pebble in a pond

A conversation

between

Stephen R. Barley

and

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on

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Paul C. Godfrey, associate academic director of BYU's Economic Self-Reliance Center, sat down with **Stephen R. Barley,** the Charles M. Pigott Professor of Management Science and Engineering at Stanford University, to discuss problems and needs associated with implementing technology in developing countries. Barley is co-director of the Center for Work, Technology, and Organization at Stanford's School of Engineering, and the co-director of the Stanford/General Motors Collaborative Research Laboratory. He has written extensively on the impact of new technologies on work, the organization of technical work, and organizational culture. Barley was a member of the Board of Senior Scholars of the National Center for the Educational Quality of the Workforce and co-chaired National Research Council and the National Academy of Science's committee on the changing occupational structure in the United States.

Godfrey: Most people believe technology is the answer for X, whatever X may happen to be—poverty, productivity, etc. The logic goes: "If we can just get technology in the hands of people, the problem will be solved." Why, in your experience, is that rarely, if ever, the case?

Barley: Why doesn't technology solve problems? I guess one reason is that people tend to think of technology as a direct cause. Two falsehoods come with this vision. First, the relationship between technology and almost everything else is not direct; it's probabilistic. Second, there are many other variables and second-order effects that influence what will happen after a technology is adopted. Those second-order effects are almost always linked to the context in which the technology is placed. And no one thinks about context!

There are cases where people have not thought through the *real* usefulness of technology. I remember a story about toilets in an African country. A company had donated a bunch of toilets—chemical ones, I think—but the donors had not really thought through the process by which these toilets were going to get cleaned. So, they provided toilets that, on the face of it, would solve a sanitation problem. But the sanitation problem actually got worse because no one wanted to clean or service the toilets. People used them en masse, but didn't clean them. The toilets became breeding grounds for dangerous bacteria and disease. Donors assumed that people in this society—with their rudimentary notion of public health—would implement standard operating procedures for using the technology that would ensure public health. Yet, most of these rural people did not have a germ theory of disease.

Godfrey: You said it's not a direct cause but a probabilistic cause—what do you mean by that?

Barley: In some of my early papers I talked about technology as an "occasion for structuring." Every kind of change is the result of a large number of factors and forces. In many cases those factors and forces represent people who live in different social worlds or subcultures and who want the technology to satisfy different goals or interests. Most people think about technology as a means to a particular end, but in reality, technology is a means to multiple ends, and the ends that are ultimately achieved are not preordained from the beginning. Just like when a pebble hits a pond, you don't know what will be affected when a technology comes into a community.

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Godfrey: Can you give me an example of a technology that people come at with different assumptions and objectives?

Barley: Okay. In the late 1940s, there were two approaches to developing automatic machine tools that could repeatedly produce the same part. One approach was an analog technology, or recorded playback, that required a machinist to make the first part. The machine recorded the movement of the cutting tools on a tape that could then be played back to run the machine time after time. After the machinist made the first cut, production could be automated.

The second approach was numerical control, which allowed the tool to be programmed without having a machinist involved. Why did numerical control became the dominant design, causing record playback to fade into obscurity? Powerful parties who were interested in automatic machine tools were not interested in recorded playback. Although these parties' interests were different, all were congruent with numerical control. The first actor was the U.S. Air Force, who at that time was interested in building jet aircrafts. To fly at near supersonic speeds required body parts with tight tolerances; otherwise, the aircraft would shake apart at high speed. The military

felt they could get much finer tolerances with numerical control than through recorded playback. So, the military was willing to front a lot of money to develop numerical control. At the same time, mathematicians at MIT were interested in numerical control as an academic problem because it allowed them to investigate interesting mathematical questions. Specifically, numerical control required math and computer programs that could control five axes simultaneously. The mathematicians were the second set of actors. The third set was corporations, like General Electric, who were looking for the ability to make machine tools in ways that would cut machinists out of the process and turn the job of conceptualizing over to programmers. These are all very different agendas, but those agendas were able to come together in such a way that numerical control dominated while recorded playback languished.

Those are the kinds of dynamics that influence the implementation of any technology. Looking at numerical control, one party sees the ability to produce much more finely machined aircraft parts. Another party sees the opportunity to solve interesting mathematical puzzles, and a third sees an opportunity to change power relations on plant floors.

Godfrey: What do you do to help students or clients see the larger context in which technology will be implemented?

Barley: The major problem with technology is that people typically view technology as a means to achieve some end more efficiently or effectively. However, a technology may also have unanticipated outcomes. Often the people who are championing the technology don't fully understand the nature of the problem the technology is meant to solve, or the people who are supposed to use the technology don't see the problem in the first place. It may not be a problem for them. For example, a situation or a technology may mean something very different for management than it does to workers.

Godfrey: That was the toilet issue in Africa. The people who received the technology didn't see the problem and were quite inconvenienced by the new technology. What are the two or three things people need to read to really come up to speed on the issues of technology?

Barley: Shoshana Zuboff's 1988 book *In the Age of the Smart Machine* and Bob Thomas's 1994 book *What Machines Can't Do: Politics and Technology in the Industrial Enterprise*. There are numerous academic articles out there, but many of them are not easily accessible. Those two books are well written.

Godfrey: You talked at the very beginning about context and how technology plays out in a context. For someone who's thinking about putting X technology in Y country, what would be the key contextual markers you would tell him to pay attention to?

Barley: Well, I'm such a contextualist that I would say you wouldn't know unless you went into a country and observed. What you really need is an anthropologist. Aside from that, I would say a significant number of technologies fail because those who implement them don't take into account the physical and social infrastructure or the tools needed for using and maintaining a technology.

Godfrey: Can you give us an example of physical infrastructure?

Barley: I remember reading a paper about the introduction of pumps designed to provide fresh water into regions of India and how these pumps ultimately rusted and ceased working because there were no tools or people to fix them.

Godfrey: And social infrastructure? In your study of radiologists, what were the social factors that determined how this new radiology technology was used?

Barley: Hospitals bought CT scanners with two notions. The medical notion was that the machines could help diagnose a whole variety of illnesses, in many cases less invasively than previous procedures. The organizational reason to adopt the machines was that they would bring a significant flow of income to the hospitals. In the early 1980s, patients were transported from one hospital to another to get a CT scan and then moved back to their original hospital, but the revenue went to the hospital with the CT scanner. So, there was a financial and medical reason to buy CT scanners.

What radiologists and administrators downplayed was that the CT scanner was a complex technology quite unlike other imaging technologies. The scanners were computational, but even more importantly, they created new kinds of images that practicing doctors were not trained to read. That meant if you somehow acquired a scanner, you had to figure out how you were going to operate the scanner and how you were going to read the images to provide accurate diagnoses. Some hospitals hired consultants to train radiologists, but there's only so much you can learn about reading a set of images outside of day-to-day practice. Others went to another hospital to learn from people who were already doing it correctly. But the only way to really solve this problem was to hire young radiologists who had trained on scanners in medical school and to hire technicians who had learned to operate the machines at other hospitals.

The influx of new people changed the status structure in these radiology departments. Literally, the most recently hired radiologist knew more about this technology than the senior radiologists. The technicians that ran these machines came to know more about how the machines operated than the doctors did. What these hospitals had not anticipated was that this technology would bring about a fundamental social change in the relationships among radiologists and between technicians and radiologists.

Sustainability requires, from the beginning, designing for the context in which the technology will be used. Instead of taking something that was designed for us, we need to look at the problem in the other country's context and design for that context.

Now, how much of this is transferable to another situation? This is a story about technological change in which the people who were likely to know most about the technology were people who were younger and just out of school. Their arrival turned a social structure, whose status previously rested on seniority, upside down. I can imagine scenarios where something similar might happen in a Third World country. Suppose you succeed in creating a class of technologically sophisticated young people. It is likely that doing so will have an impact on the country's existing status structures. That is the kind of case where technologies would interact with social systems.

Godfrey: You live in Silicon Valley, and people there often believe information technology (IT) is radically different from any other technology and that all the old rules don't apply to it. Is IT really so different from other technologies?

Barley: No, I think not. How is information technology going to change the world? Think about what you have to have for computers to change a Third World society. At minimum, people have to have a need for information. Think of the people at the base of the economic pyramid in a Third World country. How is a computer going to put shelter over their heads? How is it going to create food? How is it going to create security? Abraham Maslow's hierarchy of needs tells us that if people are worried about where food or shelter is going to come from, it's hard to think about self-actualizing or wanting to learn.

For a big chunk of the world, food, shelter, and security are far greater problems than self-actualization and learning. I don't see how computers will solve those problems. Cell phones are another example. I have a Ghanaian student who tells me almost every person in Ghana has a cell phone, but many don't have running water or enough to eat on a regular basis.

Godfrey: What are we missing in this discussion? What do you really want to talk about in terms of technology?

Barley: Some people in the engineering community are interested in using technologies to solve problems in Third World countries, and they want solutions that are sustainable. This is a new way of thinking. Sustainability requires, from the beginning, designing for the context in which the technology will be used. Most thinking about how to use technology to solve problems follows a simplistic logic: "If we just give them a bunch of laptops, they'll be okay. We'll ship technologies developed in the First World and give them to the natives, and they will then use them." All instances of failed technology began this way.

There's another way of thinking about technology and its role for bettering the lives of people in underdeveloped countries. Instead of taking something that was designed for us, we need to look at the problem in the other country's context and design for that context. It's an approach very similar to participatory design, involving users in the development of software and applications. This approach realizes that engineers in a firm somewhere in the United States are not really going to understand the context where the technology will be used. Without this understanding, they design in light of their own image of who the users are and what their needs might be. But these perceptions are usually incorrect.

Godfrey: That goes back to your point about anthropological knowledge. What would you tell NGOs to think about when in the design process? What would be the pros and cons of involving the clients in that process?

Barley: I would tell NGOs to bring the designers together with the users, to take them to the context for which they are designing. Most NGOs, I suspect, are not designers but rather facilitators and purveyors. If I wanted to solve a problem, I would get the designers and the users together in situ. At the very least, this would force an NGO to ask itself whether the people it wants to help will find the help helpful. The NGO may be interested in solving a problem that the client doesn't think exists.

Godfrey: How do we do this in a world where most designs are cranked out by corporations whose goal is standardization?

Barley: I would turn it around and ask why we rely on corporations. I know for a fact that there are a significant number of young engineers who have the goal of using their knowledge to solve social problems in Third World countries. Why not facilitate or create arenas where these engineers and designers can collaborate with each other and with users? NGOs could afford to play such a role. Universities could also play a part. There might be a place here for professional societies or even for corporations, if they are willing to recognize that this is a much more substantive way to be socially responsible.

Godfrey: And that would be a role for NGOs—to become nodes that bring together different social entrepreneurs and clients to solve these problems. They could be places where problems and solutions come together.

Barley: Absolutely. ESR