

INTERVIEWER: So this is part two of the archive project interview with Jay Forrester. When we left off last time, we were talking about the way in which your thoughts about system dynamics moved into urban dynamics and your association with Mayor Collins. I subsequently -- and I have a note that talks about Elting Morison, professor of industrial history, that you mentioned. Do you remember -- you said something to me about wanting me to remind you to talk about him. But do you remember why?

FORRESTER: Elting Morison was a professor of industrial history, and he had put a lot of emphasis on good writing when the students delivered or prepared papers. He was a strong disciplinarian on writing, and as a consequence, his classes were overloaded, because the students really wanted that experience. So at the beginning of a fall term, at a faculty meeting he asked if there would be anyone who would volunteer to mentor one of these students just because he had such a heavy load.

There were two faculty members that discounted the whole idea, said it was quite unnecessary. There were a few of us who volunteered. I went back to my office where I shared a secretary with one of those who had said there was no point in trying to improve writing, and my secretary was there beside herself because she had one of his papers to type and she couldn't even tell where the sentences were. Anyway, it reinforced my feeling that good writing depends a great deal on having written one good paper. Very often students write a paper, they get criticism, they go back, they have another paper, they get criticism, they go back, and they never have to actually make one of those papers top-notch.

So the young man that I was tutoring came in with his first paper. I couldn't tell from the title what it was about. I couldn't tell from the first paragraph or two what it was about. I couldn't tell from reading the whole paper what it was about, being four, five, six pages. So I quizzed him on it and found out that what he was really writing about was how some law passed in 1923 had turned out differently and its effect from what Congress had expected. So I asked him what did Congress expect? What did he know about that? Well, he didn't really know anything about that. So I said, you know, you're going to have to read the congressional record about this law. The only place it existed as far as we knew was in the Boston Public Library.

So he went and studied the background and came back the next week with a reasonably good title. Then after talking to him some more, he came back the next week with an attempt at a first paragraph. For six weeks he worked on this paper, coming in every week, getting comments, going back and working on the same paper. He claimed that he was working 20 to 30 hours a week on the paper, which he may have been. After about six weeks I thought he had done quite a good job.

He then took another topic and submitted a second paper. As I read it, I wondered what had happened. Had I fallen under his spell or what was going on because I didn't see anything wrong with the second paper. I excused myself and took it to Elting Morison's office, and I said, you know, look at this. Something is going on. He can't write this well, but what's wrong with it? Morison read through it and said, well, there's a sentence here and a sentence there that he ought to put a period in the middle. That was the only comment that he had.

I have found on a number of occasions when I encounter somebody that I recognize writing very well, I ask them how come? And they'll give me a story like the man who said that in high school he spent one whole academic term writing one paper, that every day every student would come up, they would circulate past the teacher, who would look at it, criticism, go back and fix this. He said that went on for a whole academic term until they had a good paper. He said that made essentially a permanent effect.

I had this experience with Constance Boyd, who was an editor of the MIT Press, when I was doing my *Industrial Dynamics* book. She was the same sort of person who would coach you on all kinds of things, and then you would work on them and improve them. She claimed no experience with mathematics, but one day on a Sunday afternoon she came to my house. There's only one mathematical derivation in that book. It's in one of the appendices. She came in and said, I don't understand what you're doing here, but I have a feeling there might be a mistake. It's just the gestalt of the whole thing didn't please her. And she was right. There was a mistake in it. So anyway, I think the difficulty in teaching writing is very often that people have never had the experience of doing a top-notch piece of writing.

INTERVIEWER: Interesting that that's not done at any point in the educational process.

FORRESTER: No, I don't think anywhere do you have to stay with a paper until an experienced editor or teacher can't find anything wrong with it.

INTERVIEWER: Let's get back to system dynamics. Among the things I read were the sort of the list of the four surprising things about corporations that were identified that you believe apply to all social systems. I was going to ask if you could speak a little bit about each one. I have the list. The first one was that most difficulties arise from internal causes. Although people usually blame trouble on external causes.

FORRESTER: Well, what we see in the modeling of essentially any social system whether it be corporations or cities or countries, the problems that suddenly appear they blame on some external influence, whereas generally they have been brought on by the policies of the system itself. You see that today in the economic downturn. It's blamed on the collapse of housing mortgages. The real problem is the pressure that Congress and the banks put on to sell more houses, issue more mortgages, provide houses for everyone whether they had the ability to pay for it or not. This leads of course to the collapse. But they don't look back to the things that they did that produced the problem.

In the same way, a family in great internal psychiatric difficulty, everyone is trying to do something to solve the problem, but everything that everybody does makes it worse. In the urban work, we found that the stagnation of cities was very strongly produced by the intended policies of building low-cost housing. Because the low-cost housing used up land that could have been used for job-creating opportunities while it brought in people that needed jobs. So it was a double-edged sword for producing poverty and producing stagnations of cities, but as a consequence of policies that were thought to be good at the time they were being implemented.

INTERVIEWER: That ties directly to the second thing on the list, which was that the actions that people take, usually in the belief that they're going to solve difficulties, are often the cause of the problems getting worse.

FORRESTER: Yes, because in the process of blaming others, they don't realize, and are unwilling to face up to the possibility, that their own actions are causing the difficulty they are in. We see this in the K - 12 education now. The policies that are being followed, the No Child Left Behind, is producing a very unfriendly atmosphere for learning. Every place you look you see this process going on.

INTERVIEWER: Can you go a little bit more into that unfriendly place for learning in the classroom? What's the connection between No Child Left Behind and --

FORRESTER: Well, the emphasis has been on examinations. The future of the teacher and the standing of the students is based mostly on exams in math and science. Now first of all, that seems to presume that everyone should be an expert in math and science. It means that everyone should come out the same, and I would suggest that the school system should turn out a diversity of people with a multitude of interests. Some of those interests really don't depend on math and science. Furthermore, the great pressure on passing the tests is essentially an educational system under a whip, under pressure, whereas real learning, I think, takes place because it's fun and because it explores new territory and gives an opportunity to go afield from what is actually being taught.

INTERVIEWER: I'll ask you much more on that in a few moments. But let me go back to the list of the four surprising things about corporations. The third was that the very nature of the dynamic feedback structure of the social system tends to mislead people into taking counterproductive actions.

FORRESTER: Yes. First of all we have to realize that we live within a network of feedback loops. Any action one takes changes the circumstances, which changes the information inputs that govern your next move. Many people think we're in a linear system: there's a problem, you take an action, and you expect a solution. That's not the kind of structure we're in. It's rather circular. We have a problem. We take action. It has some result, and it sets up a new set of issues for you to react to the next time around.

Now, our experience with systems is entirely from simple systems. One reaches out and touches a hot stove, you're burned here, you're burned now, and you understand what happened. The lesson you get from that is that cause and effect are closely related in time and in space. You're burned here. You're burned now. As soon as you go into the more complex systems -- and a complex system you begin to get into that territory when you go just beyond the complexity of driving an automobile -- you find that the causes may be far back in time and that they come from some entirely different part of the system from where you see the symptoms, where you see the results.

But the system is very devious in the sense that it will produce what you're looking for. It will produce what appears to be a cause that's close in time and space and draws people into dealing with that apparent cause which is usually only a coincident symptom. It goes along with what you're troubled by, but it is not the cause. So there are a whole set of characteristics of complex systems that we are methodically led to misjudge, be it based on our experience with simple systems.

INTERVIEWER: Is that why company policies don't work? Because they're a stagnant written guideline that doesn't react to changing situations?

FORRESTER: Well, it's not so much written guidelines. The guidelines that govern organizations are largely in people's heads and the consequence of pressures and discussion and conferences and meetings, and very seldom are the essential policies actually written down. Now what was your question?

INTERVIEWER: Is that because of the inability to see the bigger picture and the ongoing nature of a system? Is that why policies -

FORRESTER: There are a lot of reasons. One is that people are very responsive to the reward system. The reward system tends to be very short range, like how well do we do next month, how well do we do next quarter? That brings us into another one of the characteristics of complex systems. A policy that is good in the short run is almost always bad in the long run. The reward structures are set up to focus on the short run. So we see again in the present economic crisis. We had short-run incentives to go out and make unwise loans. Then the day of reckoning comes when those cannot be paid. Actually, if one were to remedy that system, the rewards of management in a corporation should be based on what they did 10 years ago. In other words, what is the situation now relative to the policies of 10 years ago rather than rewarding quarter by quarter or year by year the results which produce a tremendous pressure to attend to the short run, which is almost always detrimental in the long run.

INTERVIEWER: Okay. Before we move on, the last, the fourth surprising thing that you learned early on in system dynamics was that people have enough information in order to do successful modeling.

FORRESTER: Yes. The sources of information for modeling I think are very seriously misunderstood in the social sciences and in economics. There has developed a tradition that one uses measured numerical historical data for modeling. That is a vanishingly small fraction of the information that is available. If you speak of three databases that one has available, the mental database, the descriptive written database, and the numerical database, just for the sake of discussion and without meaning necessarily the exact ratios, the mental database probably contains a million times as much information as has ever been written down in books and newspapers. The information in books and newspapers with respect to the important issues and systems probably is a million times greater than that which has ever been numerically measured.

So let us say that there's a tendency in the social sciences to use one millionth of one millionth of the available information. They do this because it's basically reproducible. In other words, you start with this time series and you provide a certain analysis method, and somebody else can do it, and they will get the same result you do. Which is a complete misunderstanding of the nature of research in the physical sciences. I think the social sciences think they're copying the processes that have been successful in the physical sciences. But a model -- especially a system dynamics model, that's what we're talking about here -- a model is a theory of the behavior that it produces and relates to. It's in the same category as a theory in the physical sciences like Einstein's theory of relativity or Ohm's theory of the behavior of a resistor and electricity. None of those theories have any proofs. You cannot prove that one of those theories is right. You find that it works in a certain variety of situations and every one of them can probably be pushed to a limit where it is no longer applicable.

So a system dynamics model is derived primarily from the mental database, although it will use anything that's available in the written or numerical database. But the information is primarily in the mental database. Then when you have created a theory, which is the model and its structure, and you run that model and you observe its behavior, now is the time to compare it with any history that you may have.

Does it behave like the system you're representing? Not that it should reproduce everything year by year. But does it have the characteristics? Does the economic model produce business cycles? Does it produce the great depressions that come from time to time? Does it produce stagflation like we had in the, I guess the seventies or whenever it was? If it shows the process by which these characteristics are caused, then it starts to be persuasive, and there's no proof it's right. It's only that it's persuasive, that it's a better theory than would otherwise be used. The competition is what would otherwise be used. I will assert that it's entirely possible to make an economic model that is better than the model in the heads of Congressmen which will otherwise be the dominant model.

INTERVIEWER: Have you written to the president and told him this?

FORRESTER: No, I haven't because the chance of having an influence under any present circumstances is very near zero because there's no public yet that will support a major change, a reversal in normally expected policies. I think we can have influence only when our K to 12 education proposals have come to the point where there is at least a 10 percent group in the public that have some understanding of the issues we're talking about here.

INTERVIEWER: So, I'm not even sure you can answer this question, but --

FORRESTER: I can do like John von Neumann did in a conversation I was in with him once. A question came up and he said, well, I can discuss that without knowledge of any facts.

INTERVIEWER: How can you articulate what's the potential of system dynamics if it was generally understood, if it was generally adapted throughout various industries and aspects of society? What would it do? How would change our lives?

FORRESTER: I think we would have a very much better world without the kinds of crises that we observe. First of all, it deals with the issue of rising populations. It deals with environmental issues. It deals with depressions and business cycles. It deals with corporate success and failure. A deep understanding of these issues would make a very major change in the world. But that deep understanding I think has to include a public understanding, because you cannot expect these changes to come from the top of a corporation or the top of a government.

People in system dynamics as well as other approaches to policy design are always talking about convincing decision makers. There are no such people when it comes to the big issues. If a policy in government or a corporation is going in this direction, and that's a governmental policy, and you'd like to push it a little bit one way or the other, then you can persuade, and you can have lobbyists, and you can bribe a few people, and you can push it a little bit. But if the real goal is to reverse it totally, there is no government that's capable of doing that unless there is a public support. So there has to be -- it has to come up from the grassroots, I think, to be able to deal with the big issues that put the long term ahead of the short term, which is one of the main things, and which is capable of reversing a policy that the short-term pressures call for.

INTERVIEWER: So does that mean that in order to reach a critical mass to really integrate this into thinking, it's a generation or two at least away?

FORRESTER: Yes. It's a generation or two away because even in the best of circumstances, it probably takes a school at least 10 years to make the transition we're talking about. Then you're talking about bringing people up from kindergarten into positions of influence.

INTERVIEWER: It sounded a little to me in the papers that I read that you're a little frustrated with the pace of adoption? Is that so? Did I read that correctly?

FORRESTER: No, I don't think it's so. It is true of the profession. That is, people in system dynamics feel that frustration. But I think they don't understand how a totally new set of ideas develop. I would say that system dynamics now is in about the state that engineering was when MIT was founded in 1868. If you look at where engineering is now, we have what, 150 years of development? We have at least 50 years ahead of us to create a public that has some understanding of the big issues in corporate and social and family situations.

INTERVIEWER: When you first started to think about system dynamics in education, you were talking or writing about changes in management education. I'm wondering -- maybe it's the same answer as you just gave -- there are some aspects inherent in changing management education that seem to me to be real obstacles, like the independence of faculty and the specialization. How can you change the academic environment to make for a more interdisciplinary approach to problem solving?

FORRESTER: Well, maybe we should start by saying what the nature of the change is that one might expect or dream of. At the present time, management education teaches how to do finance, how to do production, how to do distribution. But it's left to the student to put these together into an integrated system, taught by a faculty that's never put them together into an integrated system. We're teaching people presumably to run corporations.

I think the most useful analogy, one that you probably read about in the papers too, relates management education to an airplane. I asked who are the two most important people in the successful flight of an airplane? One is the pilot who runs it but the other is the designer who created an airplane that could fly and could be flown and that a pilot could successfully maneuver. Now which of those two roles are we teaching in management schools? I think we are teaching the pilot to run the corporation. Then I ask and who was the designer? Now you pretty much draw a blank. The designer is happenstance. The designers are endless committee meetings. The designer is a result of pressures in the short run.

For most corporations you would have a very hard time putting a finger on who the designer is. Now, there are corporations where you can say who the designer is. But for most, you have no idea how it got designed. Then you look at it and you realize that the policies being followed in it are the ones that led to the troubles that they are in.

If you go back to the airplane analogy, pilots are taught in trade schools. They are not taught in universities. In universities you teach people to design airplanes, aeronautics departments that have to do with design. There's no counterpart at the present time in management. There's no department for the designing of corporations. So the future management school would be one devoted to the design of social and management systems. Now you ask how that can come about?

It's rather unlikely that it comes about from the existing schools. It's particularly unlikely that it comes about in the prestige schools because the prestige schools are at the peak because of what they've done in the past. It's more probable if it comes from existing universities, it will come from the second and third level ones, because they're looking for something to leapfrog into the frontier with. Or it may come from new institutions built from the ground up with a new purpose.

INTERVIEWER: So in your opinion, there are no enterprise designers being educated anywhere in the world?

FORRESTER: I would say that those that have studied system dynamics are on the verge of being designers except that they are, as far as I know, none of them actually designing corporations. They are working on smaller problems here and there for the most part. Although some of this is going on and it's very hard for any of us to know exactly how much. Because anywhere that it is particularly successful, it's considered as very proprietary and highly secret.

I had the interesting experience in Paris one day where a good system dynamacist invited me to lunch at a major European corporation. We went to lunch in the executive dining room. As he sat down he said, I'm sorry, I cannot tell you anything that we're doing in system dynamics. He said we can go out to the public meetings and we can talk about anything we're doing in economics, anything that we're doing in operations research, but we're not allowed to even say that we're interested in system dynamics. That seemed to be an example of how proprietary they felt their work was.

Now, that's a misplaced emphasis because it's a situation much more like the vice president I think of 3M once, who in front of a group of executives said, I would be perfectly willing to discuss in front of anybody all of the secrets for why we're succeeding better than they are because, he says, they won't believe a word I'm saying. Again, if this company had published what they were doing and why it was important and what it was doing for them, it would have taken 10 or 15 years for a competitor to do the same even if they wanted to try, even if they decided to try. So there's a big time lag between success and copying.

INTERVIEWER: Can you go into an existing company and restructure it successfully using system dynamics? Or does it really have to be from a new company?

FORRESTER: My personal experience of doing it successfully was largely in a new company. Yes, you can. There are examples of doing it in an existing company if they either have a sufficient distance from their existing policies or are in deep enough trouble that they have to do something. Although the window of opportunity for doing something in an existing company is fairly narrow. If the company is very successful, they don't feel the need to do anything. If it's on the verge of disaster it doesn't have time to do anything. The space in between those can be pretty short, too short maybe to make a complete overhaul. So there is a real problem there.

One of the reasons that I changed my emphasis to K-12 education was that I'd many times had the experience of working with a corporation, after four or five years getting the top management to understand the possibilities of new policies, agree to move in that direction. By that time they either retire or get fired or die, and now you face a new group at the top to start over with. It seemed very clear that we're going to have to start at the bottom and bring people up to be truly effective. Now, there's a lot of work going on in system dynamics that is successful and is working within corporations and within government, sometimes in surprising places.

INTERVIEWER: Any examples you want to --

FORRESTER: I was invited to discuss system dynamics at the CIA many years ago. They were running their own system dynamics courses internally. About 400 people showed up from the director on down to hear the lecture. At that time they had unclassified models of various countries about how they would react to economic and political conditions. I think they had also classified ones. It seemed it almost permeated the organization, the interest in the field. I don't know anything about what's happened in the last 30 years or whenever, however long ago that was. You find, again, the difficulty of really finding out what's going on in corporations. I had a man that was a very prominent management consultant who dealt with major corporations came into my office one day visiting with me. He said, do you know of the corporation that's using system dynamics in almost all of its top policies? I said, no, who? He said, I'm sorry, I can't tell you.

So there's more going on than is evident even to me. I think you uncover it here and there in the corners. In North America there are about 100 universities that say they are teaching system dynamics. I think a lot of those are probably just a lecture or two in some other subject. But it differs all the way from just an introductory session to ones that are getting reasonably deeply into the subject.

INTERVIEWER: I suppose the secrecy would be indicative that people think that it's very important.

FORRESTER: Yes, and you find surprising things. The international system dynamics annual conference was held in Shanghai one year. That was probably certainly back as far as the '80s. I've forgotten what year it was. I had one-time entry into China, a visa for one entry. And I got to my stopover in Hong Kong. I was there for three days or so, and a representative from Shenzhen across the border in China, the industrial city that was developing at that stage, came over and wanted me to come across and give a lecture on system dynamics. I didn't have a visa that would allow me to do that, come back, and then go in again. They assured me they could fix that. They came over with officials and convinced me that they in fact were able to extend my visa, and I went across to give what I thought was probably a rather futile effort. You know, what kind of a background would these people have and what would it be like? It would have to be probably through translation.

I came to the lecture room. There were probably 200 people there. Some had come 400 miles on the train to attend. I was told that it was not the custom for the audience ask questions afterwards so I should not be surprised if there were no questions. When I finished there were questions from the floor in English. There were questions sent up in Chinese to be translated. This went on for as long as the host would allow the time schedule to continue. And the questions were just as good as I would get from any audience. I mean, they were clearly deeply interested. Then when we went to the system dynamics conference, they had their own system dynamics software that they had developed. I don't know to what extent it was a copy of what was available from here. But anyway, they had computers and software doing system dynamics work and probably about 400 Chinese at this conference.

INTERVIEWER: So let's talk more about the application of system dynamics in K-12. Can you first describe for me what you see as the limitations of the more traditional educational model?

FORRESTER: The traditional educational model is completely unrealistic. To start off with, if a student is assigned a problem or a question on an exam, the presumption is that the student has been taught what's necessary to answer it. Now, that's not like real life. Out in real life you encounter a problem and you have not been taught everything you need to know to solve it. So for starters, the educational system is completely reversed from real life. Also it's reversed in the sense that it tends to teach facts, relatively little emphasis on putting them together. You may be in graduate school before you begin to put issues together into some sort of coherent picture. Why not start that at second grade? Then the other thing is that I mentioned before, there is more and more pressure on teachers and students to do the things that are producing this compartmentalization and producing the sense that you're learning under pressure rather than learning because it's exciting.

So the ideal situation -- and I'm not sure that we have an ideal running yet anywhere -- but the ideal situation is one in which the students very early on begin to look at things that are important to them in their situation and begin to analyze why they're happening and do computer simulation modeling of the forces that are at work. We see examples of high school students testifying before the local town council and making a lot more sense than any of the adults because they have thought about how things are going together and what the consequences are going to be of different policies. It's rather exciting for students to discover that they can in fact understand and shed light on things that their adult mentors don't themselves understand.

I don't know whether I've mentioned this before in this series, but as an example, had one stage at Portland, Oregon, a few years ago. Several high school students decided they would look at the future of China's population policies, the next 50 or 100 years of China's population policies. They found they could strike up an email correspondence with a fairly high official of the Chinese government who sent them, I understand, a stack of data. Rather exciting for high school students to find that you can engage the government of China in your project. They did computer simulations of what was going to unfold.

Now, what unfolds is the basis for why we have a social security problem. If you slow down the growth of a population, you end up with decades of an unusually high percentage of aging people. When they began to show the computer runs for this consequence, I'm told that their Chinese colleague essentially said go away, I don't dare know that. It was an insight he couldn't cope with. Now of course on the other hand if they don't slow down population, then they have the other problem of being driven to poverty and a system that can't support the population. So they've got these two big issues that they've got to maneuver between or find a road down the middle somewhere.

Some students in New Jersey I think I was told had done some computer simulation modeling of how diseases were going to affect the economic development of African countries. They were invited to Duke University to lecture on what they had done. And I think it's likely -- I think it's true that high school students are willing to undertake problems that the universities are afraid to try.

INTERVIEWER: Is that just because of their age?

FORRESTER: Lots of reasons. I mean, they've not been beaten into conformity yet. They are probably more daring. They don't have to have a -- they aren't protecting a reputation within a narrow discipline that would lead them to be criticized if they moved outside of it. I think there are various reasons. It's easier to teach system dynamics, I'm convinced, at the middle school level than it is in a university because there's much less to unlearn.

INTERVIEWER: So can you take us into a sort of a model classroom, like of second or third graders. What's going on? What does that classroom look like?

FORRESTER: Let's start in kindergarten. One of the fundamental characteristics of systems is that there are two variables, two kinds of variables, and only two. Now, when you come to believe that, it's a powerful organizing principle. When you look at the world around you, whatever you see is one or the other of two. Those two are the stocks, the accumulations, and the flows. The number of people in this room is a stock. The flow is the rate at which people are coming in and out of the room. The fact that there are two and only two should not surprise people, because if you look at the annual report of a corporation, there are two important pages. There's a balance sheet and the profit and loss statement. The balance sheets are the accumulations. The profit and loss statements are the flows. That is fundamental. It lies everywhere, all the time.

One school in New Jersey began to introduce this to kindergartners, to go through their environment and pick out the stocks and the flows. You see it immediately in a bathtub. The water is the stock. The flows in and out are the flows. But your reputation is the stock, and the good and bad things you do are the flows that make that reputation go up and down. Everywhere you look on every subject that's changing through time, you have that fundamental view of stocks and flows. Now that's an idea that very few people share, and yet it is understandable at the kindergarten level.

As you move up through the first two or three grades, there are a variety of games that have to do with movement in and out of circles and if you have one person go in and then you bring in twice as many, now you have three. If you bring in twice as many, you have six. You begin to plot on the graph an exponential curve, which is something that very few people truly understand and is the problem we have a population explosion in the world. I mean it's 3 percent a year, eventually will overwhelm everything. So those ideas about dynamics clearly can be taught. It's been demonstrated that by fifth grade students can do computer simulation modeling of systems that have several stocks in them. That's enough to get into all of these kinds of complex behaviors that we were talking about earlier in corporations.

INTERVIEWER: So in that --

FORRESTER: But to go back a little bit to the structure of the classroom, by the time you get to middle school or high school, students should be reading the newspapers and picking out situations to go back and model and understand and dig more deeply than you see in the press about what must be going on, and come out with insights well beyond anything you will read about in the press. Where the problem comes first and then you find out what you need to know. It's that other way around. The problem, the situation comes first. So you read a headline. okay, what's going on here? Let's dig into it and see, and that's done. Middle schools have been doing it. But nowhere is it a continuous, cumulative system yet. You find beginners at different steps in the education. There's no unified education yet that I know of that deals from kindergarten to 12th grade.

INTERVIEWER: So in that way, in the system that you're envisioning, by tackling individual problems or situations or issues, that's how all students would wind up integrating geography, math, English, history. Is that correct?

FORRESTER: I don't think we'd totally erase the kinds of things that are going on now, but you mentioned history. There have been a number of historians that have done computer modeling of the forces producing a historical evolution. One of the more interesting explanations for this is to be found in Tolstoy's *War and Peace*, which my daughter called my attention to once. If you get the unabridged edition of *War and Peace* -- it has to be unabridged because these sections have been cut out of any abridged version -- you will find that there are preludes and postludes to chapters that are unrelated to the story.

You find things like Tolstoy saying we will never understand history until the new field of differential equations is applied. Which comes right straight down to system dynamics. He says it's not the Napoleons that make history, it's the rush of people back and forth across Europe. It's the pressures, the forces at work. That's the mental image. That's pulling things out of the mental database and talking about the system that is at work in producing what's going on. So go back to the time of Tolstoy, and there are some people who've been thinking about this.

INTERVIEWER: But returning to how the interdisciplinary approach works, am I right that instead of having these schools around subjects, you're really talking about the discovery of information around dealing with issues.

FORRESTER: It's essentially impossible to deal with a major issue within one discipline. I mean, you'll get into psychology. You'll get into social behavior. If you're in physics you will tie together different things that are going on in the physical world. So yes, any modeling tends to cause the crossing of boundaries as they are now set up in academia. If you go back here at MIT to the days when Jerry Wiesner was president, he would come over about once a year and talk to me about the difficulty of getting anything interdisciplinary done within MIT because the departments are so strong that there was almost no good way to get strong activity that lay between departments. That's true in most universities.

So it's a great deal easier to start these ideas in elementary school where there are not these upper disciplines. You have a teacher that teaches everything. So now you have the things more or less fluid. As soon as you get to high school, the disciplines begin to dominate and it becomes progressively more difficult as you advance in the educational system to get the broad-ranging, the interdisciplinary view of what's going on.

INTERVIEWER: So I'd like to talk a little -- I was very intrigued about the ways in which students, how students would be different coming out of a system that was grounded in system dynamics. What changes would we expect to see in the students that pass through a system from the earliest years?

FORRESTER: They would be very skeptical of the quick fix that you read about in the papers. They would be extremely skeptical of what's going on in Washington now because we are making huge deficits in the interest of the short run, which is going to lead to the possibility of bankrupting the country or having to default on the government debt. They would see that out beyond the present, we're preparing tremendous troubles. They would be moved to introduce alternative ideas. In their own -- but then it comes down also to very personal things.

I asked one student who had been through this, one MIT student who was out for several years, what it had meant to him. He said he reads the newspapers in a totally different way. Now, what he meant was that he would relate items from last year to what's going on now, to what he would expect to happen in the future. He would find that other things going on at the same time in fact are related. He would be able to fill in between the lines knowing things that must be happening that aren't reported, that kind of thing. So I think it's a very broad, a very wide-ranging set of influences that show up in different ways.

INTERVIEWER: These students would then, I take it, it would seem, be better able to deal with real-world problems.

FORRESTER: One would expect them to be very much better able to deal with real-world problems. Because the educational system for the most part trains them to do it wrong.

INTERVIEWER: Is there a critical mass? Earlier you said something about, you know, 10 percent of the population would have to be familiar with system dynamics in order to, kind of, create a groundswell. Is that the critical mass?

FORRESTER: I don't know for sure what it is, but 10 percent that really saw a new vision would have a great deal of influence. You would include in this some journalists and a few politicians. If you get a unified view on the part of a fairly small number of people, it can be very influential. The *Limits to Growth* book was -- my *World Dynamics* book and the successor book *Limits to Growth* came out of this.

There was a man in Iowa who decided to run for Congress because of the *Limits to Growth* book and was elected and set up in each community of his district a man and wife team to be the discussion point for the long term. Now, that's a very profound idea. He got Lyme disease and resigned and didn't stay at this more than three or four years. But I would say that was a significant momentary, at least, influence. More of that would be highly desirable.

INTERVIEWER: One of the big obstacles is this difference between people making decisions for short-term benefit versus dealing with unpleasant things at the moment in order for long-term benefit. To me that's, sort of, human nature. That's not only the -- that's the fact that people want to be more comfortable and more happy and they want the best for their families and children. How do you shift that thinking so that people start to act for the benefit?

FORRESTER: The problem between the short term and the long run in politics I think is not merely the preference for the short run. It is that the short-run pressures are very visible and there may not be any general understanding that short-run good leads to long-run difficulty. So point out -- do what's obvious. Then the long run is less predictable. It is less evident. It does not speak as loudly, and it doesn't have the proponents that the short run does. I would say that what we're talking about here is to shift the balance somewhat. Now, I don't think that one needs to be overly pessimistic. Did we discuss the consequences -- the public reaction to *World Dynamics* and *Limits to Growth*?

INTERVIEWER: Only briefly.

FORRESTER: I think that told us something about the public. My *World Dynamics* book was the first of two. *Limits to Growth* was a successor book. *World Dynamics* grew out of the concern of the Club of Rome for what they called the world problematique, the great issues of the world, the huge cities growing up, the economic pressures, population growth, all the big issues. They had not had any way to deal with these issues until a conference in which I suggested that system dynamics provided a route to it. So they came for two weeks to MIT to look at what we had to offer. We had prepared in a period of three or four weeks 80 pages of text and computer runs and things to put up on the wall showing how population and agriculture and industrialization and pollution would interact with each other in the future.

It had a powerful influence on them because it really unfolded their concerns on the driving forces. They proceeded to finance a year of additional work leading to the *Limits to Growth* book. The first book, *World Dynamics*, I thought had everything necessary to guarantee that there would be no public notice. To start off with, it has about 40 pages of equations in the middle of it. It was brought out by a publisher that had published only one previous book, probably did not have the commercial status to get reviewed. The interesting materials were computer runs, computer-generated graphs that many people can't read meaningfully. The issues of importance were all 50 to 75 to 100 years in the future, presumably well beyond the time horizon of anybody. So I thought the book was for 100 people or so in the world who would like to see an interesting model to put on their computers and to work with it.

The book came out the first week of June of '71. The last week of June it was reviewed on the front page of the *London Observer*, which circulated around the world at that time. A faculty member in one of the state universities in New York wrote to me saying he'd like to know more about what we were doing because he'd been reading about it in the *Singapore Times*. The book was running through the editorial columns of mid-America newspapers. It was being debated in the population-growth press, the environmental press, and the anti-establishment underground student press. A month later in July it had the full front page of the second section of the *Christian Science Monitor*. In October it had -- in September it had I think a page and a half in *Fortune* magazine, in October a column or two in the *Wall Street Journal*. It was the subject of a half-hour prime-time television documentary in Europe. And if you don't like your literature on either the establishment right or the establishment left, then right in the middle of the political spectrum it had a full-length article in *Playboy*.

It seems as if everything that could happen in the media had happened as a result of that first book *Limits to Growth* came out nine months later, and everybody seemed to think it would be an anticlimax. It was more popularly written. It did not have equations in it. But the results were all essentially the same. It just shows you can misjudge things twice in a row in exactly the same way because the public interest went up a factor of 10 from where it had been. It was a worldwide debate on environmental issues.

Now why? I think it uncovered a deep concern of the public about the distant future. Corporations work for the next calendar quarter, but people are concerned about the world for their children and their grandchildren. I think it uncovered that kind of interest in the long term. I'm really quite optimistic that if you can present with clarity and understandability the impact of the long term that it will have great resonance. So the story really is to do a good job of simplifying it to understandable proportions and presenting it with clarity.