activities within the current paradigm.</td>
</tr>
<tr>
<td>Solution Space Ill-Defined</td>
<td><strong>Complex Problems</strong>: Dictate exploration of new ideas and realms, searching for better solutions while also exploiting what’s known.</td>
</tr>
</tbody>
</table>

(Adapted from Richardson, 2010)

Simple problems, or problems that are already defined, are easy to solve; defining the problem inherently defines a solution. Solving simple problems may lead to improvement—but not to innovation. Innovation requires that we grapple with what Horst Rittel termed “wicked” problems, which he described as having the following characteristics (Rittel & Webber, 1973):

- There is no definitive formulation of a wicked problem.
- Wicked problems have no stopping rule; in other words, the problem solver cannot tell when he or she is done.
- Solutions to wicked problems are not true or false, but rather are just good or bad.
- There is no immediate and no ultimate test of a solution to a wicked problem.
- Every solution to a wicked problem is a “one-shot operation”; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
- Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan to solve them.
- Every wicked problem is essentially unique.
- Every wicked problem can be considered to be a symptom of another problem.
- The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem’s resolution.

In short, the solution to wicked problems depends on how the problem is framed, and vice versa. The stakeholders in wicked problems have radically different world views and different frames for understanding the problem. And, the constraints to which the problem is subject and the resources required to solve it change over time. Wicked problems are never definitively solved. The military has characterized wicked problems as those that exhibit:
Problem Finding, Problem Solving

- \( V = \text{Volatility.} \) The nature and dynamics of change, and the nature and speed of change forces and change catalysts.
- \( U = \text{Uncertainty.} \) The lack of predictability, the prospects for surprise, and the sense of awareness and understanding of issues and events.
- \( C = \text{Complexity.} \) The multiplex of forces, the confounding of issues and the chaos and confusion that surround an organization.
- \( A = \text{Ambiguity.} \) The haziness of reality, the potential for misreads, and the mixed meanings of conditions; cause-and-effect confusion.

(See [http://en.wikipedia.org/wiki/Volatility,_uncertainty,_complexity_and_ambiguity](http://en.wikipedia.org/wiki/Volatility,_uncertainty,_complexity_and_ambiguity) for more on VUCA.)

Karl Weick (1984), in his research on how to tackle wicked problems by seeking a series of small wins, provides some good examples of these wicked problems:

- To solve the problem of soaring crime rates, cities expand the enforcement establishment, which draws funds away from other services such as schools, welfare, and job training, which leads to more poverty, addiction, prostitution, and more crime.
- To ward off coronary heart disease, people who live in cities spend more time jogging and cycling, which exposes their lungs to more air pollution than normal, increasing the risk of coronary illness.
- To ease traffic congestion, multilane highways are built, which draws people away from mass transit so that the new road soon becomes as overcrowded as the old road.
- To reduce energy use and pollution, cities invest in mass transit, which raises municipal debt, leading to a reduction in frequency and quality of service and an increase in fares, which reduces ridership, which further raises the municipal debt.

The pace of change of technology is accelerating, confronting us with the need to innovate nearly everything around us to keep up (Brynjolfsson & McAfee, 2012). At the same time, customers have higher and higher expectations for the products and services they consume to be differentiated and customized to meet their individual needs and provide them with transformational experiences (Pine II & Gilmore, 1998).

But, the process of defining these problems is subjective, as definition comes from a having a point of view. In effect, all of the stakeholders in these problems are equally knowledgeable (or unknowledgeable). Taming wicked problems thus requires many people, and it requires them to talk with each other, deliberate, argue and ultimately reach agreement on their collective goals and the actions required to reach them. This requires knowledge about actions, not just facts. While science is concerned with factual knowledge (what-is); the process needed to deal with wicked problems, or the “design process” is concerned with instrumental knowledge (how what-is relates to what-ought-to-be), or in other words, how actions can meet goals.

**Leading the Attack on Wicked Problems**

“Leadership is needed for problems that do not have easy answers.... For these problems there are no once-and-for-all answers. Yet we expect leaders to provide solutions” (Fullan, 2001, p. 2).

The leaders who can deal with these wicked problems will have different characteristics than they had in the past. “It seems to me that business leaders have much more in common with artists, scientists, and other creative thinkers than they do with managers. For business schools to exploit this commonality of dispositions and interests the curriculum should worry less about the logics of strategy and imposing the constraints of computer exercises and more about thought experiments in the play of creativity and imagination. If they are successful, they would then do a better job of preparing exceptional men and women for positions of leadership” (emphasis added) (Zaleznik, 1977).
Several academics have captured the traits they expect to see in future leaders, often drawing on the traits of creative people to characterize them:

<table>
<thead>
<tr>
<th>Qualities of Creative People</th>
<th>Qualities of Leaders in the Future</th>
<th>Leadership and Lifelong Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Curious</td>
<td>• Seek options, not plans</td>
<td>• Risk taking</td>
</tr>
<tr>
<td>• Energetic</td>
<td>• Look for what is possible</td>
<td>• Humble self-reflection</td>
</tr>
<tr>
<td>• Experimenting</td>
<td>• Flexibility</td>
<td>• Solicitation of opinions</td>
</tr>
<tr>
<td>• Independent</td>
<td>• Pursue vision with intent</td>
<td>• Careful listening</td>
</tr>
<tr>
<td>• Industrious</td>
<td>• Tireless, inventive,</td>
<td>• Openness to new ideas</td>
</tr>
<tr>
<td>• Flexible</td>
<td>observant risk takers who</td>
<td></td>
</tr>
<tr>
<td>• Open minded</td>
<td>are ever-hopeful builders</td>
<td></td>
</tr>
<tr>
<td>• Original</td>
<td>• Challenge assumptions and</td>
<td></td>
</tr>
<tr>
<td>• Playful</td>
<td>paradigms</td>
<td></td>
</tr>
<tr>
<td>• Perceptive</td>
<td>• Empower the talent,</td>
<td></td>
</tr>
<tr>
<td>• Persevering</td>
<td>intelligence, and creativity</td>
<td></td>
</tr>
<tr>
<td>• Questioning</td>
<td>of others</td>
<td></td>
</tr>
<tr>
<td>• Risk taker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Self-aware</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sensitive</td>
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</tbody>
</table>


Future leaders will cope with wicked problems by employing the following practices (Kouzes & Posner, 1995):

- Challenging the process: looking for innovative ways to improve the organization
  - Searching for opportunities
  - Experimenting and taking risks
- Inspiring a shared vision: creating an ideal image of what the organization can become
  - Envisioning the future
  - Enlisting others
- Enabling others to act: building spirited teams
  - Fostering collaboration
  - Strengthening others
- Modeling the way: establishing principles for how people will be treated and how goals will be pursued
  - Setting the example
  - Achieving small wins
- Encouraging the heart: making people feel like heroes
  - Recognizing contributions
- Celebrating accomplishments

**Problem Finding, Problem Solving Processes**

This class is about finding and then solving problems in a team setting. Alternatively, it is about identifying challenges or opportunities and then seeing ways to resolve or take advantage of them. Importantly, it focuses not only on solving problems, but on the framing of those problems in the first place. The materials in the class are drawn from three bodies of academic theory: critical thinking, systems thinking and creative problem solving.

**Critical Thinking**
Critical thinking “brings conscious awareness, skills, and standards to the process of observing, analyzing, reasoning, evaluating, reading and communicating” (Mayfield, 2007, p. 4). To be precise, thinking means “purposeful mental activity” and critical means to “take something apart and analyze it on the basis of standards.” While there are many definitions of critical thinking, all agree that it is guided by clear standards. These standards are “the same intellectual standards scientists and scholars have used for centuries to evaluate the reliability of reasoning and information. They include clarity, accuracy, precision, consistency, relevance, reliability, soundness, completeness, and fairness. All these standards help us aim for truth or to come as close to truth as we can” (Mayfield, 2007, p. 5).

In short, critical thinking is the ability to think clearly and rationally. It includes the ability to engage in reflective and independent thinking. Someone with critical thinking skills is able to do the following:

- understand the logical connections between ideas
- identify, construct and evaluate arguments
- detect inconsistencies and common mistakes in reasoning
- solve problems systematically
- identify the relevance and importance of ideas
- reflect on the justification of one’s own beliefs and values

Clarity and rationality constitute the common core across different conceptions of critical thinking (Lau & Chan, 2010).

The steps or activities one learns in a critical thinking class may include:

- Observation: what’s out there?
- Word precision: how do I describe it?
- Facts: what’s real?
- Inferences: what follows?
- Assumptions: what’s taken for granted?
- Opinions: what’s believed?
- Evaluations: what’s judged?
- Viewpoints: what’s the filter?
- Arguments: what’s a good argument?
- Fallacies: what’s a faulty argument?
- Inductive reasoning: how do I reason from evidence?
- Deductive reasoning: how do I reason from premises?

You can learn many of these skills by practicing them with the exercises found at: http://philosophy.hku.hk/think/.

Critical thinking contrasts with creative thinking in that critical thinking depends more on the (left) brain’s verbal, linear, logical and analytical functions, while creative thinking relies more on our (right-brain) intuitive-holistic-visual ways of knowing. “There are two basic thinking skills - critical and creative thinking. Critical thinking is the ability to think clearly and rationally. Creativity is a matter of coming up with new and useful possibilities. They are both crucial for solving problems and discovering new knowledge” (Lau & Chan, 2010).

This class will build on the need to integrate both types of thinking in our work on wicked problems as argued in, for example, A Whole New Mind (Pink, 2006). Albert Einstein is held up as an example of someone who integrated both well as he conceived theorems that proved to be both practical and beautiful. Einstein valued the creative process so highly he once said, “Imagination is more important than knowledge” (Mayfield, 2007, p. 7).

Systems Thinking
“Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations messes... Managers do not solve problems, they manage messes” (Ackoff, 1979).

Systems thinking provides the tools and techniques to think about system dynamics, or the broader effects of an action on an entire system. Robert Pirsig who wrote Zen and the Art of Motorcycle Maintenance (2008) describes the importance of systems thinking: “If a factory is torn down but the rationality which produced it is left standing, then that rationality will simply produce another factory. If a revolution destroys a government, but the systematic patterns of thought that produced that government are left intact, then those patterns will repeat themselves.... There’s so much talk about the system. And so little understanding.”

A system is “a set of things – people, cells, molecules, or whatever – interconnected in such a way that they produce their own pattern of behavior over time. The system may be buffeted, constricted, triggered, or driven by outside forces. But the system’s response to these forces is characteristic of itself, and that response is seldom simple in the real world” (Meadows, 2008, p. 2).

Systems have three kinds of things in them: elements, interconnections and a function or purpose. The elements of your digestive system, for example, are teeth, enzymes, stomach, and intestines. They are interrelated through the physical flow of food, and through an elegant set of regulating chemical signals. The function of your digestive system is to break down food into its basic nutrients and to transfer those nutrients to the bloodstream (Meadows, 2008). A football team is also a system, as is a school. A business is a system; we’ll map the elements of a system and their interactions on the business model canvas in this class.

Systems thinking forces us to move from an event-oriented view of the world, and thus an event-oriented approach to problem solving, to a systems or feedback view. Consider the following example from Business Dynamics (Sterman, 2000). In an event-oriented approach to problem solving, we assess a current state of affairs and compare it to our goals. The gap between the situation we desire and the situation we perceive defines our problem.

Event-oriented view of the world from (Sterman, 2000, p. 10):

![Diagram](image)

Suppose, for example, that sales of your organization were $80 million last quarter, but your sales goal was $100 million. The problem is that sales are 20% lower than desired. You consider a set of possible actions: cut prices to stimulate demand and increase market share, replace the VP of sales with someone more aggressive, etc. You select the option you deem best, and implement it, leading (you hope) to a better result. You might even observe that your sales increase, and thus assume the problem is solved.

Meanwhile, the system reacts to your solution: As your sales rise, competitors cut prices, and sales fall again. Yesterday’s solution has now become today’s problem. In short, “we are not puppet masters influencing a system out there – we are embedded in the system. The puppet master’s movements respond to the position of the marionette on the strings. There is feedback: The results of our actions define the situation we face in the future. The new situation alters our assessment of the problem and the decisions we take tomorrow” (Sterman, 2000, p. 10).
As *Business Dynamics* says, “When we take action, there are various effects. The effects we thought of in advance, or were beneficial, we call the main or intended effects. The effects we didn’t anticipate, the effects which fed back to undercut our policy, the effects which harmed the system – these are the ones we claim to be side effects. Side effects are not a feature of reality but a sign that our understanding of the system is narrow and flawed” (Sterman, 2000, p. 11). Systems dynamics modeling strives to help people better understand the systems in which they operate and thus to better project the potential effects of an action they might take.

For those of you interested in learning more about systems dynamics modeling, there are some resources available at: [http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntro.htm](http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntro.htm).

**Creative Problem Solving**

Creative problem solving as a field of academic inquiry traces its roots back to Alex Osborn’s publications (Osborn A. F., 1952) (Osborn A. F., 1953, 1957, 1963, 1967) on the topic in the early 1950s. After the advertising agency he founded in 1919 began floundering, he developed and applied a “think up” process to be more systematic in the creative process. Over the next 10 years, he and Sid Parnes parlayed this process into what became the Osborn-Parnes Creative Problem Solving model, and Parnes started teaching this model in the academic world. While many remember Osborn best for having invented “brainstorming”, his work was far more comprehensive and involved a multiple step process involving a variety of different tools (Puccio, Murdock, & Mance, 2007).

There are many versions of the Creative Problem Solving (CPS) process, but all basically include three main building blocks, and alternate diverging and converging cycles to iterate towards a set of solutions. The “Plain English Version” (Miller, Verhar, & Firestien, 2001) is shown here:
Problem Finding, Problem Solving

- Explore the Challenge
  - Identify the goal, wish or challenge:
    - State a variety of goals, wishes or challenges (diverge)
    - Choose a goal, wish or challenge where you have ownership, motivation and a need for imagination (converge)
  - Gather data
    - Explore all the data around the goal, wish, or challenge (diverge)
    - Identify all the relevant data (converge)
  - Clarify the problem
    - State the problem in many ways as possible (diverge)
    - Choose a problem statement to work on (converge)

- Generate Ideas
  - Think up a wide variety of ideas to solve the problem (diverge)
  - Choose the most promising ideas (converge)

- Prepare for Action
  - Select and strengthen solutions
    - Evaluate and refine the ideas you selected (diverge)
    - Select the most promising solutions (converge)
  - Plan for action
    - List assisters/resisters and actions for implementations (diverge)
    - Form a specific action plan (converge)

The CPS process is meant to be both iterative and flexible; users should employ only those phases of the process that are relevant to the particular challenge at hand. The success of the process is based on two beliefs:

- Creativity can be taught. Recent studies have shown that creativity can indeed be taught, even in short training sessions in both academic (Puccio, Murdock, & Mance, 2007) and business settings (Puccio, Firestien, Coyle, & Masucci, 2006).
- The members of the group applying the process are assigned to complete three important and distinct roles:
  - A facilitator is in charge of making the process successful and does not get involved with the content
  - A client owns the challenge
  - The resource group identifies the content

A recent version of the Creative Problem Solving model, the Thinking Skills Model, highlights the specific thinking and affective skills that are required for each step of the process (Puccio, Murdock, & Mance, 2007). The model includes a meta-cognitive activity to determine which phases and steps of the process need to be used, referred to as “assessing the situation”. The thinking and affective skills needed at each stage are shown in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Thinking skills</th>
<th>Affective skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessing the Situation</td>
<td>Diagnostic thinking</td>
<td>Curiosity</td>
</tr>
<tr>
<td>Clarification: Exploring the Vision</td>
<td>Visionary thinking</td>
<td>Dreaming</td>
</tr>
<tr>
<td>Clarification: Formulating Challenges</td>
<td>Strategic thinking</td>
<td>Sensing gaps</td>
</tr>
<tr>
<td>Transformation: Exploring Ideas</td>
<td>Ideational thinking</td>
<td>Playfulness</td>
</tr>
<tr>
<td>Transformation: Formulating Solutions</td>
<td>Evaluative thinking</td>
<td>Avoiding Premature Closure</td>
</tr>
<tr>
<td>Implementation: Exploring Acceptance</td>
<td>Contextual thinking</td>
<td>Sensitivity to the environment</td>
</tr>
<tr>
<td>Implementation: Formulating a Plan</td>
<td>Tactical thinking</td>
<td>Tolerance for risks</td>
</tr>
</tbody>
</table>
The core skills that underlie all steps of the Creative Problem Solving process include: openness to novelty, tolerance for ambiguity, and tolerance for complexity.

The class builds on these bodies of academic inquiry -- critical thinking, systems thinking and creative problem solving -- and draws from the practical implementation of those bodies of theory in industry. It is to two of those applications -- Six Sigma and Design Thinking -- that we turn now.

**Quality Improvement Processes: Six Sigma**

The roots of quality management can be traced to the early 1920s when statistical theory was first applied to control the quality of products in a manufacturing environment. These statistical tools were then embedded in broader quality management programs the principles of which rested on the ideas of well-known quality leaders W. Edwards Deming, Joseph Juran and Armand Feigenbaum. Their ideas were elaborated on primarily in Japanese companies beginning in the 1950s. As they spread around the world, the focus also broadened in subsequent decades from quality of products to quality of all issues within an organization, and ultimately led to the present incarnation of quality improvement methods, Six Sigma.

Because Six Sigma encapsulates the process and work that preceded it, we focus here on a summary of the elements of the Six Sigma approach. Six Sigma is often defined as “a comprehensive and flexible system for achieving, sustaining, and maximizing business success”. Basically, Six Sigma is a method to methodically improve a process by identifying a problem, studying its natural occurrences, and then gradually reducing the variability of these occurrences so that eventually there is so little variability in the functioning of the process that the differential appears nonexistent when charted.

The most commonly used Six Sigma process is often referred to as DMAIC and contains the steps shown below:

**DMAIC Process:**

- Define the project goals and customer (internal and external) deliverables
- Measure the process to determine current performance
- Analyze and determine the root cause(s) of the defects
- Improve the process by eliminating defects
- Control the process to continue achieving the desired results

Philosophically, Six Sigma is built around six themes:

- Genuine focus on the customer
- Data and fact-driven management
- Process focus, management and improvement
- Proactive management
- Boundary-less collaboration
- Drive for perfection

The genuine focus on the customer and boundary-less collaboration themes are repeated in the current “design thinking” approaches to which we turn next. There is a considerable body of work online about Six Sigma and its implementation in various settings if you are interested in learning more about it.
**Design Thinking**

“Design thinking can be described as a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity” (Brown, Tim, 2008).

We have generalized a model of design thinking to create the Problem Finding, Problem Solving model we will use in this class. It is built on Charles Owen’s work at the Illinois Institute of Technology combined with models from Experiential Learning Theory (Kolb & Kolb, 2005)(Beckman & Barry, 2007):

Design thinking toggles between the concrete world and the abstract world, employing both analysis and synthesis in the process. It grounds itself in observation, a process of learning deeply about the context surrounding the problem and often involving direct observation of customers and users of a product or service. It takes the data gathered in the observation phase and moves to the abstract space to identify patterns and elicit insights from that data. Those insights in turn are used to synthesize a set of imperatives around which to proceed in solving the problem, or in generating alternative solutions for the customer. Finally, the process returns to the concrete space in which solutions are generated that embody the imperatives in a concrete form.

**Grounding in Learning Theory**

It appears that if you trace back the development of the Six Sigma and Design Thinking problem finding, solving processes, they both have their origins in models of how we learn.

Some argue that learning theory goes as far back as 450 B.C. when Confucius said “Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand.” In 1938, John Dewey suggested that “experience plus reflection equals learning” (Dewey, 1938). Many, many models of how we learn have been developed since then. One synthesis (Juch, A., 1983) of seventeen different models provided the following depiction:
This description of learning parallels the design thinking model we just described: we start our learning process by seeing or observing something. We then think about what we’ve observed, and determine a new way of thinking or an action we might take as a result. We then do that action, launching a new learning cycle.

Experiential learning theory models take this one step farther by suggesting that we each have a preferred approach or focus for how we learn. The model on which that test is based is shown below (Kolb, 1984):

Design Thinking – Learning Theory

Abstract

Assimilating (Thinking)
good at understanding a wide range of Information and putting it in concise, logical form

Converging (Planning)
good at finding practical uses for ideas and theories; solving problems

Analysis

Diverging (Observing)
good at seeing concrete situations from multiple viewpoints

Accommodating (Doing)
good at learning from hands-on experience

Concrete

Problem Finding, Problem Solving at Haas
Here are the activities in which we will engage this term in the Problem Finding, Problem Solving process:

a) **Observe and Understand:**
   i) Define the problem, challenge or opportunity space in which you want to work. Realize that your definition is very likely to change as you do research to better understand it.
   ii) Learn as much as you can about what is already known in that space from subject matter experts and other sources. In particular, learn about trends and their potential business impacts as well as new techniques and technologies related to the field.
   iii) Collect information firsthand through
       (1) asking open-ended questions
       (2) seeing (observing) people and processes
       (3) engaging participants in co-creation activities to uncover new patterns of behavior

b) **Extract Insights:**
   i) Recognize patterns and anomalies from both secondary research and observation
   ii) Develop insights around which to generate new concepts

c) **Ideate:**
   i) Ideate solutions based on the insights gleaned
   ii) Embody them in artifacts or use other means to communicate them
       (1) To share research findings with others in the organization
       (2) To get feedback from other stakeholders
       (3) Use them to communicate and share research findings

d) **Prototype and Experiment:**
   i) Develop meaningful measures to validate solutions against identified needs
   ii) Use the artifacts or stories to collect feedback
   iii) Document evidence of progress
   iv) Refine solution prototypes for higher chances of success

**References**


