

Mark Stefik on Invention and Innovation

"Breakthrough" book looks at the creative cycle. How does one prepare to become an inventor? What does an "Aha!" feel like? What do repeat inventors do?

Mark Stefik and Barbara Stefik are the co-authors of the new MIT Press book, "Breakthrough: Stories and Strategies of Radical Innovation." Barbara has a doctorate in transpersonal psychology and is in private practice. Mark is an inventor at the Palo Alto Research Center (PARC), where he directs the Information Sciences and Technologies Laboratory.

UBIQUITY: Before we talk about your new book, why don't you remind us of the history of PARC?

STEFIK: PARC was founded by Xerox in 1970. It was created to provide a path to the digital future and a window to Silicon Valley. PARC was chartered to explore "the office of the future." PARC was the starting point for writing the "Breakthrough" book, but the stories of invention and innovation are a lot bigger than PARC. PARC's research culture is organized to create breakthroughs. Although PARC is small- to medium-sized as a research organization, it has made big footprints in the world of innovation.

UBIQUITY: How so?

STEFIK: The innovation with the most obvious impact on Xerox was probably the laser printer. There's been a whole series of supporting inventions on semiconductor lasers, imaging software, and scheduling algorithms. More recently, PARC has been a contributor to building Xerox's service offerings and consulting capabilities. With its incorporation in 2002, PARC's mission is to create breakthrough technology that may come to market through Xerox or another of our strategic partners.

Historically, some of PARC's inventions have had a business potential that could not be realized completely within Xerox. In many cases, Xerox created start-ups or joint ventures to commercialize PARC technology. One of the most successful of these was Spectra Diode Labs, set up as a joint venture between Spectra Physics and Xerox. It

was eventually acquired by JDS Uniphase. Others include SynOptics, and Placeware Systems, which became Microsoft LiveMeeting. I was involved in the technology development for ContentGuard, a joint venture with Microsoft now owned mainly by Microsoft and Time-Warner.

UBIQUITY: What is the current status of PARC?

STEFIK: In early 2002 PARC was incorporated. It is now a wholly owned subsidiary of Xerox. PARC's mission was expanded to apply its breakthrough-creating culture to a broader set of challenges and opportunities. Although Xerox is still a significant partner for PARC, we also have strategic research engagements with other companies. It is also engaged in government-funded research, and is active in licensing its technology and intellectual property.

UBIQUITY: How big is PARC nowadays?

STEFIK: There are about 180 researchers, and then overall -- counting interns, consultants, and the administration -- about 250 people.

UBIQUITY: How does your group fit into the organization chart?

STEFIK: I direct the Information Sciences and Technologies Laboratory, which is one of five laboratories inside PARC: Computer Science; Device Hardware; Electronic Materials; Information Sciences and Technologies; Systems and Practices. PARC also has two technology groups -- Technology Advancement Group and Biomedical Sciences -- that are focused on engineering and technology hardening.

UBIQUITY: And how would you describe the Information Sciences and Technologies Laboratory?

STEFIK: ISTL is exploring how people find, understand and use information. Over the past decade there has been a shift towards personal computers as an intermediary for information. The technology includes graphical user interfaces, databases, networks and the worldwide web. Advances in wireless and sensors are extending the human-information interface to mobile devices.

Attention is now the scarce resource. There is far more information out there than we can pay attention to. In a changing world each of us is challenged to figure out what's going on, to learn new things and to be flexible. We need help in making sense of information. The next leaps will come from technologies that understand meaning more like people do, and that interact with people in ways that are shaped by context and meaning.

ISTL has researchers in cognitive psychology, natural language, visualization, other kinds of content analysis, and machine learning. We are working on new generations of systems to support how we acquire and make sense of information.

UBIQUITY: You mentioned all the disciplines represented in the lab. What is your own discipline? What did you get your Ph.D. in?

STEFIK: I have a doctorate in Computer Science from Stanford. My dissertation was about representation and planning in an expert system for gene-cloning experiments. I seem to shift my focus every 5 or 6 years. By the early '90s I had worked on VLSI design and collaborative systems. We built a facility for supporting collaboration in meetings -- the "Colab" project. I had some ideas about trusted systems and how they could enable the sale and downloading of music and books and other digital works. I worked with content creators, publishers, and others. My dream was that creative people should be able to publish on the Web and get paid for it. That idea led to the creation of a joint venture, ContentGuard. After that company was launched, I turned my attention to sense-making.

UBIQUITY: Your wife and collaborator on your new book has degrees in psychology, is that right?

STEFIK: Barbara's bachelor degree is in clinical psychology and her doctorate is in transpersonal psychology. She works with clients in private practice. She also works with students at the Institute of Transpersonal Psychology. Her primary interest is in dream work and spiritual guidance. She also works with people who have creative blocks. She pays a lot of attention to what is meaningful in a person's work life, to their dreams, and the essence of what people are trying to express.

UBIQUITY: How did you happen to write the book?

STEFIK: In December 2001, I became a lab manager at PARC to provide leadership through a big transition. In the period of a year, all of the management above me changed. This included the head of my lab, the head of PARC, the head of corporate research, and the president of Xerox. PARC's business also changed from being a corporate research laboratory to a new research company. Silicon Valley was also changing. When PARC spun out the dot-com boom was in full force, but four months later it crashed. I had done several tours of duty as a group or "area" manager at PARC. I had never run a lab before. I began asking questions about the different ways people invented.

UBIQUITY: How did you do that?

STEFIK: I sent out an e-mail message to PARC asking people to tell me their stories of invention and innovation. I was trying to figure out what we did well. As PARC looked into its future, what parts of its culture should be preserved and what parts needed to change? I went around with a tape recorder doing interviews and was talking with Barbara about the process. She said, "This is really interesting. Did you ask about this? And did you ask about that? Why didn't you ask this question?" Soon we were both engaged in the interviews. We were addressing basic issues about invention and innovation and decided to turn it into a book.

UBIQUITY: How long did it go on?

STEFIK: It was an intense learning experience lasting about three years. After three months we decided to broaden our perspectives and take our inquiries beyond PARC.

UBIQUITY: What was the process like?

STEFIK: We wrote the book on our own time. For me it was a personal journey. In my "day job" I would experience and handle whatever crises and management issues arose at PARC. Then in the evenings, on weekends, and on vacations, Barbara and I would go off to digest the stuff and try to figure out what it meant. We selected

people to interview on the important themes. We reorganized and rewrote the book five times. There was a lot for us to learn. The intensity of the experience doesn't come across in the book because it was not our intent to give it that flavor. It was very stimulating to spend time with so many bright people in different places.

UBIQUITY: Is Barbara affiliated with PARC?

STEFIK: Barbara is a visiting researcher at PARC.

UBIQUITY: How did the interviews proceed?

STEFIK: As an inventor and a computer scientist I tended to focus on questions about the technology and the practice of invention. I understood that part and got right into it. "Why did you develop this idea? What were the science and technology trends? How does this work?" I was very curious.

Then Barbara would come in and she'd ask, "What was the experience of doing that. What did that feel like, what did that mean?" She is very tuned to deeper meanings and the subtleties of experience.

Afterwards, we would transcribe the interviews, pull out the themes, and fit them into the thematic structure of the book. If I got stuck on the big picture or if she found my explanation of it lifeless or opaque, we might go off for a cup of coffee at Café Borrone in Menlo Park. Then she would interview me to pull out the deeper meanings. A lot of clarity emerged in these sessions.

UBIQUITY: Give us an example.

STEFIK: Well, take the chapter in the book called "Walking in the Dark." This part is about what happens for inventors when they get stuck. That's not something you typically find discussed when people talk about innovation or invention. The well-known stories are about the glorious parts, when someone has a breakthrough. But those stories miss the reality that invention comes in phases. Inventors have periods of great inspiration, but they also have periods when they're dry and confused. One of the insights that came to us going over stories over coffee was that repeat

inventors have different methods for dealing with their dry periods than new inventors. Barbara saw that there is a hidden hazard for new inventors.

UBIQUITY: How is it a hazard?

STEFIK: Suppose you are a new inventor and have a terrific "Aha!" The emotional experience of an "Aha!" can be overwhelming. You also get a lot of attention from people. Money flows and your projects start growing, and so on. The hazard -- and it's not at all unusual -- is to believe that the great invention comes from your genius. You must be great! Look what you have accomplished.

This is a hazard because a dry period eventually follows. When that happens, confidence can ebb. If you believe that invention comes from your genius, then what is at risk during a dry period is that your genius is gone. What's wrong? Everything is at risk. Maybe you aren't a genius after all! That's the hazard.

We found that people who have gone through the creative cycle many times have grown beyond that. They no longer attribute insight to their genius. They pay attention to the conditions under which ideas arise. When they hit a dry spot, they say. "Oh, dry again. Let's see. What do I do when I'm in a dry spot?"

UBIQUITY: So what do repeat inventors do in a dry spot?

STEFIK: The conditions that inspire good ideas are different for different people. Repeat inventors learn what works for them. Some inventors talk with more people. Some inventors immerse themselves in the data. Some inventors change their scenery, or take a shower or go for a walk. I think that is a terribly important message for new inventors. Barbara's background was essential in noticing this hazard and framing the questions about the creative cycle.

UBIQUITY: Do companies have innovation dry spots, too?

STEFIK: This is a big question, and a central theme in our book. Fortunately, when we were looking at innovation cultures we had access to multi-year data from

several companies. The best predictor for a company's approach to innovation is the position of its products on the technology adoption curve.

You can divide the S-curve into three regions: the slow beginning, the rapidly rising middle, and the peaking at the top. The pattern is that companies in the rapidly growing part of the curve are busy building market share. They don't have time for breakthroughs. At the beginning of the curve they need innovation to create a business. When companies approach the peak of the curve and recognize that their business strategies are approaching an endgame, they shift gears and start seeking invention and innovation again.

UBIQUITY: Are there repeat-inventor companies?

STEFIK: Companies that have survived multiple product cycles, or ones that have multiple product lines at different points of the cycle, tend to use a mixed strategy.

UBIQUITY: How do your ideas relate to Clayton Christensen's book "The Innovator's Dilemma"?

STEFIK: We took Christensen's analysis as a starting point and then started looking at dilemmas that arise at different parts of the curve and for other kinds of organizations. Innovation takes place in an ecology in which big technology companies are one kind of important player. The ecology also includes universities, federal research funding agencies, small companies, and investors including venture capitalists. A recurring theme is that most organizations evolve to optimize their routine work. Breakthroughs are not routine. They are out of the ordinary. A consequence is that organizations tend to get rigid in ways that inhibit innovation. They need to take special measures to enable the kinds of activities that drive innovation and change. There are blind spots and dilemmas present for all of the kinds of organizations in the innovation ecology.

UBIQUITY: Talk a little about some the breakthroughs you cover in your book.

STEFIK: Most of the breakthroughs in our book are drawn from the computer industries, because these are the people we had the best access to. Naturally we

cover some breakthroughs from PARC, including early ones like the laser printer and the personal computer. We also look at some breakthroughs in biotech.

UBIQUITY: Going back to PARC, do you think of it mainly as a place of invention or as a place of innovation?

STEFIK: PARC is most famous as a place of invention. It has grown into a place that fosters innovation, where innovation means taking an invention all the way to a product. PARC is a research laboratory, whereas innovation requires other functions like development, manufacturing, and marketing. When PARC innovates it needs to partner. Either it partners with a company that has the additional assets, or PARC works with others to create a new company.

UBIQUITY: If some smart outsider like Peter Drucker came to take a fresh look at PARC right now, what do you suspect he or she would have to say about it in its current state of organization?

STEFIK: Someone familiar with PARC from a few years ago might be surprised by the changes. Some of the projects we have going, in biotech, for example, wouldn't have made much sense if we were only doing research for Xerox. There are also new cultural features. Now that PARC works with multiple sponsor companies, we have a process for starting a research engagement. At the beginning of a possible engagement, we develop a workshop bringing together selected PARC researchers with relevant stakeholders in the company representing its technology, development, and finance people. The goal of the workshop is to identify points of value and leverage that we can agree on before we start a full-scale engagement.

UBIQUITY: What kinds of engagements are most common?

STEFIK: Most companies come to PARC when they want to start something new. They may have recognized a need for a strategic new direction. Of course you are not going to get an answer overnight. Perhaps Drucker would approve the focus on identifying a valuable problem. Barbara and I talk about this process in terms of the "dance of the two questions."

UBIQUITY: What are the two questions?

STEFIK: This is very simple but also fundamental. The two questions are "What is possible?" and "What is needed?" When a workshop identifies a valuable problem, this is the "what is needed" question. When it explores what could be done with emerging technologies, this is the "what is possible" question. The magic is in the dance. The business and marketing people tend to have strong insights about what is needed, but they don't have a good grasp of what is possible, especially if it involves advanced technology. So they limit their search to familiar paths. The technology people have a better handle on what is possible, but less insight as to what is needed. When you bring these groups together productively, the marketing guys might say "I didn't know that was possible" and the researchers might say "I didn't know you needed that."

UBIQUITY: So how are the two views reconciled?

STEFIK: A synthesis becomes possible when you bring people together in a focused way around valuable problems.

UBIQUITY: In a note warmly praising your book, Peter Denning says that the Stefiks "deftly examine the kinds of observers that inventors must be." Very briefly, how would you explain the point of his remark?

STEFIK: Peter is referring to a chapter on "seeing differently." Inventors see the world differently from most people. The difference comes in how they notice and understand rather than what the world presents them. After we had completed about twenty interviews, we looked carefully at the ways that inventors described how they came up with inventions. Of course different people work in different ways. One thing that intrigued us, though, was that there were four main methods that inventors used, sometimes in combination. For example, some people focus heavily on "what is needed?" and tend to frame everything that they see during the day as part of their search for solving their current problem. By holding the problem in the back of their mind, they see the world differently as part of their search for a solution. We call that method "need-driven." There are three other methods. Read the book!

UBIQUITY: One final question. Who really needs this book? Who should go out and borrow money in order to buy this book?

STEFIK: The book is for people who need to understand how invention and innovation work. This includes people in companies whose products are approaching market saturation or who want to start a new line of business. It shows why engaging the marketing people with the technology people can be crucial for finding opportunities. It also shows why companies develop blind spots and how they can engage an outside research organization to see opportunities that they are overlooking.

There are also people who just want to know what it is like to be an inventor. How you prepare to be one? What does an "Aha!" feel like? What do repeat inventors do? This includes graduate students in science and engineering and people thinking about such a career. If you know a student who is puzzling about a major or wants to understand what graduate school is all about, buy this book as a present to help him or her figure it out.

Finally, the book is for people engaged in science policy and investment. It helps to know what works in setting up research programs and funding priorities. There are issues about timing and expectations and there are a number of traps and blind spots. One of the people interviewed in the book just told me, as he was heading off to a National Science Foundation workshop on Design and Innovation, "This book is going to be on the table, because it's something all these people need to read."

UBIQUITY: Let's hope that they do. It's a very interesting, engaging, and comprehensive piece of work.

STEFIK: Well, I hope it's a lot of fun for people. It is meant to be a popular book, and I hope it will turn out that way.

Source: Ubiquity, Volume 5, Issue 35, <http://www.acm.org/ubiquity/>

[END]