

Making friends with disruptive technology:

an interview with Clayton M. Christensen

Clay Christensen is a professor at the Harvard Business School and author of the best-selling business book, The Innovator's Dilemma: When New Technologies Cause Great Companies to Fail (Harvard Business School Press, 1997). Daniel J. Knight, president of High Performance Strategy Associates (www.HPStrategy.com) and a member of Strategy & Leadership's editorial advisory board, conducted this interview following Professor Christensen's keynote address at the Cap Gemini Ernst & Young Conference on "Measuring the Future: Navigating the New Economy" in Boston, Massachusetts, on 1 October 2000.

Strategy & Leadership: In your book, The Innovator's Dilemma, you address what you call "disruptive technology." What do you mean by that term?

Clayton Christensen: If I were to write the book today, I don't think I would use those words. In most cases, technology is simply the infrastructure that facilitates a new business model. New technology may allow an established company to bring to market a product or service that its most profitable customers cannot use. This new product or service may also appear to be unprofitable relative to the other options on the company's innovation menu. For these reasons, established companies find it difficult to embrace the opportunities of a new technology.

My research shows that the trajectory of technological progress almost always outstrips the ability of customers to absorb it. As the technology rapidly improves, however, it will eventually intersect with customers' needs. When that happens, it becomes disruptive and destructive to the leading firms in the industry that are based on the old technology.

S&L: A classic economics concept called "creative destruction" concerns developing a new capability that eradicates an old one. Does disruptive technology do the same?

C.C.: Disruptive technology is actually a great case study of Joseph Schumpeter's creative destruction theory. Historically, his idea was framed in terms of an S-curve. An S-curve shows that continually applying an existing technology solution will eventually reach a point where improvement stops, and a new technology must emerge to supplant it.

I think disruptive technology is a different type of creative destruction in that it affects the business model. Like a technology solution, a business model will reach its limits to do better. So the ability to creatively destroy existing business models actually becomes the key to growth in the whole economy.

S&L: Did Schumpeter influence your thinking as you did your research?

C.C.: Not really. It's not that I ignored him, but until the research was finished, it wasn't apparent to me that disruption was another example of creative destruction. Actually, it was a former student of mine who made the connection. He is Japanese, and his father was such an admirer of Schumpeter that he named his son Schumpeter Tamada.

Schumpeter Tamada came to the USA to study, and he attended my course. Upon returning to Japan, he became an official in Japan's Ministry of International



Trade and Industry. One of his assignments was to write a plan for the resurrection of the Japanese economy. He worked on this problem for a year or more before he called me to say that he could find no solution to Japan's economic malaise. At that point, he was looking at the problem through the lenses of traditional, macroeconomic policy variables.

He asked if he could come to the USA with some of his colleagues and wrestle with this problem through the lens of my research. As we reviewed his data, it became clear that Japan's economy grew so dramatically in the 1960s, 1970s, and 1980s because every one of the industrial engines of its economic growth was a disruptive technology industry. Over and over again in automobiles, steel, consumer electronics, photocopying, and watches, Japanese companies started at the low end of the industry and invaded markets with simple, inexpensive products. Then they moved to the top of the markets and just cleaned the competitors out.

Today, Japan's economy doesn't have the infrastructure to facilitate that same kind of creative destruction. Leading Japanese companies have become enormous and manufacture the world's best products in their categories. And they're stuck at the high end just like American companies.

In the US economy, people have the ability to leave a company, pick up venture capital, and start new waves of disruptive growth. The ability to execute this kind of creative destruction within the economic infrastructure is the key to the robustness of our economic system. Japan doesn't have a venture capital infrastructure, and Japanese employees can't leave their companies to start new disruptive businesses. So Schumpeter Tamada came to realize Japan cannot execute creative destruction on itself.

S&L: *You also speak about good companies being able to absorb and benefit from what you call "sustaining technology," while being defeated by disruptive technology. What's the difference between these two technologies, and what lessons should strategic leaders take away?*

C.C.: Consulting firms and academics often embrace a view essentially asserting that once a company grows big and successful it becomes risk-averse and bureaucratic and loses its ability to achieve breakthrough innovation. My research shows that this view is not true.

I believe there are two kinds of technology innovation that leaders in an industry need to track. First, there are sustaining technologies, which can be the simple incremental improvements you'd expect all companies to grind out year after year. Or they can be radical, up-market technology innovations that leap-frog ahead

of the competition. The evidence shows that sustaining technology consistently appears on business leaders' radar screens because it enables them to bring forth better products that can be sold for higher margins to their best customers. Disruptive technology, on the other hand, initially gives them neither a better product nor acceptable margins, so it tends to be overlooked or ignored.

S&L: *The new economy seems to be largely defined by the Internet. What impact does disruptive technology have on the new economy?*

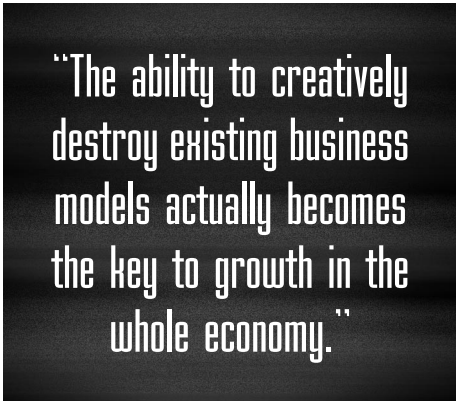
C.C.: Equating the Internet to disruption has caused a tremendous amount of dysfunctional thinking and faulty application of the disruptive technology model. As I've puzzled with this question, I've learned a few things I didn't articulate in my book because the book is not about the Internet or the new economy, it's about a general phenomenon of which the Internet is one example.

In the first place, the concept of disruption is a theory of relativity. It's not an absolute phenomenon that applies in the same way to all instances at all points in time. Dell Computer is a good example of this point. Prior to the advent of the Internet, Dell tried to establish a retail distribution system and failed, so it retreated to selling computers by telephone. This approach required large, expensive banks of telephone operators who couldn't be simple order takers. They had to walk customers through the process of putting together feasible configurations of parts, and they had to enter each order by hand. Now, introduce the Internet. For Dell, it's actually a sustaining technology that helps it do everything better. When established practitioners spot a sustaining technology (which they nearly always do), my research shows that their success rate in aggressively implementing it is nearly 100 percent.

The same Internet, however, is very disruptive to Compaq's business model. In response to Dell's success, Compaq tried to sell directly to customers early in 1999, and it had its head bitten off by its retail channel. After about three weeks, Compaq had to retreat, apologize and promise to maintain the status quo.

Observers praise Michael Dell as the prophet of the Internet, while Eckhard Pfeiffer was fired for not transforming Compaq. My guess is that they are equally capable business leaders. It's just that, for Dell, the Internet was a sustaining technology, and for Compaq, it was a disruptive technology.

There's no reason for us to expect that Dell would need to spin out an independently run, Internet-based operation, because the Internet is a sustaining



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technology for it. Whereas there's probably no way Compaq could address the Internet from within its existing business model. The company would have to set up a separate organization.

When my students bring me business plans about dot-com start-ups, I ask them to look across the horizon to see whether there's already an established player to whom the Internet appears to be sustaining in character. If there is, I'll bet on the incumbent every time. If there isn't, I'll bet on the new entrant.

For example, some big venture capital has backed PlanetRx.com. As I look at the horizon, I stop at Merck Medco. Here's a mail-order pharmacy taking orders by phone, mail, and fax and shipping out hundreds of thousands of orders every week to individual customers. It has an infrastructure in place that can easily move to the Internet as a sustaining technology. Not surprisingly, Merck Medco does ten times more volume than PlanetRx.com over the Internet. In the end, Merck Medco will win. Similarly, LandsEnd.com is very successful because the Internet is a sustaining technology for it, while for traditional brick-and-mortar clothiers it appears to be a disruptive technology.

S&L: *We see leaders in companies with everything going for them one year stumble the next year because of disruptive technology. What other patterns should strategic leaders look for and act on?*

C.C.: For one thing, my theory allows strategic leaders to see things they might not otherwise see in the data. Looking back, we note that Digital Equipment needed to establish itself in the personal computer industry between 1981 and 1984. But those were the very years Digital's mini-computer business was at the top of its game, and business was booming. At the time there was nothing in Digital's income statement suggesting that its business was in crisis. When the disruption became powerful enough to affect Digital's financial statements, the game was already over.

We see the same phenomenon today at EMC, which is one of the most successful businesses in the booming market for data storage. Right now, things couldn't be better for them. But if you look at the bottom of the market, you'll see Veritas Software, Network Appliance, Procom, and Snap Appliances (which was spun off from Quantum). Their products aren't nearly as good as

EMC's, and they are sold to customers that aren't big or sophisticated enough to afford and operate an EMC Symmetrix System. To EMC, this bottom market looks exactly like personal computers looked to Digital in 1982. Now is the time when EMC can address this issue to avoid future disruption. The company must act during the very years in which its core business is absolutely booming. I must add that EMC's leaders are familiar with my research and are very capable of making the right moves. The question is whether knowing what to do will make a difference.

Similarly, the Harvard Business School is at the top of its game, but it's facing disruption by corporate

universities. There are no data in the Harvard Business School world suggesting that our business is threatened, but looking at things through the lens of the disruptive technology model reveals a fault line. Sending an employee to HBS costs a company an average of \$130,000 a year. Companies can't absorb these costs, so they are seeking alternative ways of training their managers. For example, last year 50 percent of McKinsey's consultant hires weren't MBAs. They had technical and government degrees, and McKinsey put them through an in-house, mini-MBA program.

S&L: *Looking at today's business horizon, can you give us some other examples of disruptive technology and explain how leaders are dealing with them?*

C.C.: I believe investment banking is on the brink of some very serious disruption. For example, W.R. Hambrecht has online debt offerings. Within a year or so, Northwest Mutual Life will no longer have to call Salomon Brothers

to sell bonds from its portfolio but can use an Internet-based secondary market exchange to sell bonds directly. Since the buy-sell spread in bonds on Wall Street was about \$25 billion in profit last year, I think bond traders will definitely be disrupted.

The investment banking industry will dis-integrate as well. Historically, investment bankers have dominated this industry as integrated institutions, but in the future we'll see specialized providers come in with disrupting, value-added slices such as independent research.

As disruptive business models come into the mainstream, they tend not to come as integrated companies. Again, compare Dell and Digital Equipment. Every piece of Dell's personal computers is

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made by a different company, while Digital's mini-computers were made entirely inside the company.

S&L: *It sounds like you're talking about the unbundling of corporations.*

C.C.: Unbundling can happen only when disruption occurs. The disintegration of long-distance telephone companies is happening with the introduction of Internet-based telephony. Internet-protocol telephones use packet switching to route calls over the Internet. Fast routing technology makes a routed call indistinguishable from a circuit-switched call. As a result, the whole business model of charging for time on long-distance calls will be gone within a year and will be replaced by a flat fee for unlimited time.

In the power industry, micro-turbines are currently enabled by deregulation. The first wave of change comes with medium-scaled gas turbines, which are much more efficient than the huge power plants. So when micro-turbines are deployed on sites where 100 percent reliability is needed, they could prove to be very disruptive to established power companies.

S&L: *What about fuel cells? Don't they have the capability to destroy the value of the electric power industry's investment in infrastructure?*

C.C.: Micro-turbines exist today as gas turbines that fire conventional electrical generators. A fuel cell goes beyond that. It creates electrical current through a chemical reaction, and I wouldn't call it disruptive yet. Whether fuel cells achieve disruption depends upon the ability of the marketers to find new applications that proactively value the attributes of the technology and then to design it into a disruptive business model.

Fuel-cell companies like Ballard Power Systems have lots of money coming from investors and government contracts, and they're looking at a huge, lucrative, potential market for electric vehicles. However, when you try to cram a disruptive technology into a mainstream market like automobiles, the market puts high-performance demands on the technology, and electric cars can't achieve that level of performance yet.

But what if fuel-cell companies were to go to Bangalore, the booming, "Silicon Valley" part of India? Bangalore has to shut down different parts of its electric power system every day because of lack of capacity. If fuel-cell companies marketed to the small Bangalore computer companies, fuel-cell electricity would likely be a cheaper source of consistent power than the other alternative. The fuel-cell companies wouldn't have to bring wires in over the grid, so they wouldn't have to go

through all the regulatory hassles. The challenge for a disruptive technology is always to find a market where it is not forced to compete with the old technology.

S&L: *You say that "resources, processes, and values" constitute the major internal factors in an organization's business model and dictate what that organization can and cannot do. How can strategic leaders use these factors to deal with disruption?*

C.C.: Organizational resources – which consist of people, technology, and cash – are very flexible. For example, an engineer can leave IBM to work for a start-up company and continue to be equally productive.

Conversely, organizational processes and values are very inflexible. A process is inflexible because it's designed to do one thing repeatedly and reliably. When you try to get a process to do something it wasn't designed to do, you start to hear words like "bureaucratic" and "slow." Values are inflexible because they serve as the criteria managers employ to make prioritization decisions. For example, managers can't prioritize high-margin and low-margin products simultaneously.

For Digital, the questions were: Did they have the resources to be successful in the personal computer business? Would their processes support this move? Would their values allow them to prioritize this new direction? The answer is: Even though Digital had a lot of resources to throw at the personal computer

business, any change effort would be locked up in its processes, which weren't designed for the personal computer, and in its values, which wouldn't allow prioritizing the personal computer business because of lower profit margins.

Looking through these lenses, you can see that Digital didn't really have the capability to succeed with personal computers. It needed to establish a different organization whose processes were tuned to the rhythms of the PC world and whose cost structure or values were such that the PC business was an important, profitable priority. So the rule is, if you want to innovate successfully, you must be sure you're putting your resources in an organizational context where processes facilitate and values prioritize the innovation.

S&L: *So how do you organize to successfully innovate?*

C.C.: Your question can be answered by drawing a fairly simple, four-quadrant model (see Figure 1).

An innovation project that is a good fit with both processes and values would be in the lower left quadrant. In this case, a functionally organized team works quite well, with assigned representatives from manufacturing,

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Figure 1 — Organizing to innovate

Organizational Processes	Bad Fit	Form an independent, "heavyweight" team.	Spin out all operations to an independent organization.
	Good Fit	Coordinate the work of a cross-functional team.	Form a "heavyweight" team for development, but spin out commercialization.
		Good Fit	Bad Fit
		Organizational Values	

marketing, engineering, and so on. Team members continue to work for their functional areas, and the project is coordinated across departments.

An innovation project that is a good fit for values but in which different people will need to interact over different issues and with different timing than they historically have done is in the upper left quadrant. In this case, you need a "heavyweight team" that can create new processes required for successful innovation. But it can be done within the existing organization. Members of this team work solely on the innovation project, control their own resources, and shoulder the full responsibility for project success.

An innovation project in the lower right quadrant, with a good fit for processes but a bad fit for values, can be developed within the processes of the mainstream organization, but successful commercialization will require you to spin out the project into an independent organization, because different values are involved.

And finally, an innovation project with a bad fit in both processes and values, positioned in the upper right quadrant, cannot leverage anything but the resources of the mainstream organization. It must be developed and commercialized within an independent organization.

S&L: *Your model is very instructive. What might trip us up?*

C.C.: Let me answer your question with a brief story. In the Middle Ages, when people were trying to fly, they fabricated wings, strapped them on their arms, and climbed up to a high spot. They jumped off, flapped real hard, and fell to their deaths. For centuries, succeeding innovators assumed that those before them just had the wrong design of wings, or didn't bulk up enough, or didn't flap hard enough, and they continued to kill themselves.

In the thirteenth century, Roger Bacon wrote an influential article in which he proved that humans would never be able to fly, because we have solid bones and birds have hollow bones. He proposed a design for a machine that flapped its wings. Of course, those machines didn't work either, because there were some laws of nature like gravity, which they either didn't understand or didn't account for. Once they understood these laws – how the world works – and then designed

machines that harnessed or accounted for them, they could fly quite well.

Once fluid mechanics became understood, for example, Bernoulli could design an airfoil to create lift. And once we knew that air was matter, we could harness the resistance to create rudders and flaps to stabilize an aircraft. It was only after we understood how the world worked that we could actually fly well.

In this same way, I hope my research shows managers more about how their world works, so they can avoid being tripped up by trying things that don't work. The inflexibility of processes and values is neither good nor bad, it's just a statement of fact. Understanding this fact will help managers know when they can set up an innovation inside the organization and when they need to move it outside.

S&L: *I've heard you tell another story, one about a professor who advised you to study disk companies because, like fruit flies in biology studies, they have the shortest product life span, and you could learn things more quickly. What can evolutionary biology teach strategic leaders about organizational innovation?*

C.C.: While the fruit fly analogy is very descriptive, it would never prove anything. However, I've realized that people can learn more powerfully by an analogy about a theory than they can from an expert.

For example, I made a presentation to Intel management about my theory using the story about how steel mini-mills picked off the rebar segment from the big, integrated mills. As I finished the presentation, Andy Grove said he could see immediately that Intel needed the Celeron chip. Without the context of the disruptive technology theory, Intel managers could never have learned anything from the steel industry; with it, they could learn a powerful lesson. In the context of a sound theory, I gave them an analogy that helped them think more deeply about their problem. If I had tried to become an expert on microprocessors and tried to convince them from my expertise to launch the Celeron chip, they would never have gained the insight they needed. I believe an analogy helps people learn how to think. It gives them a common language and a common way to frame their problems. This contribution, as people in such a wide range of industries have seen relevance of the theory to their situations, has been the most gratifying piece of my work the last couple of years.

There are several analogies from evolutionary biology that can be instructive regarding innovation. In the theory of allopatric speciation, Stephen Jay Gould articulates an exact parallel of the disruptive phenomenon. In the geologic record, we find that species seem to exist for eons without evolving, then they'll suddenly disappear, and at some distance, a new species will emerge very suddenly (in the geologic scale).

Gould theorizes that if a mutant emerges within the mainstream of a population that is well adapted to its

environment, the mutant characteristics won't produce an advantage. As the mutant interbreeds with normal members of the population, the characteristics of the mutation quickly dissipate and almost no change occurs. Whereas, if the same mutation occurs at the periphery of the environment where the species isn't well adapted, the mutant will either die or gain a big advantage, because there aren't as many members of the normal population at the population's edge.

S&L: *So, species mutation is a parallel to business innovation?*

C.C.: It's a parallel phenomenon, but it's not proof. When we look at how companies like Hewlett-Packard have transformed themselves over the years, we find that most of them set up new organizations to pursue a

disruptive business opportunity and then shut down or sold off their old businesses. Johnson & Johnson and General Electric have also done it this way. The individual business units – like the mainstream population in our biology example – remain inert to change because their capabilities reside in processes and values, which are inherently inflexible. Jack Welch can tune up GE's jet engine business and move it up the sustaining trajectory of the S-curve in a very deliberate way, but the unit's business model won't change.

Business units and their business models just mature and die. By using the lens of the disruptive model, strategic leaders can learn how to cause their organizations to evolve successfully. 