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Teaching Students Problem Framing Skills with a Storytelling Metaphor*

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In 1973, Horst Rittel and Melvin Webber introduced the term 'wicked problems' to describe problems characterized as volatile, uncertain, complex and ambiguous. Although that description has been around for some time, it has seen resurgence in the literature in the past few years with the increased recognition that the problems with which we grapple globally are indeed wicked. Framing of the problem is often the most difficult and important element of dealing with wicked problems, and yet much of our education system focuses on solving rather than framing problems. Recent interest in 'design thinking' focuses on problem framing, and provides a framework for teaching students the skills they need to do problem framing. This paper reports on an approach used to teaching problem framing, and in particular the skills needed to effectively engage in framing: empathy, insight recognition, thinking divergently, and learning through failure.

Keywords: wicked problems; problem framing; design process; storytelling; empathy, insight; divergence; iteration

1. Wicked problems

In 1973, Horst Rittel and Melvin Webber introduced the term 'wicked problem' to describe problems that had the following characteristics [1]: There is no definite formulation of a wicked problem; wicked problems have no stopping rules; solutions to wicked problems are not true-or-false, but better or worse; 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'; 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; every wicked problem is essentially unique; every wicked problem can be considered to be a symptom of another problem; the causes of a wicked problem can be explained in numerous ways, and the choice of explanation determines the nature of the problem's resolution; when working with wicked problems, the planner has no right to be wrong. While in the hard sciences, researchers are allowed to make hypotheses that are later refuted, when dealing with wicked problems there is no such immunity. With wicked problems, the goal is not to find truth, but to improve some characteristic of the world in which people live. Thus, planners (or engineers) must take responsibility for the consequences of the actions they generate [2].

The need to address the many types of wicked problems confronting society today shows up in a broad range of literature. For example, [3] describes the need to deal with the cognitive, strategic and institutional uncertainty associated with wicked problems in environmental management by engaging the many stakeholders in regular interactions. Lucky [4] makes a general plea for engineers to consider the wicked nature of problems on which they are working. Ritchey [5] describes various approaches for mapping and then engaging in the solution of wicked problems. One of the fundamental competences required of 21st century engineers according to ABET is 'the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context', or in other words to be able to deal with wicked problems [6]. Today the notion of wicked problems has been embodied in the acronym VUCA, coined by the military to describe the current security environment, which is described as Volatile, Uncertain, Complex and Ambiguous [7].

2. Importance of problem framing for wicked problems

At the heart of working with wicked problems is the need to step back and frame what the problem is in the first place. As Albert Einstein suggested, 'The formulation of a problem is often more essential than its solution' [8]. Frames are the 'underlying structures of belief, perception and appreciation' [9], comprised of implicit assumptions about what issues are relevant, what values and goals are important, and what criteria can be used to evaluate success. The frames that designers or engineers use

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work in concert with their professional knowledge to influence the decisions they make and the actions they take [10]. Frames form the basis upon which designers pair problems with solutions [10–12]. The selection (or assumption) of a desired end state or goal implicitly includes the identification of a problem or need and conversely, the identification of a problem or need implies some desired end state or goal [13]. Dym et al. [14] clearly state the need to teach engineering students how to frame problems, citing Aristotle's proposal that 'the kinds of questions we ask are as many as the kinds of things which we know' [15] and conclude that '*knowledge resides in the questions that can be asked and the answers that can be provided*'. They proceed to discuss the need to have students learn when to ask and when to answer questions, or in the terminology used in this paper to have students know when to frame or reframe a problem and when to solve it.

Despite its importance, there is little attention paid to problem framing. Organizational theorists, for example, rarely consider how problems are discovered and chosen from a behavioral viewpoint [16]. The behavioral theory of the firm [17], for example, which adopts a process-perspective, assumes the existence of a problem. Descriptions of other processes such as nominal group technique, brainstorming and Delphi methods named in the literature on how groups search for and choose solutions do so as well.

The engineering education literature similarly seems to focus largely on problem solution rather than problem framing. Problem-Based Learning [18], one of the methodologies used to increase professional competence among engineers, is described in [19] as 'based on finding the solution to a real problem. The problem that is presented to the students addresses the whole learning process and is the vehicle that enables the skills required for a satisfactory professional performance to be acquired.' García-Barriocanal et al. [20] acknowledge that in Problem-Based Learning environments, there is a challenge in that 'ineffective problems could affect whether students acquire sufficient domain knowledge, activate appropriate prior knowledge, and properly direct their own learning', but focuses on the means by which instructors define problems for the students rather than on how students define them. Other papers such as [21] focus on developing creativity, but do so around specified problems given to the students. Many of these papers [e.g., 22, 20] also focus on helping students see mistakes they are making, which implicitly assumes there is a correct answer to the problem to be solved. This assumption does not necessarily hold for wicked problems.

Recent work to develop the Conceive, Design, Implement and Operate or CDIO [23] initiative does acknowledge the need to engage students in the upfront exercise of problem framing and extends the CDIO framework to include Observation, making it OCDIO [24]. It describes three observation exercises in which students review opportunities created by new technologies with an expert panel, research technological advances published in the literature, and observe the behavior of people in communities of interest to their projects. At the end of this observation stage, the students capture their learning and create a project proposal [24]. In doing so, they engage in problem framing before they begin conception and design.

3. Approaches to problem framing

Nickerson et al. [16, p. 216] identify two broad types of processes for identifying or framing problems: analytic and synthetic. They define 'An analytic process [as] a sequence of steps—what might also be described as a structured set of steps—that an individual or organization takes to produce stimuli helpful in identifying problems. . . . the process steps disassemble and decompose the value chain to quantitatively evaluate each step.' They cite quality management tools and techniques such as Six Sigma, lean manufacturing and quality function deployment as examples of analytic problem identification approaches in widespread use in organizations today.

In contrast, they define synthetic processes as ones that 'generate inductive, exploratory synthesis in identifying novel problems, . . . are designed to actively combine and integrate, . . . and have much more to do with asking novel and what might be called catalytic questions in response to ambiguity. . .' [16, p. 218]. Examples in this category include processes that focus on discovering customer needs, entrepreneurial opportunities and radical innovation. While analytic processes tend to rely on deviations from the norm and waste from repeated activities for problem definition, synthetic process use stimuli from less structured environments. As a result, the types of problems that analytic processes solve are often well structured and targeted while those identified by synthetic processes are less constrained, less certain, and less well-structured. The recently popular focus on 'design thinking' leverages synthetic approaches to problem formulation.

3.1 Design thinking

The resurgence of attention to 'wicked problems' has come about in part due to, or along with, the increased attention paid to 'design thinking'. Richardson [25], for example, directly connects the need to grapple with wicked problems to the need to engage more in design thinking. It is difficult to trace the origin of what we call design thinking today, but [26] provides an interesting perspective: '. . . we have seen design grow from a trade activity to a segmented profession to a field for technical research and to what now should be recognized as new liberal art of technological culture.' He goes on to argue that the attention to design thinking intends to serve a particular purpose. 'Without integrative disciplines of understanding, communication, and action, there is little hope of sensibly extending knowledge beyond the library or laboratory in order to serve the purpose of enriching human life.' This argument sets up the need to integrate analytic and synthetic approaches in teaching not only engineering students but other students as well.

There are many design thinking frameworks that have been put forth in the past few years. Brown [27], for example, describes the activities in design thinking as inspiration, ideation and implementation. The model of design thinking upon which this paper builds was first introduced by Charles Owen . Owen [28] suggests that the design process has both analytic and synthetic elements, and that it operates in both the real and abstract realms. In the analytic phases of design, one focuses on finding and discovery, while in the synthetic phases of design, one focuses on invention and making. Movement between the real and abstract realms happens as participants in the process draw insights from what they have learned in the concrete or real world, convert them to abstract ideas which are translated once again to the real realm in the form of artifacts or institutions. Beckman and Barry [29] recast his model as shown in Fig. 1. This process starts with immersion in the context for which the design work is targeted through direct observation and experience as well as through collection of data. It then moves to the abstract realm in which it extracts insights from the data gathered during the observation phase, and then switches from analysis to synthesis to generate alternative concepts or ideas. Finally, it returns to the concrete space to embed those concepts in concrete solutions or experiences.

The focus of the design thinking process is, in large part, to identify the right frame for the problem to be solved. The activities in the observation and insights phases of the process, force the designer to step back from solutions and focus on understanding the problem to be solved. In simple terms, it drives the designer to learn as much as possible about the target customer for the design and to ask why. (Note: the term customer is used broadly here to refer to the targets for a design or innovation.) The activities in the ideas and experiences phases are more solution focused, but are often part of a large iterative cycle in which designers experiment with alternative solutions in order to refine their understanding of the definition of the original problem.

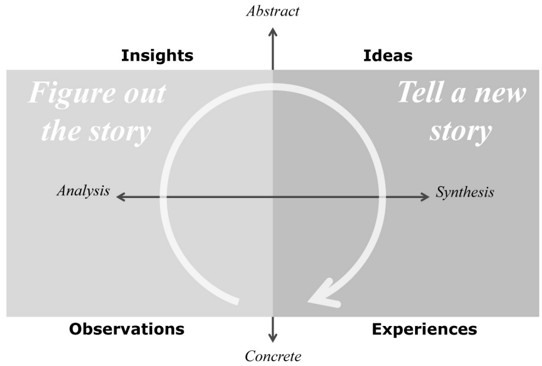

Fig. 1. Design thinking process.

3.2 Design as storytelling

The design process can also be viewed in terms of storytelling [30]. The design team must first understand the story of how things are today— which is the problem framing part of the process —and then create a new story to be materialized and rolled out for the future. This moves our view of the design process from one of problem solving to one of exploring the stories that are being told by customers and of crafting and then performing a new story on their behalf.

There is ample discussion in the literature of the role of stories in organizations. Stories are the means by which knowledge is exchanged and consolidated, and corporate cultures are developed and maintained. Storytelling in organizations has been identified as a means to share norms and values, develop trust and commitment, share tacit knowledge, facilitate unlearning, and generate emotional connection [31]. In a very practical sense, storytelling is recommended as a superior approach to executing, gaining buy-in for, and communicating strategic planning in organizations [32]. Although many of these research studies examined organizations at large, the results can be applied to design teams as well. Hey et al. [13], for example, describe the importance of stories about customers in helping design teams negotiate shared frames for their work together.

There are two types of stories that are important to design teams. Stories that inform the team come from customers. These stories surface contradictions, spoken and unspoken norms, workarounds, and the successes and failures that are core to really understanding customer needs [30]. A design team collects dozens of stories, and then must sort through them to identify the important ones, the ones that need to be changed, the ones around which new stories can be crafted. Stories that inspire come out of the design process. They are the stories that motivate the design team to imagine new and interesting solutions and, when told outside the company, inspire customers and users to participate in the new story. The most inspiring stories appear to follow three primary dramatic plot structures: the challenge plot, the connection plot and the creativity plot [33]. These stories are developed in a highly iterative fashion as the design team plays with the data it has gathered from customers, extracts meaningful insights from that data, frames and reframes what problem it is solving for customers and then generates alternative solutions to that problem.

In the end, the objective of the design process is to tell a new story on behalf of the customer. Once the team has come up with the new story, it often seems terribly obvious. Getting there, however, is not so obvious. There is a great deal of ambiguity in the highly iterative search for understanding of the existing story and then development of the new one. Design teams must thus understand the basic scaffolding of a story, must know when they know enough about the protagonists in the story to move forward, and must be comfortable with living a story themselves.

4. Teaching problem framing with a storytelling metaphor

The wicked problems facing engineering students today require that those students know how to frame and reframe problems. Further, it requires that they integrate synthetic modes of problem formulation with the analytic modes with which they are likely more familiar. The design thinking process, and in particular the storytelling framework for that process provides a way to teach the problem framing skills that are needed. This section of the paper provides background on how the authors have been teaching design-related topics up to now, and a recent experiment to focus students on learning the skills needed to capture and tell stories.

4.1 Some background

The authors have taught design-related topics in various settings for many years. Barry has taught a class on *Needfinding* in the Product Design Program within the Mechanical Engineering Department and now the Hasso Plattner Institute of Design at Stanford University for 15 years. The class averages 49 students per year, and with an average of 7 students per team, 7 teams per year. Students in this class are given a broad area of interest from a corporate partner (e.g., global home water provision for Zuvo Water Filtration Systems) and are taught to conduct ethnographic research to understand the area of interest, formulate a problem or opportunity statement and then generate alternative solutions to that problem. Barry has also supervised over 100 Masters' thesis projects in which students select challenging areas, like energy, sustainability or education and work simultaneously in the creative framing of the problem domain and generating a wide array of innovative solutions.

Beckman has taught a class on *Managing the New Product Development Process* at University of California, Berkeley for 17 years. She has participated in 18 sections of the class, which includes both MBA and Engineering students from UC Berkeley as well as design students from the California College of the Arts. There have been 60 Berkeley students in the class on average, and a range of 12– 20 teams per section. Students in the class propose general areas of market potential that they want to explore (e.g., bicycle theft, feeding lunches to low-income kids), perform ethnographic and quantitative market research, frame and reframe the problem to be solved, and generate and test alternative solutions. She has also taught classes in workplace design (*The PostDilbert Workplace*) jointly with the Departments of Architecture and Psychology, *Design and Systems Thinking for MBAs* and *Design Thinking* in the business school.

Most of these classes aimed to teach the students a process of design. The *Needfinding, PostDilbert Workplace* and *Design Thinking* classes used the design thinking process introduced earlier, while the *Managing the New Product Development Process* class started by using the process outlined in Ulrich and Eppinger [34], but in the past seven years has used the design thinking process as well. Through the process of teaching these classes, the authors have watched as teams have gotten stuck trying to doggedly follow the process as laid out, unable to fluidly exercise the elements of the process as needed to achieve meaningful results. Entire teams showed themselves incapable of moving into specific quadrants of the model as they, for example, focused quickly on solutions before defining the problems themselves. These types of observations led to the question as to whether or not there is a basic set of problem framing skills that needed to be taught independent of the process employing those skills, and thus to an experiment in Fall, 2010 with a course called *Problem Finding, Problem Solving* (PFPS).

PFPS was offered to all incoming full-time MBA students at the Haas School of Business as a prerequisite to their participation in a set of experiential learning classes. The idea behind the class was that the students would need problem framing and solving skills to approach the real world challenges put to them in classes such as *International Business Development, CleanTech to Market, Social Sector Solutions, Entrepreneurship* and the like. Further, the dean of the Haas School chartered its faculty to develop the skills in MBA students to be innovative leaders. The class was thus formulated as a one-unit class (15 class hours) that would provide a set of design and innovation, or more specifically, problem framing, tools to the students that they could then apply in the experiential learning classes.

4.2 The students

There were 243 students in the first offering of the PFPS class. At the beginning of the class, the students were asked to participate in Kolb's [35] Learning Style Inventory to assess their learning styles. Experiential Learning Theory [35] posits that a person acquires knowledge by grasping and transforming experience along two dialectically related continuums (Fig. 2): Concrete Experimentation or Abstract Conceptualization, which measure how an individual perceives information, and Reflective Observation or Active Experimentation, which measure how an individual processes information. Learning styles are determined by the combination of modes a person prefers for perceiving and processing information. The diverging learning style maps to the observation step of the design process, assimilating maps to the insights step, converging maps to the ideas step, and accommodating maps to the experiences step. (See [36] elsewhere in this issue for more explanation, also [29] for connections between Kolb's learning theory and design process.)

As shown in Table 1, 52% of the MBA students fell in the converging learning style space. The dominant learning abilities of those with a converging style are abstract conceptualization and active experimentation. Convergers are 'best at finding practical uses for ideas and theories . . . [and] have the ability to solve problems and make decisions

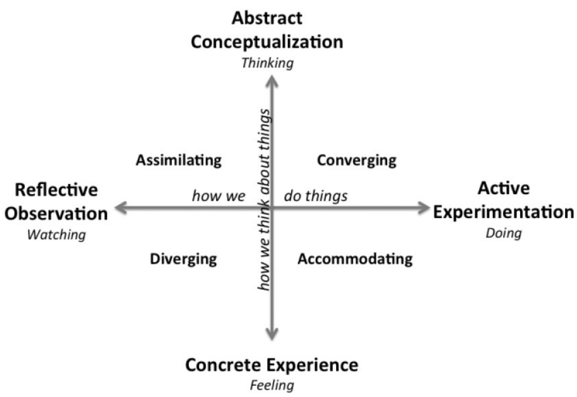

Fig. 2. Experiential Learning Styles [35].

Table 1. Learning Styles of Students in PFPS

Learning Style	Number of Students	Percent of Students
Diverging	5	2%
Assimilating	40	17%
Converging	126	52%
Accommodating	20	8%
Balanced	50	21%
Did not complete survey	2	
	243	100%

based on finding solutions to questions or problems' [35]. Convergers tend to perform well on conventional tests, and employ deductive rather than inductive reasoning. Convergers are strong at decision-making, problem-solving and logical thinking, and are action-oriented. These characteristics are critically important to moving a project along, particularly as the design process moves into the ideas part of the cycle, or the solutions side of the process. But, dominance of convergent thinkers on a team may well pull the team too quickly to conclusions, often over generalizing in the process, and not allow it to adequately explore the design space. In short, too much convergent thinking on the team will lead it to focus on problem solving rather than on problem framing.

This surprising result cast the challenge of teaching design skills in a different light. The students entering the PFPS class were predisposed to focus on solutions rather than on framing the problem in the first place. (Note that data collected from engineering students in the authors' other classes shows a similar percentage of convergent learners.) The specific skills and student reactions to being taught those skills, particularly in light of their converging tendencies, are described in the following section.

4.3 Teaching the basic skills

PFPS was an experiment in teaching MBA students four skills critical to problem framing, skills that are important to gathering and interpreting the stories that inform as well as to generating stories that inspire. (Note that the class was not intended to teach all skills one might associate with design, or more particularly with engineering design, but rather the skills core to formulating the problem itself.) The development of these skills was done both individually through homework assignments and in groups as they processed their work collectively. The 60 students in each section of the class worked in 12 teams of 5. (There were three teams of 6 to accommodate the 243 students.) They were provided with ample workspace, flipchart paper, Post-it notes and pens so that much of the work was visual and thus shared by the team. There was one faculty member present in the room along with a coach to help the teams through the activities.

The students in the class were asked to keep journals as they went through the class sessions, and were regularly asked to make entries in those journals during in-class reflection times. In the following descriptions of the skills and how they were developed in the class, there are also quotes from some of the students' journals describing what they did (or did not) learn.

4.3.1 *Empathy*

At the core of being able to hear and understand the stories customers are telling and then to create a new story on those customers' behalf is basic interest in, curiosity about and empathy for them [37,38]. Kelley and Littman [39] powerfully describe the possibilities of having empathy for customers: 'Pay attention to how your customers might like to interact with your products or services, and a remarkable change takes place. You can do more than simply satisfy their immediate needs. *You might actually make your customers feel like heroes*' (emphasis added).

Having empathy requires the ability to identify assumptions, particularly assumptions made about customers and the problems they are trying to solve. Design is not alone in requiring thoughtful identification of assumptions: critical thinking similarly puts identifying assumptions at its core [40]. Critical thinkers are taught to identify the facts, inferences and assumptions they are making when observing. Students, for example, are shown a photo of four people sitting around a table outdoors that has food on it and asked to identify the facts, inferences and assumptions they make as they view the photos. The viewer might, for example, infer that it is a family based on assumptions about the composition of typical families. The same framework can be applied in observing customers—their behaviors, actions, environments, body language— and in interpreting the stories they tell.

Identifying assumptions, however, is far from trivial. David Foster Wallace [41] starts a commencement speech the students in PFPS were asked to read with a story about two young fish swimming along. An older fish passes them and calls out 'how's the water?', which puzzles the younger fish. 'Water, what the heck is water?' they ask one another. Students were asked to reflect on the reading, to think about their own 'water', and to think about how they might become more empathic in their own daily lives. Giving students tools to put themselves in another's shoes is core to developing the ability to 'see the water.'

The PFPS students were given instruction in observation and ethnographic interviewing and then asked to go into the field and observe use of Automated Teller Machines for half an hour and then report back on what they learned. (Other versions of this assignment that the authors have used over the years include observing fruit consumption, use of bottled water and the behavior of teenagers.) Some of the students, as one described in his journal, learned that 'Gathering data—whether in the form of pictures, numbers, or even stories—is a fundamental part of solving business problems. The point I took from the [observation] assignment was that in order to gather the most meaningful data and to inspire truly innovative ideas, we have to immerse ourselves in observation and slow it down.' Other students brought back great stories such as one about a freshman woman they observed carefully following the instructions her mom had given her for using the ATM. This led to conversations about how people learn about ATM use, and the possibility that something different might be done to instruct new users.

Other students, however, did not fully internalize the lesson. One, for example, reported back during class that he learned that 'as I expected, old people are slow'. It required a fair amount of feedback from the faculty in the class to get students reporting only 'what they expected' to try different hypotheses about what they had seen. In a later class exercise in which students were asked to interview customers of the start-up companies they were studying, many conducted 'expert interviews' rather than 'ethnographic interviews'. They asked people for their opinions about the companies rather than about their personal experiences with solving the problem the company purported to solve. These kinds of difficulties with stepping into the shoes of those they are observing often leads to an inability to really bring the customer alive for the design team, and to hold the image of the customer at the center of the design process. They keep the designer from engaging in what Leonard calls 'empathic design' [37].

4.3.2 *Generating insights*

Generating insights is perhaps the most difficult part of the story-telling design process. In effect, it requires that the design team identify the most important theme for the story that the customer is living today, which in turn will allow it to choose a theme for the new story it will tell on behalf of its customers. That theme in turn will drive all the other elements of the plot, or in other words will determine the solution set that is generated and the choice of solutions to be delivered. While observation occurs in the concrete realm, generating insights requires abstract thinking, or the synthetic processes described earlier in this paper [16].

Choice of a theme is all about framing the problem to be solved (or the opportunity to be leveraged) at the right level of abstraction. Charles and Ray Eames' video 'Powers of 10' [42] brings this notion alive for students. The video starts with a shot of a couple enjoying a picnic on the Chicago lakeshore. Each 10 seconds the camera moves an order of magnitude farther away from the couple, eventually showing Earth, the galaxy and beyond. The students are told that finding meaningful insights requires framing and reframing problems at different levels, each of which provides a different perspective on the possible solution set and thus the possibility of telling a different story for the customer.

Generating the insights that lead to possible new story themes requires sorting through the mass of data generated from the customer. It requires understanding the customers' 'water', and then deciding which elements of that 'water' are most relevant and meaningful. It requires forming alternative hypotheses about what has been observed, about what might be happening for the customer, about how to explain particular customer actions. It requires finding patterns in ambiguous and complex data sets, extracting nuggets of information from customer stories, and finding the stories that reveal commonly shared interests or concerns. The tools provided to the PFPS students to frame and reframe ranged from general tools such as information mapping, mindmapping and creating webs of abstraction to tools such as customer empathy maps and customer journey maps focused specifically on capturing and framing customer needs. Giving those teams such tools helps, but they also need to have patience with the story-development process.

One student neatly expressed the challenges of insight generation: 'I used to always think about synthesis in a very analytical, philosophical context, but I've realized that often times the broader, more associative and lateral forms of thinking can provide valuable connections as well. Ideas are not always connected by horizontal bonds . . . dialectics are nice for system building, but not when you're trying to weave together the varied details of a narrative. I think the analogy between synthesizing and scratching a lottery ticket is particularly appropriate. Synthesis involves unearthing connections in a way that isn't always as fluid or graceful as we might like. Throw in other people with conflicting perspectives and the process can be as grating as it is fertile.'

The inherent ambiguity associated with extracting insights makes many students uncomfortable, and as a result they often gravitate to findings that are obvious, but largely 'uninteresting'. That a solution should be 'easy to use', for example, is not a terribly interesting insight and one that could likely have been written before doing any observation work. Students often default to identifying insights at the levels of the use and usability of a solution rather than at the meaning level where ultimately more interesting innovation work can occur [29,43]. It seems likely, although this requires more research, that students are well-indoctrinated in the analytical approach to problem framing introduced earlier in this paper and are thus less comfortable with synthetic approaches.

4.3.3 Diverging

Peter Senge [44] used to use the movie *Dances with Wolves* to describe our need to be more divergent at times. He described the Native Americans in the movie and how they met to discuss the stranger who had come to inhabit their land. At the end of their discussions, they would often say 'this is a complex issue, we should talk some more.' Senge contrasted this with the way in which we conclude our staff meetings in a highly convergent manner with conclusions and a list of 'to dos'.

In its simplest sense, diverging is the ability to come up with a wide range of alternative ideas applying, for example, the basic rules of brainstorming [45]. Students and practitioners alike, however, often find this simple form of diverging can be very difficult. Kelley and Littman [39] suggest that brainstorming is a 'muscle' that must be exercised, and so the students in PFPS were given many short diverging exercises to help them learn what actually applying the rules of brainstorming can look like. For example, they applied diverging to generating a list of potential interviewees, a set of hypotheses to explain the arrest of Wen Ho Lee, and alternative business models for their start-up companies.

Diverging, however, goes beyond the generation of many ideas. In the end what we seek from the design process is a new story that can be told on behalf of the customer. That story is generated by divergent thinking, identifying multiple alternative frames for the problem to be solved as well as multiple different solutions. It also entails leaving open the choice of a frame for the problem until enough has been learned about the implications of the alternatives to choose among them. This ability distinguishes the notion of divergence being discussed here from simpler notions of brainstorming. Brainstorming is indeed a tool, but the ability to diverge and remain in a divergent state is a skill that has to be developed, and is inherently uncomfortable for those accustomed to convergence.

There are tools that can help students imagine alternative story lines. Metaphors, for example, can be used to describe both an existing situation as well as new story. Students in PFPS were asked, for example, to imagine how their start-ups might deliver their solutions if they were Apple, Google or Starbucks. These tools were needed to help the students get beyond where they believed they could get. Many students shared the sentiment of their classmate, 'I couldn't imagine how I was going to come up with the ten ideas we'd been asked to create for class. The first few were alright, but it took me awhile to get the others.' Much of the faculty facilitation work at this phase focused on getting teams to avoid converging too quickly on a single idea that caused them to have trouble seeing other potential options.

One student captures what he learned about diverging in PFPS: 'I was most surprised about the benefits of the open brainstorming process. In the end, we ended up combining multiple ideas and one of the ideas that we used was one that I developed at the very end of the brainstorming process. In all honesty, it was a 'throw-away' idea to get us to the recommended 20 threshold outlined to us by the instructor. On its own, it would not have been that interesting, but combined with another idea, it was a successful feature that addressed one of the key problems.'

The greater challenge of keeping teams from converging too quickly, and helping them to remain open to exploring alternative directions is still one that so far has only been resolved through frequent faculty intervention.

4.3.4 Iterate

The paper opened with a description of wicked problems and the inherently iterative nature of the process required to deal with them. At the core of being able to iterate is the ability to 'make it and break it.' Students must learn that discarding a story, an idea, or a prototype is just a part of the process. It is not an indication of failure, but simply a part of the cycle of learning.

This is a particularly difficult skill to teach students who are highly convergent. There is a tendency on the part of the teams composed primarily of convergers to attach themselves to the first solutions they identify, to be unwilling to then generate alternative solutions, and to have great difficulty giving up the solutions they have developed. They have to be forced to throw away the solutions they have generated, forced to take alternative points of view in the concept generation phase, and taught to carefully listen and respond to feedback on their first-phase prototypes.

On the first day of class, the PFPS students were asked to redesign wallets. After taking a tour of each others' wallets and eliciting stories about the use of the wallet, they came up with insights and developed a new story to tell about wallet use. Even in such simple exercises, students fall in love with their prototype solutions. When asked to share those solutions with others, they defend them rigorously making it hard to hear the important feedback they are getting about potential changes to the solution. When asked to give up their initial prototype vision and build alternative ones (based on compelling feedback) they instead often simple construct a more polished, higher resolution version of their current model. This feeds into an overall difficulty with process iteration. Without strong coaching, students rarely cycle through their design challenges multiple times, effectively rejecting the advice that things don't have to be finished on the first pass through.

For some this message came through: 'I think it [the design exercise] also showed that just picking something and charging ahead is fine—you don't always have to have the perfect idea.' 'I found the feedback from another group to be extremely helpful. We were too close to the idea to see a flaw in our design.'

Teaching students to learn from failure requires teaching them to design inexpensive experiments that they can run to learn about various aspects of their proposed solutions. This, in turn, requires them to think through the risks associated with their solutions. This requires a shift in mindset for many of them from one of choosing and implementing a single solution to playing or experimenting with multiple solutions and a process of successive approximation.

4.4 Results

It is still early to determine the effects of the class on the students' ability to engage with framing wicked problems, as they are just returning for the second year of the program in which they will have the best chance to apply the skills. Some early indications, however, suggest that they have been able to apply some of the skills to the more complex problems they are encountering.

One team of first-year students took first place in the 8th Annual Innovation Challenge [45] in a field of 143 teams from 47 schools. The team credited PFPS with providing them with the tools they needed to generate an innovative business model for Jiffy Lube. Another student reported, 'I thought you might like to share with next year's class how PFPS has already proven invaluable to the inaugural class.' He shared that others in his *International Business Development* class had also applied the skills gained in PFPS to their projects. Finally, this testimonial from another student provides more detail as to what she took away and applied:

> *'First, for my Board Fellows project with the Berkeley Community Fund, I was asked to evaluate their existing student mentoring programming. I wanted to really*

understand the 'customers,' so I [dove] into some 'ethnographic/day in the life' type research. . .. From all this info I was able to generate a whole host of areas for the org to improve its program. I really think PFPS helped me tackle a pretty nebulous topic by having some clear steps for approaching it.

These are early indicators that the lessons of the class have proven valuable to the students. Ideally, there would be an assessment of their ability to apply these skills both before they enter the MBA program and afterwards. At present, however, these anecdotes are all that are available.

5. Conclusion

We are increasingly faced with the need to grapple with the wicked problems that characterize our world. At the core of dealing with wicked problems is the ability to adequately frame and reframe them before generating alternative strategies for coping with them. However, much of the focus of our education system, not just in engineering, but in business schools as well, has been on having students learn to solve problems, not frame them. The design processes we teach, whether captured in the OCDIO structure or in design thinking models, acknowledge the importance of framing, but exposure to those processes may not be enough to develop the required skills. The PFPS experiment suggests that it is possible to teach students synthetic skills—empathy, insight generation, diverging and learning by trying, the skills they need to both take in and produce stories. Further exploration is needed to determine whether or not this is a sufficient basic skill set, and more testing is required to assess the uptake of the skills by the students in the class. Hopefully, however, this experiment provides some early guidance for thinking about curriculum development around story gathering and creating skills for problem framing.

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