PEGASUS COMMUNICATIONS

THE SYSTEMS THINKER™

BUILDING SHARED UNDERSTANDING

VOLUME 11
NUMBER 10
DEC./JAN.
2000/2001

Celebrating 10 Years!

A PIONEER ON THE NEXT FRONTIER

AN INTERVIEW WITH JAY FORRESTER

Management consultant Diane Cory recently interviewed Jay Forrester for *THE SYSTEMS THINKER*. Forrester is professor at the Sloan School of Management at the Massachusetts Institute of Technology. During the first wave of modern computers, he invented random-access magnetic-core memory. He then founded the field of system dynamics, which is the analysis of the behavior of systems. It includes computer simulation modeling, in which users create models that show how specific problems are being produced and experiment with various policy alternatives to improve the system's performance.

Diane Cory is a facilitator, coach, and consultant whose areas of expertise include organizational learning, servant leadership, storytelling, creativity, and coaching.

DIANE CORY: This first question is from a manager at Xerox: "How can I help overcome the common perception among upper managers that system dynamics is too complex and takes too much time and effort to apply to a business environment?"

JAY FORRESTER: I think we should start by realizing that system dynamics is a profession like learning engineering or medicine. The idea that it is quick and easy to acquire is fallacious. We've had the experience of running a basic training program in system dynamics here at MIT the last three years by e-mail for professionals around the world; about 20 took it each year. It was a very intensive program in which participants received an assignment each week that took them about 15 hours to complete. That is a big load on top of their normal activities. The program ran for 30 weeks. Thirty weeks at 15 hours a week is 450 hours of work on their part. At the end, many said, "I'm now beginning to see enough of this field to know that I need to go further."

We have seen people going to three-day conferences and thinking they're experts in system dynamics. They set themselves up as consultants or to bring the ideas into a corporation when, in fact, they don't have enough insight to know how to approach the subject. You can draw an analogy to medicine. I think a one-day first-aid course is useful. It will help you with simple things in medicine, but it does not prepare you to do heart transplants. System dynamics covers fully that wide a range.

The activity called "systems thinking," which is talking about systems, recognizing there are systems, and agreeing that systems are important, is really at the level of the one-day first-aid course. It is not sufficient for understanding the dynamics of an organization. I have no doubt that a brief introduction can be useful; it just isn't sufficient. The introduction from systems thinking is not strong enough and not persuasive enough to reverse detrimental policies that are strongly held, because there's no solid basis for the argument to change. A systems thinker cannot, I believe, achieve the kind of position that one can have working from a good system dynamics simulation model.

With a solid, thoroughly studied system dynamics model, you know the assumptions that are in the model, you know the behavior those assumptions lead to, and you know how the behavior will change from a wide variety of different policies. If everything you say at the level of policies, at the level of structure, and at the level of behavior is correct in the eyes of participants who know various parts of the real system, it becomes persuasive. And that's what the expert system dynamics practitioner should aspire to.

I would say that any attempt to introduce a deep understanding of

Continued on next page ➢

INSIDE

➢ Continued from previous page

systems on a broad sweep through the organization by simply talking about it probably will not be effective. The right way is to go deeply into some specific issues, do serious computer simulation modeling, and show how the troubles of the organization are being generated, how problems evolved out of past policies, and how alternative policies would improve behavior. To effectively create and use a model requires skill. People will spend tens of millions of dollars over a period of five years or more to develop a new product, but are reluctant to spend anything like that amount in preparing themselves to make the corporation more successful.

I think the way to introduce system dynamics is to find colleagues, build a grassroots understanding, develop skills, and get help from people who understand system dynamics very well. Engaging an expert consultant in system dynamics can accelerate the launching of a program. System dynamics is for solving problems. An effort should start by selecting an important problem. Decide what difficulty to work on and model its causes, rather than starting to model the entire system.

Most people believe their problems are created from outside. In system dynamics modeling, we usually find that the problems are being created on the *inside*. A corporation that is having problems and is being overtaken by other organizations is operating in the same outside world as those other corporations. Therefore, it must be something they themselves are doing that is causing them to be different and less effective.

Beyond the "Quick Fix" Mindset

DC: In some of my meetings with management teams, something seems to be missing in terms of the way that problems or issues are approached. The thinking somehow doesn't encompass what you just talked about.

JWF: People expect a quick fix in a year. A company's problems take years to develop and the fixes take years to repair the damage. If you look carefully at the difficulties of many major corporations, you find the cause of troubles began 10, 15, or 20 years before symptoms are recognized by management or the public.

It's a mindset of the whole society that's standing in the way—the mindset on short-term results. In complex systems, we usually see that policies that are good in the short run produce troubles in the long run and vice versa. Therefore, to do something good in the long run probably imposes some pain in the short run. With hired managers who are in their positions only one to five years, their personal interests tend to be in the short run. They are not committed to the long-run good of their organizations. The financial markets also tend to impose that same detrimental short-run view.

People will spend tens of millions of dollars to develop a new product, but are reluctant to spend anything like that amount to make the corporation more successful.

The attitude of founder-owner-managers is substantially different. Those who found a company, who are significant owners, and who are managing without expectation of going to some other corporation can have a 20-year view or more. I think many of today's corporations that are being run by short-viewpoint managers will disappear in favor of a new wave of founder-owner-manager companies.

DC: Compare the current state of the field of system dynamics—its development and acceptance—with your own hopes and expectations.

JWF: It's probably developing faster than I would have expected. The growth rate in the field—number of people interested in it—is probably doubling every four years or so, which is a very rapid growth rate. We are arriving now at the point where it really can't be ignored. The consulting companies are looking more and more for people with system dynamics backgrounds. And, of course, my own work is helping to infiltrate system dynamics into the kindergarten through 12th-grade educational levels. I think it's going very, very well.

A lot of people in the field express disappointment. They say, "Why isn't it developing faster?" Well, it can't because one of the great dangers is running ahead of the number of people who can practice it effectively and correctly.

I think one can argue that great frontiers don't stay as frontiers; they become a part of everyday life. The most recent frontier has been exploring science and technology. I think the next great frontier is to truly understand and be able to improve the behavior of our social, economic, and managerial systems. The understanding of those systems has not improved markedly since the time of the ancient Greeks. My wife and I were taking a tour through the Alhambra, the great Moorish castle above Granada, Spain. Our guide stopped at one point to show us the room where the Moors around the year 1300 met to discuss their problems of inflation and balance of trade—problems that are still with us.

It's clear why the understanding has not advanced until recently—there has not been any effective means to understand dynamic complexity of social systems. Mathematics is a weak science when it comes to dealing with dynamics. It can deal with extremely simple systems, but in realistic social systems, there is no possibility of getting mathematical solutions. Therefore, simulation is the only known approach. System dynamics modeling is like doing experiments in the laboratory instead of trying new policies on a corporation. The simulation experiment is much clearer than trying policy changes in real life because you know the circumstances under which you did the experiment, you know the policy changes that were made, and you know nothing else has changed. If you carry on those same experiments in real life, results are very ambiguous, because you're never quite sure what other things affected the results.

Are We Doomed?

DC: In my work, I keep running into deep frustration that employees lower within an organization experience, and the high levels of burnout, cynicism, and turnover that result. I believe that this is linked to not using system dynamics more effectively in running organizations.

JWF: Well, you find a lot of reasons for frustration. Demands are put on people that they cannot possibly achieve, because they aren't given the resources and authority to produce what is demanded. Furthermore, people haven't been educated in what they need to know to succeed. Those lower-level people are squeezed by demands for impossible performance. That's very frustrating.

DC: My sense is that people tend to blame upper management for the problem.

JWF: I suppose it's fair enough from the viewpoint of the middle level to blame upper management. But upper managers are in the same situation; they also do not know what to do and are themselves under pressures from the outside world. Everybody is operating under the pressure of growth. Why should they be? Why not just run a successful business? It is not possible for everybody to grow beyond the capability of the system. We have great pleading to allow people to immigrate into this country because we think we need more labor. Why should we want to do more than we are able to do? The attitudes that society has drifted into create pressures not only at the middle levels, but also at the top of corporations. Many top managers are coping with problems created by predecessors who focused on the short run.

DC: Are we doomed?

JWF: A lot of large corporations are doomed, yes, and properly they should be. It is good for society to have decaying organizations eliminated. Great depressions like in the 1930s have traditionally helped solve such decay and inefficiency. Severe economic downturns wipe out a lot of dead wood in corporations and open the door for new, vital growth.

DC: What do you see in the future as potential breakthrough areas in the field of system dynamics?

JWF: We need a different approach from the one followed in the early days of system dynamics. The result of a system dynamics study will almost always show that the serious problem at hand arises from policies people know they are following but believe are the solution to their problems. You often have to say to people, "Your problems are because of what you're doing that you're proud of, and you must reverse your course." It takes three or four years for them to accept that point.

We've often worked many years to introduce system dynamics into corporations from the top down. It takes three or four years with even a receptive top management before they fully understand. Then the people you're dealing with retire or die, and you have to start over with another group. This is one of the main reasons why I shifted over to system dynamics in kindergarten through 12th grade, to bring up a society that has a better understanding of the nature of the systems within which we live.

It is much easier to teach system dynamics to fifth graders than it is to CEOs or parents. As children ask questions that people can't answer, they learn it's politically incorrect to ask questions that embarrass people. So they finally stop addressing the big issues. However, at age 10, children have much less to unlearn and they have more open minds. They are more inquisitive; they have not yet had stamped out of them the desire to understand what is difficult.

The Linking of People and Modeling Skills

DC: I have found a lot of fear in people trusting that there might be a different way to do things.

JWF: That's right. There are two big hurdles in system dynamics: having enough people with enough competence, and finding out what to do about people being afraid to take the steps necessary to improve their situations. There are great challenges in implementing policies that are opposite to what people have been doing and what they believe is successful, even though those policies are getting them into worse and worse difficulty.

DC: Does it mean that system dynamics professionals also need to be fairly skillful in dealing with people? They can't just be good modelers?

JWF: To be successful, yes. Sometimes we see a team where several people have different roles, with one doing dynamic modeling work and others paying attention to how to get people to understand it, why are they balking, and why they find it so difficult.

DC: What career advice would you give young system dynamics practitioners?

JWF: I suppose the main thing would be to keep building skills. Very few have read all of the available good system dynamics literature, and probably very few are trying to establish an apprenticeship with an expert. Just as in medicine, one needs to go through an internship. One does not just go to medical school and then do major operations or deal with the most serious illnesses—most learning comes from experience. You don't learn system dynamics by just going to conferences; you must have working experience. System dynamics is not a spectator sport. Like learning to ride a bicycle, listening to lectures is not sufficient.

I would say that a young system dynamicist who goes by himself into a company and is doing simulations will have great difficulty in building acceptance. The best choice would be to go into a place where there is already some level of acceptance, but also to be careful not to be subverted by bad system dynamics that may already be going on there. There's a lot of so-called system dynamics work that is very bad practice. People who are not yet competent are trying to

Continued on next page ➣

➢ Continued from previous page

do things well beyond their ability because system dynamics seems deceptively simple. The major books in the field can be read by almost anyone. *Urban Dynamics* was, I think, on the list of books for discussion by the League of Women Voters and PTAs. People can read those books and understand them, and the process looks very straightforward. Then, when the person closes the book and says, "I'll do some of that for myself," there isn't the slightest idea of what to do next. Also, the accessibility of system dynamics software allows people to build things that look like system dynamics models but may not be useful. There is a great need for processes for developing high levels of skill.

DC: If you were going to design a corporation, how would you introduce system dynamics?

JWF: It's like introducing system dynamics into K–12 education. In K–12, very few places have a way to learn system dynamics. System dynamics needs to become a part of everything else that's going on. It has to be widespread to be most effective. In a corporation, suppose we have a top management that has some serious problems, and the long-term dynamic solution requires reversing cherished policies. Assume top management accepts the reversed policies, they believe in the new policies, they are willing to act, and they issue instructions to do so. Below the top will be several levels of managers who see it as their duty to protect the organization from the idiosyncrasies of the top. The understanding of policy design must extend down through many levels.

DC: So even if you had a group of executives who decide to change policies, they may still be in trouble.

JWF: As an example, take one of the early studies in system dynamics done by a couple of graduate students. It dealt with a two-terminal trucking company between Boston and Philadelphia. Their big problem was that trucks tended to be at the wrong end of the route. When they needed to ship things from Boston to Philadelphia, they had too many trucks in Philadelphia and vice versa. The modeling showed how the terminal with extra trucks could provide prompt service, and business there would increase until trucks were concentrated at the opposite end, resulting in poor service and decline of business at the first terminal. Then service would improve and business would pick up at the second terminal. Business would swing back and forth as the stock of trucks shifted.

The solution then became relatively obvious: They needed to keep their trucks balanced, even if they sometimes had to send empty trucks from one end to the other. Management understood and issued orders but nothing happened, because the people in the dispatching office and on the shipping dock knew the company didn't make money driving empty trucks around. Nothing happened until the model was explained on the shipping-room platform and in the dispatchers' offices. I was told that one could hear truck loaders on the dock discussing the model. At that point, management could get the policy implemented, because now it made sense and everyone understood why. Previously, the lower-level employees, who were making day-by-day decisions, saw the policies as totally irrational and believed they should resist in the best interests of doing a good job.

"The high-school teachers who know what's going on here are terrified. They see the day coming when the elementary schools and the middle schools will be delivering to them little monsters who can *think!*"

"Delivering Little Monsters Who Can *Think!*"

DC: Is your K–12 initiative developing as you had anticipated? What have you been learning from it?

JWF: Yes, I think it's developing as rapidly as is reasonable. Moving to system dynamics is a difficult transition. A particular school may start with one enthusiast but, even in a receptive environment, it may take 10 years to get to a self-sustaining, schoolwide activity.

There are now conferences for teachers interested in system dynamics in K–12 education. My wife and I went to one at the end of June 2000. There were nearly 200 teachers present. Never before in any field have I gone to professional meetings where the excitement is so high and the enthusiasm about the future so great. Teachers come up to me and say, "I had no idea these students could do so much." One teacher reported that in the junior high, the students in detention hall for misbehavior dropped from an average of 50 to an average of 5. It's the first time they've seen students who want to come in before school starts and stay after it ends. My favorite sound bite was from the teacher who said, "The high-school teachers who know what's going on here are terrified. They see the day coming when the elementary schools and the middle schools will be delivering to them little monsters who can *think!*"

DC: Jay, what are they doing in high schools around system dynamics?

JWF: Most of what's going on so far is very elementary. Furthermore, there is not yet any continuous program that builds on itself from kindergarten through 12th grade, to say nothing about going on through undergraduate college and graduate schools. There's no organized developmental path yet. Eighth, ninth, or tenth graders should be able to move well head of what is now being taught in the graduate schools. There's the challenge of developing new material for high school, and for four years of undergraduate and three years of graduate school. That would be some 12 years of material not yet on the books. The system dynamics challenge for the future lies in developing such additional depth and breadth.

Worcester Polytechnic Institute is the first school to organize a four-

year undergraduate program leading to a bachelor's degree in system dynamics. It will take a long time to get system dynamics introduced widely into teachers' colleges. The teachers that are coming into system dynamics now are doing so through knowing others who have become enthusiastic and by reading the limited amount of available material. They become intrigued, they introduce a little into a class, and then it begins to evolve. You hear stories like a teacher begins to introduce system dynamics in biology, and other teachers find that their students are taking notes in system dynamics stock and flow diagrams. Then the other teachers go to find out what is happening.

System dynamics runs across all disciplines. The application to physics is fairly obvious because of the dynamics involved, but it's probably not one of the most active areas. In social studies, students can use system dynamics to explore the economic and social forces causing various things to unfold in history. There are English teachers doing computer simulation modeling of the psychological dynamics in various pieces of literature. System dynamics provides a foundation that underlies most of the subjects. A student discovers a new mobility between subjects. If one understands a particular dynamic structure in one setting, the behavior is the same in all settings.

DC: So it seems as though for children who experience feedback dynamics over a number of years, there's a deep difference in the way they perceive things.

JWF: Entirely different. One father of a junior-high boy told me his son had gone on a tour of Europe. He came back with descriptions of the way things are interrelated far beyond what you see in the newspapers, because he looked at things differently. Another boy, when asked what all this has meant to him, said, "I'm much better able to deal with my mother." It gets down to things that matter. After all, that's a very complicated interacting feedback system.

The system dynamics mentor to the schools in Glynn County, Georgia, has written that some of her most interesting experiences come when she is talking with teachers and students about modeling discipline problems. As she develops a diagram of the processes and interactions going on, the students suddenly see why what they're doing gets the teachers so frustrated. The teachers also see that the discipline system they've set up is preordained to create trouble.

On the Cliff's Edge

DC: When you wrote *Urban Dynamics,* you bumped up against people's cherished beliefs by putting out something very different. What allows you to continue to work when you stir up a lot of controversy or receive a lot of criticism?

JWF: Pioneers always find that. The very definition of pioneering is that you're doing something that people don't already know and don't already believe. I have been a pioneer in several different fields. In the early days of digital computers, we were building a computer using the binary system of calculation. Many people said it would be useless unless we did decimal calculations. Of course, all modern digital computers are binary.

Before that, I'd been in the pioneering of feedback control systems for the military in World War II. I graduated in electrical engineering, electronics, and we found ourselves working on systems to control Army gun mounts. The Army wouldn't trust anything made out of electronics except their radios. So my first professional job was to design high-performance controls using hydraulic oil pressure, with an emphasis on reliability. We were doing one of these for the Navy, and the question naturally arose, what will happen with the equipment in an ocean environment? So I thought I'd better know. I went down to the beach and brought back a gallon of genuine Atlantic Ocean water, mixed it half-and-half with the oil, and ran the equipment in it all winter. Everything still worked.

DC: So part of the success of moving the field of system dynamics forward has to do with your own comfort in being a pioneer?

JWF: Yes.

DC: And knowing what that entails as you're moving things forward.

JWF: Knowing the opposition, knowing a little bit about how you bridge the gap. But it takes time. And, of course, being very much in touch with the real world. I grew up on a cattle ranch in Nebraska. And there, if things didn't work, you found out fast. In my senior year in high school, I built a wind-driven electric plant that provided the first electricity we had on our ranch. And it worked. So I think you develop a feeling for where the edge of the cliff is. If you step out too far, you're a crackpot and you fall off. If you stay back too far, you're just part of the crowd. ◘

RESOURCES

Papers

The following papers are available at http://sysdyn.mit.edu/people/jay-forrester.html:

"The Beginning of System Dynamics"

"Designing the Future" (also available in Spanish)

"Learning Through System Dynamics as Preparation for the 21st Century"

"Market Growth as Influenced by Capital Investment"

"System Dynamics and Learner-Centered-Learning in Kindergarten Through 12th Grade Education"

"System Dynamics and the Lessons of 35 Years"

Books

Available at www.pegasuscom.com

Collected Papers of Jay W. Forrester (Pegasus Communications, 1975)

Industrial Dynamics (Pegasus Communications, 1961)

Principles of Systems (Pegasus Communications, 1968)

Urban Dynamics (Pegasus Communications, 1969)

World Dynamics, Second Edition (Pegasus Communications, 1973)

Audio/Video

Available at www.pegasuscom.com

Designing Corporations for Success in the 21st Century

The Growth and Collapse of Markets: Navigating Through the Next Downturn