T O O L B O X R E P R I N T S E R I E S

THE "THINKING" IN SYSTEMS THINKING

Seven Essential Skills

BY BARRY RICHMOND

INTRODUCTION

What do we mean when we say, "systems thinking"? We can use the phrase to refer to a set of tools—such as causal loop diagrams, stock and flow diagrams, and simulation models—that help us map and explore dynamic complexity. We can also use it to mean a unique perspective on reality—a perspective that sharpens our awareness of wholes and of how the parts within those wholes interrelate. Finally, systems thinking can refer to a specific vocabulary with which we express our understanding of dynamic complexity. For example, systems thinkers often describe the world in terms of reinforcing and balancing processes, limits, delays, patterns of behavior over time, and so forth.

One thing we do know is that systems thinking is also a discipline that requires intensive practice and patience. To that end, there is a series of seven different cognitive processes that seasoned systems thinkers employ as they address problems or concerns. The seven skills complement one another in that each one is used at a different point during the design of a systems thinking intervention. In this volume, we start with an overview of these thinking skills. We also show how each skill can be mapped onto the four-step systems thinking method, and we contrast the skills with their non–systems thinking counterparts. Then, we explore each skill in detail, one at a time, providing examples, diagrams, and tips for honing the skill.

Some of these skills will seem familiar to you and relatively easy to grasp. Others require lots of practice to master. As it turns out, certain aspects of systems thinking just don't come naturally to many of us. The key is to be patient with yourself. This volume should help you to begin honing each of the seven thinking skills. Once you're more familiar with them, you can then experiment with putting them all together to address an issue. As you gain ability and confidence, you'll find that you'll begin to see the world in new, more dynamic and holistic ways—which is really the most powerful advantage that systems thinking offers.

THE LANGUAGE OF LINKS AND LOOPS

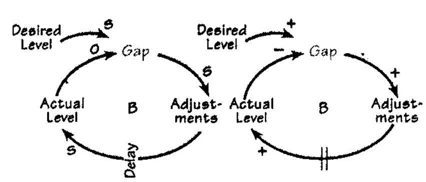
s → / + → A causal link between two variables, where a change in X causes a change in Y in the same direction, or where X adds to Y.

o → / – → A causal link between two variables, where a change in X causes a change in Y in the opposite direction, or where X subtracts from Y.

R A "reinforcing" feedback loop that amplifies change.

B A "balancing" feedback loop that seeks equilibrium.

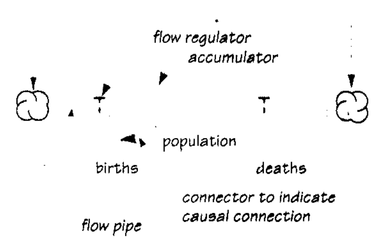
BALANCING LOOP EXAMPLE



If there is a gap between the desired level and the actual level, adjustments are made until the actual equals the desired level. The starting variable is grey.

THE LANGUAGE OF ACCUMULATORS

"clouds" represent the boundaries of what we want to include in the diagram



THE "THINKING" IN SYSTEMS THINKING: AN OVERVIEW OF SEVEN SKILLS

Despite significant advances in personal computers and systems thinking software in the 1990s, learning to apply systems thinking effectively remains a tough nut to crack. Many intelligent people continue to struggle far too long with the systems thinking paradigm, thinking process, and methodology.

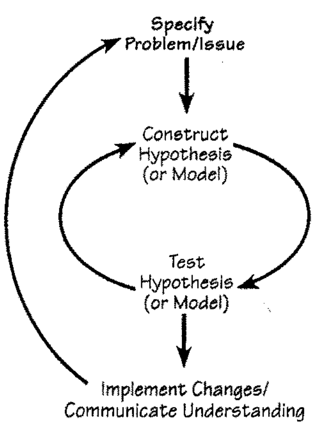
Systems thinking's steep learning curve is likely related to the fact that the discipline requires mastering a whole package of thinking skills.

Much like the accomplished basketball player who is unaware of the many separate skills needed to execute a lay-up under game conditions, veteran systems thinkers are unaware of the full set of thinking skills they deploy while executing their craft. By identifying these separate competencies, both new hoop legends and aspiring systems thinkers can hone each skill in isolation, before trying to put them all together in real-life applications.

THE SYSTEMS THINKING METHOD

The seven skills that make up systems thinking are best understood when seen in the context of the iterative, four-step process that constitutes the systems thinking method (see "Steps in the Systems Thinking Method"). Each skill plays a role in supporting one or more of these steps. In employing systems thinking, you first specify the problem or issue you wish to address. You then construct a hypothesis, or model, to explain the cause of the problem. Next, you test the hypothesis by simulating the model. If the model can generate the problem, you have an entertainable hypothesis. If not, you must modify the model and retest it. Once you have arrived at an entertainable hypothesis, you can then communicate your new-found clarity to others and begin to implement change.

STEPS IN THE SYSTEMS THINKING METHOD



Begin by specifying the problem you want to address. Then construct hypotheses, or models, to explain the problem. Test your hypotheses by simulating them. Only when you have an entertainable understanding of the situation should you begin to implement change.

When we use the term "model," we mean something that represents our assumptions (or hypotheses) about how a particular piece of the world works. A model can be a single assumption that we hold in our mind; for example, "The best way to beef up profits is to launch promotions." Or, it can be a complex set of assumptions that we have made explicit as a diagram, a set of mathematical equations, or some other form. One strength of computer simulation models is that they let you rigorously test how your assumptions and decisions might play out over time. Such models contain equations, written by the model builder, that explicitly express the model builder's assumptions about how certain variables influence each other. A simple example would be: Sales = 2*Promotions ("Sales, in dollars, is equal to twice the number of dollars invested in promotions").

An important thing to realize about all models is that they are always wrong in some respects. Every model is necessarily an incomplete representation of reality and therefore not "true." The real test of a model's value is therefore not how "right" it is, but rather how useful it is. Some models are more useful than others because they help us understand reality better than others. There is a tendency in the business world, and in academia, to try to "validate" models, which is to say to anoint them as "true" in the sense of being numerically accurate in a predictive sense. In systems thinking, we tend to be more concerned with how much confidence we have in a model's utility for shedding light on an issue or problem. For example, rather than seeking to use a model to answer the question "Will sales be $10 billion by the third quarter?" systems thinkers would be more interested in using a model to decide which strategies would enable sales growth to be maximized, or to figure out where a growth strategy is most at peril from competitive assault.

The bottom line is that all models are only as good as the quality of the thinking that went into creating them. Systems thinking, and its ensemble of seven critical thinking skills, plays an important role in improving the quality of our thinking—and hence the usefulness of our models.

THE SEVEN THINKING SKILLS

As you practice applying systems thinking to an issue, you will find that certain skills predominate during various steps in the systems thinking process. There are at least seven separate but interdependent thinking skills that seasoned systems thinkers have mastered. The seven unfold in the following sequence when you apply a systems thinking approach:

Specifying the problem or issue, and setting boundaries for your model (or hypothesis):
Dynamic Thinking
System-as-Cause Thinking
Forest Thinking
Constructing your model:
Operational Thinking
Closed-Loop Thinking
Quantitative Thinking
Testing your model:
Scientific Thinking

The first of these skills, Dynamic Thinking, helps you cast the problem you want to tackle as a phenomenon that unfolds over time—as opposed to a one-time "event." The next two, System-as-Cause Thinking and Forest Thinking, are invaluable in helping you to determine what aspects of reality to include in your hypothesis, and how detailed to be in representing each.

The fourth through sixth skills, Operational Thinking, Closed-Loop Thinking, and Quantitative Thinking, are vital for representing the hypothesis as a model that you can rigorously test.

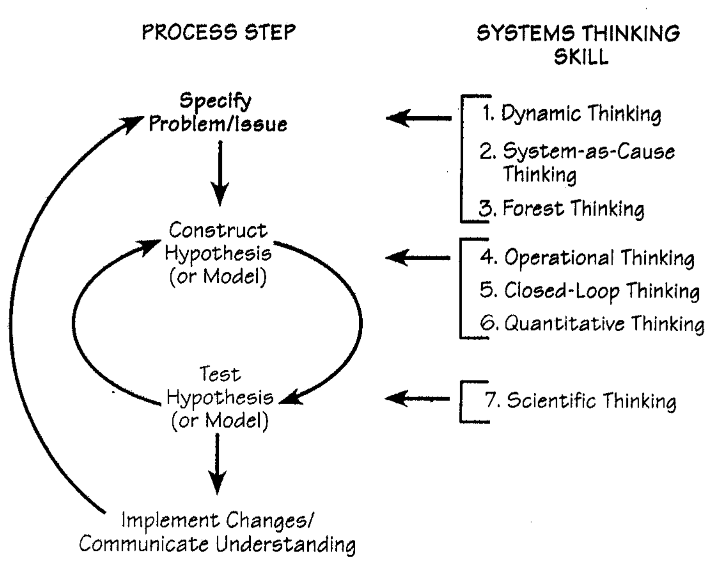
The final skill, Scientific Thinking, is useful in executing tests of your model (see "Systems Thinking and the Seven Skills").

Each of these critical thinking skills brings something unique to a systems thinking analysis. Below, we'll define each skill by contrasting it with its "non–systems thinking" counterpart (which dominate in traditional thinking), and then identify how you can strengthen each.

DYNAMIC THINKING. Dynamic Thinking enables you to frame a problem or issue in terms of a pattern of behavior over time. For example, sales might rise for a while after every promotion but then fall to a lower and lower point each time. Dynamic Thinking contrasts with Static Thinking, which leads people to focus on particular events, rather than on the longer term patterns within which such events reside. Systems thinkers implicitly assume that "events" don't just "pop up." Rather, they result from the continuous build-up of pressures within a system. For systems thinkers, it follows that in order to have any chance of reliably predicting such events, or doing anything to prevent them, it is essential to understand the underlying, continuously operating relationships that produce them.

You can strengthen your Dynamic Thinking skills by drawing behavior-over-time (BOT) graphs. For example, take the columns of data in your company's annual report and graph a few of the key variables over time. Divide one key variable by another (such as revenue or profit by number of employees), and then graph the results. Or, pick up today's newspaper and scan the headlines for any attention-grabbing "events." Then, think about

SYSTEMS THINKING AND THE SEVEN SKILLS



Various steps in the systems thinking process involve specific thinking skills.

how you might see those events as the culmination of a longer term build-up of pressures. The next time someone suggests that doing this-and-that will fix thus-and-such, ask, "Over what time frame will that occur?"

SYSTEM-AS-CAUSE THINKING. Dynamic Thinking positions your issue as part of a pattern of behavior over time. The next step is to develop a hypothesis (construct a model) to explain how that behavior arises. Any model has both an extensive (breadth) and intensive (depth) boundary (see "Extensive and Intensive Model Boundaries"). System-as-Cause Thinking can help you determine the extensive boundary of your model—that is, which variables to include in your model and which to leave out. This thinking skill dictates that you should include only those variables that are within management's control and that are capable of generating the behavior you want to explain. The relevant question from this perspective is: "In what ways are we 'doing it to ourselves'?"

By contrast, the more common System-as-Effect perspective views behavior as "driven" by forces external to the system. Competitors, the economy, weather, or the government did it to us! The System-as-Effect perspective often leads you to include more variables in your model than are necessary. Because external variables are by definition beyond your control, there's no benefit to be gained from including them in the model. System-as-Cause Thinking thus focuses your model more sharply, because it places the responsibility for the behavior on those who manage the processes, policies, strategies, and structure of the system itself.

To develop your System-as-Cause Thinking skills, try turning each "It's their fault" you encounter into a "How could we have contributed to the problem?" It is usually possible to see any situation as caused by "outside forces." Such forces certainly exist, and certainly they have an impact on performance. But it is also usually possible (and almost always useful!) to ask, "What did we do to stimulate those forces, or to make ourselves vulnerable to them?"

FOREST THINKING. In most organizations, the prevailing wisdom is that, to really know something, it's necessary to focus on the details, to "get the numbers right." This wisdom is confirmed by day-to-day experience—life is experienced as a sequence of detailed events. Let's label this more traditional perspective Tree-by-Tree Thinking. Models that we create by applying Tree-by-Tree Thinking tend to be large, very detailed, and characterized by an obsession with numerical accuracy. Their intensive boundaries run deep (again, see "Extensive and Intensive Model Boundaries").

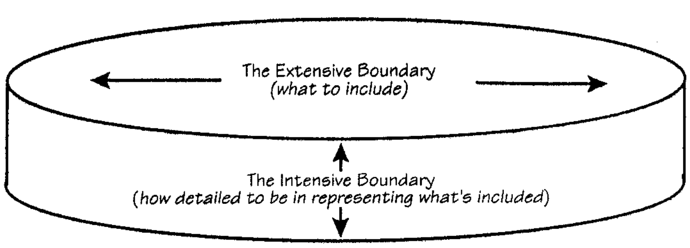
By contrast, Forest Thinking is the "view from 10,000 meters." Forest Thinking–inspired models group the details to give us more of an "on average" picture of the system. To illustrate, in using a Tree-by-Tree model, we'd focus on when particular part numbers were out of stock at which warehouse. Using Forest Thinking, we'd be more interested in the fraction of parts that "stocked out" across the entire system.

To hone your Forest Thinking skills, practice "clumping" or "clustering" like data. For example, rather than thinking in terms of the umpteen different medical specialties represented within the population of doctors and nurses at a hospital, just divide the population into doctors and nurses—or, even better, "clump" them into the one category of medical staff.

OPERATIONAL THINKING. Operational Thinking helps you get at causality—how is performance actually being generated? Operational Thinking contrasts with Correlational, or Factors Thinking. Steven Covey's *The Seven Habits of Highly Effective People,* one of the most popular nonfiction books of all time, is a prime example of Factors Thinking. So are the multitude of lists of "Critical Success Factors" or "Key Drivers of the Business" that decorate the office walls (and mental models) of so many senior executives. We humans like to think in terms of lists of factors that influence or drive some result.

There are several problems with mental models that bear list structures, however. Most important, such lists do not explain how each causal factor actually works its magic. Instead, they

EXTENSIVE AND INTENSIVE MODEL BOUNDARIES



The extensive boundary is the breadth or scope of what's included in the model. The intensive boundary is the depth or level of detail of the items included in the model.

hand-wave causality, merely implying that each factor somehow "influences," or is "correlated with," a corresponding outcome. These "seven habits" produce highly effective people—but *how* they do it is left to the imagination of the reader.

Influence or correlation is not the same as causality. For example, if you use Factors Thinking to specify the influences on learning, you can easily come up with a whole "laundry list" of factors (see "Two Representations of the Learning Process"). But if you use Operational Thinking, you would depict learning as a process, one that is literally driven by the flow of "experiencing."

Operational Thinking seeks to capture the nature of the learning process by describing its structure. By contrast, Factors Thinking merely enumerates a set of factors that in some nonexplicit way "influence" the process.

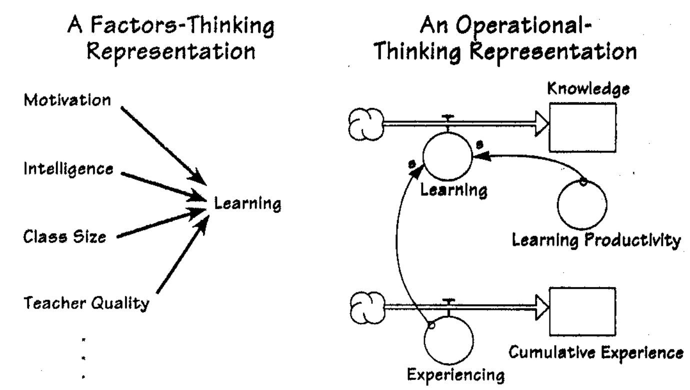
To develop your Operational Thinking skills, think about the various activities that define how a business works. Such activities include hiring, producing, learning, motivating, quitting, and setting prices. In each case, ask, "What is the nature of the associated process?" as opposed to "What are all of the factors that influence each process?" For example, consider the activity of "producing"—an activity fundamental to any business enterprise. Lots of "factors" influence producing. Employees, information, raw materials, the quality of management, and leadership are but a few. But if you instead consider the nature of the producing process by asking, "What actually *causes* producing?" the laundry list of factors disappears. Employees cause producing. The other "influences" determine employee productivity, the rate at which employees can produce. But none of the other factors causes producing. For example, abundant raw materials don't automatically cause producing to increase! In fact, without employees to actually execute the producing activity, no amount of raw materials will cause producing to occur. Raw materials enable producing to occur, but they don't cause it.

CLOSED-LOOP THINKING. Imagine discussing your company's profitability with some co-workers. In most companies, the group would likely list things such as cost structure, product quality, leadership, or competition as influences on profitability (see "A Straight-Line vs. a Closed-Loop View of Causality"). The assumptions behind this way of thinking are that (1) causality runs only one way—from "this set of causes" to "that effect," and (2) each factor is independent of the other factors. These assumptions stem from Straight-Line Thinking.

In reality, the "effect" usually feeds back to influence one or more of the "causal factors," and the factors themselves also affect each other. Closed-Loop Thinking skills help you to see causality as an ongoing, interdependent process, rather than a one-time, one-directional event caused by independent factors.

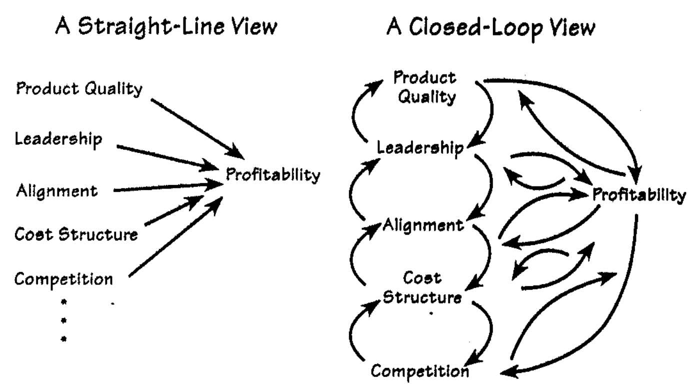
To sharpen your Closed-Loop Thinking skills, take any "laundry list" that you encounter and think through the ways in which the causes

TWO REPRESENTATIONS OF THE LEARNING PROCESS



Factors Thinking merely enumerates a set of factors that in some way "influence" the learning process. Operational Thinking captures the nature of the learning process by describing its structure.

A STRAIGHT-LINE VS. A CLOSED-LOOP VIEW OF CAUSALITY



The assumptions behind Straight-Line Thinking are that causality runs only one way and that each cause is independent of all other causes. Closed-Loop Thinking shows that the "effect" usually feeds back to influence one or more of the "causes," and the causes themselves affect each other.

and effects drive each other. In addition, instead of ranking the variables in terms of their importance as drivers, seek to understand how the dominance among the causal variables might shift over time.

QUANTITATIVE THINKING. A key point associated with Quantitative Thinking is that "quantitative" is not synonymous with "measurable." The distinction between the two concepts is often blurred, perhaps because both usually involve numbers. The presumption in the Western scientific world is that "to know, one must be able to measure precisely." Although Heisenberg's Uncertainty Principle caused physicists to back off from making precise measurement a precondition for "knowing," most business people don't seem to have gotten the message. Instead, they continue to search for perfectly accurate numerical data. Many an analysis has been abandoned, or has gotten bogged down, because "perfect numbers" were not available. Measurement Thinking continues to dominate in business, and much of academe, today!

But think about it: There are a whole lot of things we will never be able to measure very accurately. These include almost all "soft" variables, such as motivation, self-esteem, commitment, and resistance to change. Many so-called "hard" variables are also difficult to measure accurately, given the speed of change and the delays and imperfections in information systems.

Would anyone want to argue that an employee's self-esteem is irrelevant to her performance? Who would propose that employee commitment is unimportant to a company's success? Although few of us would subscribe to either argument, things like self-esteem and commitment rarely make it into the spreadsheets and other analytical tools that dominate business analyses. Why? Because such variables can't be measured. But if you omit them from your analysis, you are saying that you can't think rigorously about them—or worse, that they're not important!

Fortunately, you don't have to leave them out of a rigorous analysis. *They can be quantified.* Here's an example of how: Zero would mean a total absence of commitment. One hundred would mean being as committed as it's possible to be.

Are such numbers arbitrary? Yes. But are they ambiguous? Absolutely not! If you want your model to shed light on how to increase employee commitment—as opposed to predicting exactly what value commitment will take on in, say, the second quarter of 2003—you can include "strength of commitment" as a variable in your model, and do so with no apologies. *You can always quantify, though you often can't measure.*

To improve your Quantitative Thinking skills, take any analysis that your company has crunched through over the last year and ask, "What key 'soft' variables have been omitted?" Things like employee motivation, perceived reputation, and quality of leadership are some good examples. Then, ruminate about the possible implications of including them. Systems thinking gives you the power to ascribe full-citizen status to such variables. You'll give up the ability to achieve accurate measurement. But if

TRADITIONAL BUSINESS THINKING VS. SYSTEMS THINKING SKILLS

TRADITIONAL SKILL	SYSTEMS THINKING SKILL	
Static Thinking Focusing on particular events	**Dynamic Thinking** Framing a problem in terms of a pattern of behavior over time	Specify Problem/Issue
System-as-Effect Thinking Viewing behavior generated by a system as driven by external forces	**System-as-Cause Thinking** Placing responsibility for a behavior on *internal* actors who manage the policies and plumbing of the system	
Tree-by-Tree Thinking Believing that really knowing something means focusing on the details	**Forest Thinking** Believing that, to know something, you must understand the context of relationships	
Factors Thinking Listing factors that influence or are correlated with some result	**Operational Thinking** Concentrating on getting at causality and understanding how a behavior is actually generated	Construct Hypothesis
Straight-Line Thinking Viewing causality as running one way, with each cause independent from all other causes	**Closed-Loop Thinking** Viewing causality as an ongoing process, not a one-time event, with the "effect" feeding back to influence the causes, and the causes affecting each other	
Measurement Thinking Searching for perfectly measured data	**Quantitative Thinking** Accepting that you can always quantify, though you can't always measure	
Proving-Truth Thinking Seeking to prove models to be true by validating them with historical data	**Scientific Thinking** Recognizing that all models are working hypotheses that always have limited applicability	Test Hypothesis

you're honest, you'll see that you never really had that anyway—even with the so-called "hard" variables.

SCIENTIFIC THINKING. The final systems thinking skill is Scientific Thinking; its opposite might be called Proving-Truth Thinking. To understand Scientific Thinking, it is important to recognize that progress in science is marked by discarding falsehoods, not ascertaining "truth." The current prevailing wisdom is always regarded as merely an "entertainable hypothesis," just waiting to be thrown out the window. On the other hand, too many business models are revered as truth and defended through recourse to statistical "goodness-of-fit" tests.

Seasoned systems thinkers continually resist the pressure to "validate" their models (that is, "prove truth") by tracking history. Instead, they work hard to become aware of where their models cease to be useful for guiding decision-making, and to communicate this to their clients. "All models are wrong," said W. Edwards Deming. "Some models are useful." Deming was a smart guy, and clearly a systems thinker.

In using Scientific Thinking, systems thinkers worry less about outfitting their computer models with precise numbers and instead focus on choosing numbers that are simple and easy to understand, and that make sense relative to one another. They justify doing this because they believe that insight arises from understanding the *relationships* between numbers rather than the numbers themselves. Systems thinkers also pay lots of attention to robustness—they torture-test their models. They want to know under what circumstances their models "break down." They also want to know, "Does it break down in a realistic fashion? What are the limits to my confidence that this model will be useful?"

What does breaking down in a realistic fashion mean? One example is that, if the model builder's business goes "belly-up," the model does so in the same way. When a business dies, cash is probably close to zero, employee head count is reduced, accounts payable are high, accounts receivable low, etc. There's a whole set of variables in a real business whose behavior patterns and interrelationships show an internal consistency. To judge the robustness of your model, ask yourself whether its variables show the same kinds of internal consistency.

The easiest way to sharpen your Scientific Thinking skills is to start with a working computer model and "shock" it. For example, transfer 90 percent of the sales force into manufacturing. Set price at 10 times competitor price. Triple the customer base in an instant. Then see how the model performs. Not only will you learn a lot about the range of utility of the model, but you also are likely to gain insight into the location of that most holy of grails: high-leverage intervention points.

A DIVIDE-AND-CONQUER STRATEGY

As the success of Peter Senge's *The Fifth Discipline: The Art & Practice of the Learning Organization* has shown, systems thinking is both sexy and seductive. But applying it effectively is not so easy. One reason for this difficulty is that there are lots of different thinking skills needed to do so. Also, the skills contrast sharply with the skill set that most of us currently use when we grapple with business issues (see "Traditional Business Thinking vs. Systems Thinking Skills" on p. 8).

By separating and examining the seven skills required to apply systems thinking effectively, you can practice them one at a time (see "Practicing the Skills"). If you master the individual skills first, you stand a much better chance of being able to put them together in a game situation. So, practice . . . then take it to the hoop! ◘

PRACTICING THE SKILLS

SYSTEMS THINKING SKILL	GOOD PRACTICE
Dynamic Thinking	Construct behavior over time graphs; think of events as interesting points in a variable's overall trajectory over time.
System-as-Cause Thinking	Instead of blaming, ask "How could those within the system have been responsible?" or "What could those within the system have done to make it more resilient to external shocks?"
Forest Thinking	Focus on similarities rather than differences.
Operational Thinking	Ask, "What is the *nature* of a process?" rather than "What are all the factors that influence the process?"
Closed-Loop Thinking	Take a laundry list and try to understand how the items on it might influence each other.
Quantitative Thinking	Ask what key "soft" variables have been left out of analyses, and ruminate about the implications of including them in the model.
Scientific Thinking	"Shock" a computer model by drastically changing the values of certain variables, to see how the model holds up.

DYNAMIC THINKING

The first thinking skill in the systems thinking paradigm is Dynamic Thinking. It's first because you must be able to think dynamically in order to use the other six skills. Dynamic Thinking skills enable you to depict your issue or challenge as a set of patterns that unfold over time. A graph over time shows how the variables of interest have changed in the past, how they're doing now, and how you expect them to change over time in the future. Dynamic Thinking thus puts a current situation in the context of where you came from and where you are going.

Though Dynamic Thinking is one of the easiest of the systems thinking skills to master, it does not develop naturally for most people. Static Thinking seems to be the normal default. For Static Thinkers, the starting point for understanding change is where the system is right now; that is, its current state. Static Thinkers tend to see change as "jumping" from the current state to a future desired state—with little happening between the two points. On graphs produced by Static Thinking, often a straight line connects the two dots. For example, Static Thinkers don't consider that a problem might get worse before it gets better, or that the current state might have been preceded by an "interesting" path. The trajectory leading up to the current state, and the unfurling of the pathway from the current state to the future condition, typically don't receive much attention.

THE BENEFITS OF DYNAMIC THINKING

Why embrace Dynamic Thinking? Let's look at some of the problems associated with the alternative and then see what opportunities Dynamic Thinking provides for addressing these problems.

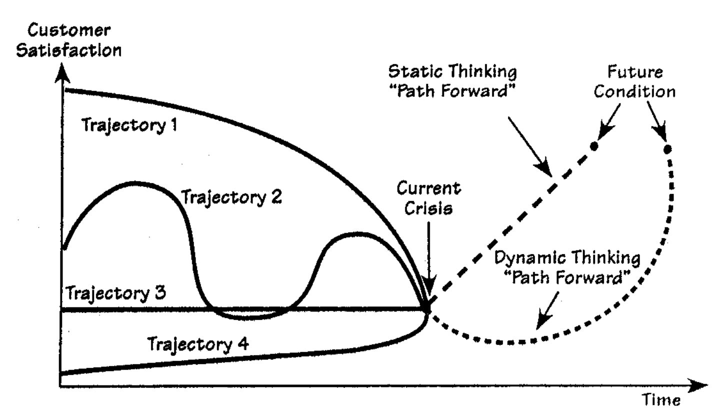
In describing what ails their organizations, people tend to focus on the current crisis—e.g., profit margins are razor thin, the attrition rate is too high, customer satisfaction is in the pits. "Victory" is then defined as boosting profit, lowering attrition, or raising customer satisfaction. This approach, which reflects Static Thinking, has two basic problems.

First, the observation that "customer satisfaction is in the pits" says nothing about the path it followed to get there (see "In the Pits"). As the figure "In the Pits" illustrates, there are several different ways a current crisis point may have been reached. If leaders and managers want to succeed at moving a system from its current state to some more desirable future state, they must investigate the nature of the relationships that brought the system to where it is now—and that may be holding it there! Dynamic Thinking encourages people to use the past to both generate insights and guide inquiry into what produced the current state. The insights that arise from such inquiry can help people design a much more effective change initiative.

Second, like the past, the "path forward" gets relatively little attention in Static Thinking. As the illustration "In the Pits" indicates, people often implicitly project the pathway from "current crisis" to "future condition" as a straight line, assuming that improvement will proceed rapidly, at a steady pace, in one direction. The assumption underlying such a projection is that improvement trajectories can be "engineered"—i.e., that the system is a "mechanism" and hence will passively accept change.

By contrast, those employing Dynamic Thinking skills generally see the "path forward" as nonlinear. Their

IN THE PITS



The trajectories indicate that there are several different ways to reach a current crisis point. Static Thinkers commonly project the path from "currrent crisis" to "future condition" as a straight line. Dynamic Thinkers chart paths that are longer and less linear, incorporating a "worse-before-better" segment.

assumption is that organizations are more like organisms. The system will both adapt to, and resist, change. As a result, the paths forward charted by Dynamic Thinkers are typically both longer and less straight-ahead than those traced by Static Thinkers. In particular, they often show a "worse-before-better" pattern. Such patterns reflect the idea that, to improve a situation, you must first "invest" in order to wrest the system from its current mooring. Investing, in turn, usually implies taking some sort of short-term "hit" before things can start rolling in the right direction. Basically, you must first climb out of the hole you've rolled into. Climbing is an uphill struggle, and sometimes you roll back down. Once you're out of the hole, performance can be improved without the extra drag associated with a steep hill-climb.

HONING DYNAMIC THINKING

The most useful tool for honing your Dynamic Thinking skills is the Reference Behavior Pattern (RBP), which is a behavior-over-time (BOT) graph. A BOT graph is any graph over time with one or more variables. The graph can accurately reflect history or can be a made-up sketch of an anticipated future trajectory. An RBP is a BOT graph usually consisting of only one variable that captures the BOT essence of the issue that you wish to address. Often, the RBP has a historical component ("This is how things have been") and a "to be" component ("Here's how we'd like to see things change").

Developing an RBP at the outset of any performance improvement effort is one of the best ways to focus a group's energy while also encouraging a Dynamic Thinking perspective. Here is an example of how to use this tool most effectively.

DECLINING REVENUES. This example involves a group at a financial services company where the number of cardholders, amount of revenues, and number of transactions were all growing over time in absolute terms. Therefore, RBPs of almost all the company's key measures trended upward. Things got more interesting when the group began looking at *relative* revenue measures. For example, dividing annual revenues by the number of cardholders produced a curve that rose for a few years and then turned *downward* and continued to fall for the last five years. The decline of revenues-per-cardholder suggested that the company was gaining increasingly marginal customers—that is, people who either felt less inclined to use their cards, or who had less discretionary income. Either is a potential sign of market saturation—a common limit to growth "engines."

The time axis you select in defining an RBP is of critical importance. Think carefully about whether the issue of interest is unfolding in minutes, weeks, quarters, or years.

This example indicates something else that's important to remember in constructing RBPs: It often is useful to focus on a relative, rather than absolute, performance indicator. As the previous example shows, "dividing through by cardholders" reveals *relative* changes—which often serve as better stimuli for insights.

The example also makes it clear that the time axis you select in defining an RBP is of critical importance. Always think carefully about whether the issue of interest is unfolding in minutes, weeks, quarters, or years. Electric utility people, for example, "live" with hour-to-hour load fluctuations and associated purchase price swings. But the long-term economic viability of a utility depends on capacity decisions that play out over decades! It doesn't make sense to cast an RBP in hours when you want to examine trends over a number of months or years. Paying close attention to the time units in an RBP is a great way to separate tactical from strategic issues and hence to generate clearer insights about ways to improve performance.

By focusing attention on patterns of behavior over time, Dynamic Thinking encourages you to look more closely at underlying relationships. This thinking skill also directs your attention to the shape and timing of the "path forward," stimulating you to think about the many possible pitfalls that may derail a change effort. By using Reference Behavior Pattern graphs, you can hone your Dynamic Thinking skills. The new perspective that results from this kind of thinking will then establish a context within which you can develop high-leverage improvement initiatives. ◘

SYSTEM-AS-CAUSE THINKING

Use of Dynamic Thinking casts an issue or challenge as a pattern of behavior over time. When effectively constructed, such patterns then prompt us to think about how an underlying set of relationships might be causing the pattern. For example, if a financial services company experiences a rise in the number of cardholders, but a drop in the annual revenue per cardholder, this inverse relationship might lead managers to investigate whether the company was experiencing the effects of market saturation.

The second thinking skill in the progression, System-as-Cause Thinking, can help you determine which underlying set of relationships are most relevant for improving the behavior pattern of interest. In particular, System-as-Cause Thinking holds that relationships that are not under the control of decision-makers within a system should be *excluded* as candidates for hypotheses about what's causing the problem. The only hope we have of improving a system's performance is to focus our efforts on things we *can* control or guard against. Therefore, it makes sense to include only those relationships within our models of the system.

DEFINING THE SKILL

System-as-Cause Thinking is best appreciated when contrasted with its opposite, System-as-Effect Thinking. Adopting a System-as-Effect perspective means viewing a system's performance as the result of a set of forces that lie *outside the control* of decision-makers within the system. A company that sees itself as being "preyed upon" by a larger competitor, subject to the whim of the Fed's interest-rate policies, or the victim of natural calamities would provide a good example of this perspective in practice.

By contrast, System-as-Cause Thinking encourages us to view the system *itself* as the cause of the behavior it is exhibiting. Large, predatory competitors *do* exist, interest-rates swing, and natural disasters do happen. But a company embracing a System-as-Cause perspective would ask: "What are *we* doing to make ourselves smell so much like prey, be so vulnerable to such swings, or put ourselves in the path of a natural calamity?"

System-as-Cause Thinking encourages us to view the system itself as the cause of the behavior it is exhibiting.

Neither the System-as-Cause nor the System-as-Effect viewpoint is "correct." Each can provide a reasonable explanation for a particular behavior being exhibited. However, the two viewpoints carry very different implications for how an organization will operate, and hence fare. For instance, if decision-makers embrace a System-as-Effect viewpoint, they generally operate in a "predict and prepare" manner. Because they believe that outside forces are "doing it to them," they expend lots of energy trying to predict when and where the blow will be delivered, as well as with how much force it will strike. They then position themselves in such a way as to minimize damage. Such decision-makers are predictive, reactive, and defensive.

System-as-Cause thinkers take a different approach. They seek either to alter the relationships that are causing the blow, or to change their internal structure so as to cause the force to have a less destructive impact on them. Such decision-makers are proactive and offensive.

THE BENEFITS OF SYSTEM-AS-CAUSE THINKING

Adopting a System-as-Cause perspective is useful in two important ways. First, as noted above, decision-makers who embrace this perspective perceive themselves as "driving" rather than being driven. They seek actions that might produce desirable behavior patterns, rather than trying to predict which patterns are most likely to "happen to them."

Second, because System-as-Cause Thinking means focusing your model, or hypothesis, about a problem's cause on only those variables that you can control, the resulting models are simpler. And simpler almost always means better! As a result, you can focus your time and energy on actions that you actually can initiate—which are the highest leverage actions there are!

HONING THE SKILL

One excellent way to hone System-as-

Cause Thinking skills is to work consciously at reframing your perceptions of any behavior that has been chalked up to "outside forces." Instead, view the behavior as a result of relationships involving variables that decision-makers within the system *can* control. Probe your organization's history, or pay close attention during meetings, in order to identify cases in which outcomes have been attributed to "uncontrollable forces." Competitors, the government, the economy, foreign markets, nature, and consumer tastes are popular "uncontrollables." See if you can view these outcomes as being caused (or at least exacerbated) by relationships over which people within your organization had some control. Also, ask, "How did we make ourselves vulnerable to dynamics over which we can exert little control?" Such recastings are not likely to win you any popularity contests, and therefore need not be broadly publicized. But they do provide excellent exercises for strengthening your System-as-Cause Thinking muscles.

Another thing you can do is to look at current spreadsheet models. How many of the variables within the models are "drivers," and how many are factors over which someone within the organization can exert some control? Drivers typically include things like interest rates, stock prices, GNP, and industry sales. Whenever a model is "driven" by such variables, the implicit view underlying the model is that "performance is something that happens to us." In most cases, the purpose of such models is to *predict* a particular numerical outcome—like the value of net income, market share, or EVA (economic value added). System-as-Cause Thinking can help you understand how to *influence* that outcome, rather than simply waiting for it to happen.

In practice, it is usually easy to determine which variables are completely beyond the control of decision-makers. The real challenge lies in identifying those variables that are partially under management's control. Making this distinction is key, because the variables over which management can exert some control—even if limited—frequently constitute high-leverage intervention points.

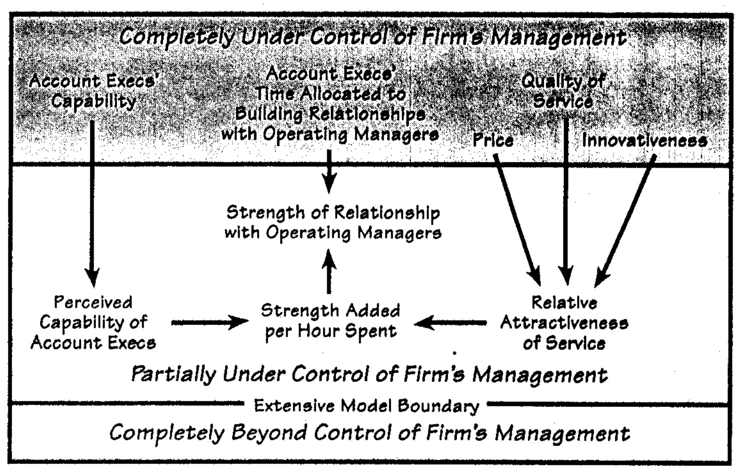
AN EXAMPLE

An information systems (IS) company, serving a large client, easily identified the variables that fell under the complete control of managers within their organization. They also distinguished which variables the client organization could control. However, they found several variables that existed in relationships between the two companies. One example was the strength of the relationships that had been established between account executives in the IS firm and operating managers in the client organization. These relationships were deemed vital to the ongoing success of the IS provider, but also were considered to be outside its management's control.

Using System-as-Cause Thinking, the IS provider found that its account executives indeed had the power to strengthen these relationships—simply by allocating time to the task (see "Segmenting Variables Within a Model's Extensive Boundary"). And determining time allocation lay squarely within the control of the IS firm's management. For example, the increment added to the strength of the relationship that came from each hour an account executive spent with an operating manager depended on the perceived capability of the account executive, the price, and both the perceived quality and innovativeness of the services delivered. All were variables that the IS company could manage. As such, they offered leverage points for shaping the IS firm's future.

The second systems thinking skill, System-as-Cause Thinking, is vital for establishing a perspective of personal responsibility for performance. Using this viewpoint can also help in identifying which variables fall under your control and hence offer potential high-leverage intervention points.

SEGMENTING VARIABLES WITHIN A MODEL'S EXTENSIVE BOUNDARY



Often, variables that lie at the boundary between two organizations serve as high-leverage intervention points because they unlock synergies fueled by both organizations.

FOREST THINKING

The first two systems thinking skills, Dynamic Thinking and System-as-Cause Thinking, help you cast your issue as a dynamic pattern of behavior and focus on those relationships over which you exert some influence. The third of the seven systems thinking skills, Forest Thinking, helps you finalize the breadth and depth that your hypothesis, or model, will have.

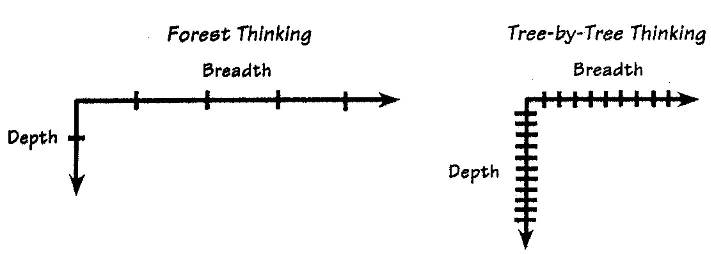
"THE VIEW FROM 10,000 METERS"

Forest Thinking is best thought of as "the view from 10,000 meters." You can liken it to the experience of looking down at the ground while traveling at cruising altitude in a commercial airliner. It contrasts with Tree-by-Tree Thinking, which is a more "natural" viewpoint because of our small physical stature and limited perceptual reach relative to the expansive boundaries of the systems within which we must operate.

For example, when walking in a forest, you generally see trees. Because they tower over you, you usually perceive only one tree at a time (and really only a particular portion of that tree). If you walk often in the same forest, you may become very familiar with the details of particular trees that capture your attention. The more you frequent the forest, the more intimate your knowledge of individual trees becomes.

In organizations, we experience a similar phenomenon. We have difficulty seeing outside the functional, business-unit, or geographic silos within which we operate. Given our small stature and limited perceptual reach, relative to the size of the organization as a whole, we tend to focus on local "trees." Manufacturing people, for example, usually see yields and work-in-process inventories, while finance denizens focus on profit margins and RONA calculations. The longer we operate within a particular part of an organization, the more details we tend to see in the particular surrounding "trees"—and the less perspective we attain with respect to the larger "forest."

FOREST VERSUS TREE-BY-TREE THINKING



Forest Thinking tends to yield broad, highly aggregated models with few variables per relationship. Tree-by-Tree Thinking tends to produce just the opposite—narrow, highly disaggregated models with lots of variables per relationship. In these figures density is represented by hatchmarks on the breadth and depth lines.

Forest Thinking gives us the ability to rise *above* the local trees. It enables us to view the links connecting the different parts of the forest. However, because Forest Thinking gives a broader overview of "the big picture," it also necessarily gives us a shallower view of the organization than we would get from employing a Tree-by-Tree perspective. In addition to helping define the breadth and depth or our perspectives, Forest Thinking helps us determine the *density* of our viewpoints—and resulting mental models.

The figure "Forest Versus Tree-by-Tree Thinking" graphically represents the models that typically result from employing the two types of thinking. As the figure indicates, models developed using Forest Thinking tend to be broader, shallower, and less dense than their Tree-by-Tree Thinking counterparts. An example from the healthcare industry might help illustrate these ideas. A "broad" model would include stakeholder groups defined as, say, doctors, nurses, patients, and administrators. If the model were also "dense," it might include eight different kinds of doctors, four different kinds of nurses, seven categories of patients, etc. In a "shallow" model, each type of doctor would be represented with just a few attributes, such as average experience level, motivation, etc. By contrast, a "deep" model would break one attribute into lots of subattributes. For example, health-practitioner skill level might be broken into medical skills, bedside-manner skills, communication skills, interpersonal skills, etc.

RISING ABOVE THE DETAILS

Mental models that derive from a Forest Thinking perspective help us to rise above the details and craft above-the-silo solutions. Tree-by-Tree

Thinking tends to pull us down deeper and deeper into the "trees" when we're confronting a problem. People embracing this perspective tend to burrow into the details, conducting ever more refined analyses while paying very careful attention to numerical accuracy.

But unfortunately, breaking things down into more detail and increasing numerical accuracy rarely provides the leverage needed to break a logjam in our thinking, identify a high-leverage strategy, or defuse resistance to an organizational change effort. Instead, what we need is exactly the opposite: more synthesis, more knitting pieces together so as to see *new* connections. A Forest Thinking vantage point encourages and facilitates synthesis. By viewing a system "from 10,000 meters," we can see how relationships that may extend far in space or time can be contributing to a local outcome. For example, the problems that manufacturing is experiencing with process yields today may be the result of design decisions made nine months ago way over there in engineering. Investigating the connections between organizationally distinct parts of a system in this way can reveal important new leverage points for positive change.

ELEVATING AND FILTERING: HONING THE SKILL

There are two kinds of skills that make up Forest Thinking capability. The first is elevation, the ability to rise above local space-time surroundings. The second is filtering, the ability to sift out all but the most essential detail.

One of the best ways to develop your *elevation* skills is to start consciously noticing where you currently perceive boundaries to lie in your environment. Then ask: "How do we influence what's on the other side of the line, and how does it influence us?" Boundaries can take the form of assumptions that are creating an unproductively narrow definition of a problem. They also can be the "walls" surrounding a function, business unit, or geographic locale within which you operate. Every environment has imposed boundaries. Make them explicit, consciously transcend them, then explore the new set of boundaries you inevitably encounter. Repeat the process until you achieve an elevation sufficient to give you a whole-system perspective on the problem, issue, process, or organization.

To build your *filtering* skills, look for similarities rather than differences in people, situations, companies, and problems you encounter. This is surprisingly difficult to do, because our human perceptual apparatus apparently is set up to naturally discriminate, make distinctions, and seek differences. And of course, reality is only too willing to oblige. Distinctions and differences abound, providing ample opportunities for us to hone our discriminatory capabilities.

But if you employ a more penetrating gaze, you will discover an equal abundance of similarities. As any good consultant understands, organizations from industries as diverse as financial services and pulp-and-paper share many generic infrastructures and interrelationships—albeit cloaked in superficially distinct outerwear. If you can train your mind to see through the outerwear to the essence, you will also be training it to see what's most important. Seeing in this way helps you create models that are, as Einstein urged, "as simple as possible, but no simpler."

AN EXAMPLE

A senior official at the MBTA, the agency that manages public transportation in metropolitan Boston, had a problem. There had been a sharp falloff in subway ridership. In describing the problem, the official was fixated on one particularly horrendous day (during the height of Christmas holiday shopping) during which several trains broke down in the middle of rush hour.

This MBTA official's mental model of the underlying problem was so narrow, deep, and dense that it was extremely difficult to elevate his sights. His focus was locked on particular engines (he could even cite engine numbers) that needed repair. He could not elevate or filter to the point where he could see that there was a *general* relationship between the average age of the equipment and the likelihood that it would break down. It took concentrated effort for him to see that the trend in ridership had been drifting downward for more than five years. Only then could he accept that leverage for increasing ridership did not lie either in making repairs to particular train cars and rail sections, or in a massive public-apology campaign. The real solution was to put a process in place for systematically monitoring the age of equipment and initiating maintenance and new investments accordingly.

The third systems thinking skill, Forest Thinking, completes the trio of skills you need for defining an effective scope and level of detail for your mental models. Forest Thinking keeps models broad enough to capture the relevant set of relationships, yet shallow and "airy" enough to be cognitively manageable. Such models support the out-of-the-box/above-the-silo thinking needed to reveal high-leverage interventions. ◘

OPERATIONAL THINKING

The first three systems thinking skills help you establish the breadth, depth, and density of your models (be they mental, diagrammatic, or computer-based). The next three skills—Operational, Closed-Loop, and Quantitative Thinking—help you specify the relationships that will reside *within* the boundaries you have established. Let's turn now to the first of these skills: Operational Thinking.

PROCESS VERSUS FACTORS

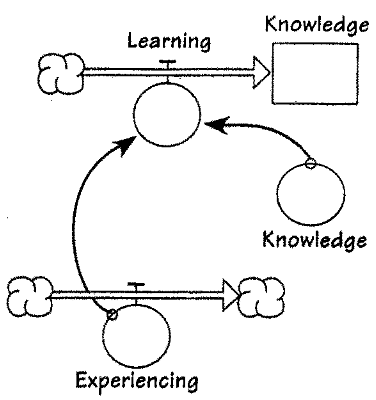
A model designed to forecast U.S. milk production appeared a while back in a well-known econometric journal. In the model, milk production is specified as depending upon GNP growth, interest rates, fertilizer prices, and so on. But nowhere in the model can you find *cows!* Voilà the difference between correlational and operational thinking.

Operational Thinking is one of the most powerful systems thinking skills. Yet unfortunately, it also appears to be one of the most difficult to master. The difficulty arises because the alternative thinking paradigm—Factors, or Correlational, Thinking—is so deeply ingrained. People using Factors Thinking ask "What factors influence . . . ?" or "What critical success factors drive . . . ?" By contrast, those doing Operational Thinking ask, "What *causes* this outcome?" or "How does this activity really work?" The difference here is between thinking correlationally and thinking causally.

The seemingly simple question, "How does learning occur?" provides an illustration of the distinction between the two kinds of thinking. People inevitably hear this question as "What factors influence learning?" They usually respond with a list of things that bear upon learning. Typical lists include motivation, teacher quality, IQ, parental involvement, quality of teaching materials, and so on. But such lists do not describe the *process* of learning (i.e., how it occurs)!

The figure "How Learning Occurs" seeks to portray the process. The diagram assumes that the activity-basis for learning is a stream of experiences. In essence, the causal description of the learning process is: *We learn through experience.* Learning experiences would include such things as reading, doing, listening, conversing, and reflecting. People "take away" or learn a certain amount from each experience. The product of number of experiences and the amount of learning per experience defines the rate at which a person learns.

HOW LEARNING OCCURS



Learning is a flow that is generated by a simultaneous flow of experiencing. Each experience yields a certain amount of knowledge.

THE BENEFITS OF OPERATIONAL THINKING

Thinking operationally has two important benefits. First, it supports more effective communication. Second, it enables you to identify leverage points for improving performance.

Words are notoriously imprecise. This imprecision in turn limits our effectiveness in communicating what we really mean. Because Operational Thinking encourages "telling it like it is," it imposes a substantially higher degree of precision in the use of words and thereby reduces the likelihood of misinterpretation.

To illustrate how thinking operationally can help in identifying leverage points, let's return to our cows. Although the "variable to be forecasted is a function of . . ." approach will work well for predicting the future if historical correlations persist, it does little to reveal actual levers for creating the future. So, for example, if you wanted to increase milk production, you would need to examine how milk is actually produced. Doing so would yield "number of cows" and "milk per cow per year." No amount of rise in GNP per capita or decline in fertilizer prices will produce milk! As a first lever for increasing milk production, you could grow the number of cows (by either stimulating cow births, importing cows from somewhere else, or decreasing the rate at which cows are retired from milk-producing duties). If you elected any of these options, you would have to endure the associated delays (gestation in one case, and logistical details in the other two).

A second set of levers for increasing milk production center on increasing milk per cow per year. Pulling these levers also raises operational issues, such as farmers' financial ability to invest in automated milking technology and the speed with which they can assimilate new animal husbandry practices.

This example illustrates the shift in perspective that operational thinking brings about. Viewing milk production as "driven by" external factors such as GNP is tantamount to assuming that it's something that "happens to you." Seeing milk as being produced by cows causes you to focus on the actual levers that you could manipulate to bring about improved performance.

HONING THE SKILL

The first step in honing your Operational Thinking skills is to become more aware of when you are *not* thinking operationally. When you find yourself or your organization making a list of "critical factors" or "drivers" to explain a particular event or trend, complete that process. Then call a time out and ask, "What really causes this phenomenon? How does it actually work?" You'll be surprised at how often the answer is as obvious as "cows" or "I learn through experience."

In thinking operationally about how something works, look for two categories of "production functions." The first is stock-generated (like the stock of cows that generates milk production). The second is flow-generated (like the stream of experiences that generates learning). Think hard about which kind of production function best characterizes the activity or process you are examining. Doing so will force you to think in operational terms about what's really going on.

AN EXAMPLE

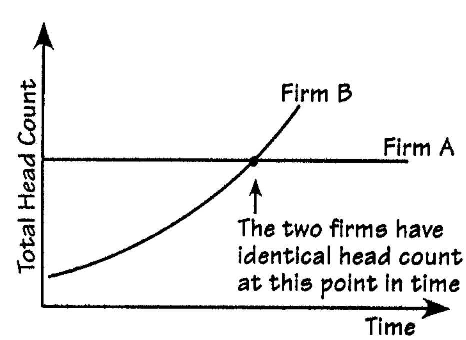
One of today's hottest management approaches, benchmarking, provides a conspicuous example of correlation-based Factors Thinking. In benchmarking, organizations measure a variety of their operating ratios against "best-in-class" ratios to determine where they stand and what they need to improve. The problem with this approach is that operating ratios are not operational descriptions of how a business works. Rather they are statistical calculations that correlate with performance.

For example, a senior VP of a well-known technology company was puzzled by the fact that his organization's human resources department didn't "fit the model"—meaning that the ratio of HR professionals to total head count was significantly higher than "best in class." Even more puzzling was the fact that HR consistently complained of being terribly overworked!

Constructing a simple, operational model of demand for HR services shed significant light on the mystery. The model clearly showed that demand for HR services—for any given level of staffing—could be vastly different depending on the rate at which the organization's head count was expanding. As the figure "The Problem with Benchmarking" illustrates, a firm experiencing rapid growth in head count (such as this VP's company) should expect far greater demands for HR services than an identically sized firm with *stable* levels of staffing. In this light, benchmarking an organization against a *single,* best-in-class standard can be seen as potentially very misleading.

Although the benefits of Operational Thinking are clear, implementing the skill poses a serious challenge for most adults. The reason for this difficulty is that correlationally based Factors Thinking is widespread and deeply ingrained in most of us. But honing your Operational Thinking skills will pay big dividends in terms of your ability to communicate effectively and to identify real leverage points for change. ◘

THE PROBLEM WITH BENCHMARKING



When the total head count for the two firms is equal, Firm A (which has a stable head count) will generate less demand for HR services than Firm B (which is growing rapidly). Thus, the operating ratio of HR professionals to total head count would be higher in B than in A. But, if B is benchmarking against A, B's managers may conclude that their HR ratio is too high.

CLOSED-LOOP THINKING

Along with Operational and Quantitative Thinking, Closed-Loop Thinking helps you specify the relationships within your model. As we saw, Operational Thinking yields the "spinal cord"—i.e., the stock and flow infrastructures—that give a model its shape or structure. Closed-Loop Thinking lets you join the various stock and flow pieces together to form "feedback loops." If Operational Thinking produces spinal cords, Closed-Loop Thinking adds the nerves that radiate signals out to the various parts of the body and that carry signals back to the brain for processing. It's Closed-Loop Thinking that brings "structure" to life, enabling a model's dynamics to unfold.

CHICKEN *AND* EGG: DEFINING THE SKILL

A recent article in the popular press described a study that linked obesity in children to hours of television watched. The study clearly showed that the more hours of TV that children viewed, the higher their body fat content was. The article went on to explain researchers' frustration at not being able to assign causality. Was it that watching TV led to higher body fat because of the associated inactivity and tendency to munch high-fat snack food? Or was it that higher body fat dictated a more sedentary lifestyle? This problem mirrors the old philosophical debate, "Which came first, the chicken or the egg?"

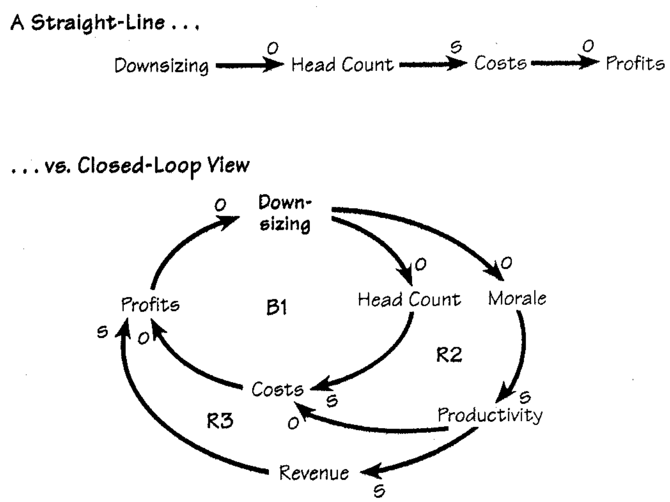
Had the researchers, or the person writing the article, embraced Closed-Loop Thinking, they wouldn't have encountered a chicken-or-egg dilemma. Instead, they would have characterized the situation as chicken *and* egg! Chickens lay eggs, and eggs then produce more chickens . . . who lay more eggs. It's an ongoing circle of causality. The "Which came first?" question reveals a static mind-set, or Straight-Line Thinking, which contrasts sharply with Closed-Loop Thinking.

To someone using Closed-Loop thinking, the issue of which came first is less important than, say, the issues of at what rate the chicken population is doubling, and at what point it will outstrip the resources that support it. In the case of the TV/obesity issue, the question would become, "Regardless of their TV viewing habits, what can we do to reduce obesity in children?" The dynamic, ongoing relationships that sustain obesity, not the force that might set it in motion, become the relevant issue.

The distinction between Closed-Loop and Straight-Line Thinking is profound and very important. Chickens do lay eggs. But that's not the end of the story. Eggs produce more chickens. And, left unchecked, such circular causal spirals can produce all sorts of mayhem.

For example, Straight-Line Thinking gave us "downsizing," under the premise that cutting staff would reduce company costs and hence increase profits (see "Downsizing"). Unfortunately, as many firms discovered, the one-way causality defining this mental model told only the first part of the story. Layoffs did cut costs in the short term. But they also demoralized the workers who remained, as they watched friends depart and fearfully anticipated their own pink slips. In addition, much of the work previously performed by

DOWNSIZING



Straight-Line Thinking gave us "downsizing," under the premise that cutting staff reduces company costs and hence increases profits (B1). But, as the Closed-Loop View shows, the one-way causality embedded in this mental model tells only the first part of the story. Layoffs demoralize the remaining workers, reducing productivity, revenue, and, ultimately, profits—which often leads to more layoffs (R2 and R3).

departed colleagues fell on the shoulders of those who remained—causing further demoralization and sometimes producing burnout.

These unanticipated secondary consequences eventually caused productivity to fall, boosted costs, reduced revenues, and eroded the profitability gains realized from the original downsizing effort. The net change, in many cases, was thus reduced profitability—not the increase suggested by the mental models founded on one-way causality! Worse, because companies often didn't understand the true causality behind their falling profits, lower profitability often prompted them to implement another round of layoffs, reinitiating the downward spiral.

Closed-Loop Thinking means seeing causal relationships in circular terms—as *two-way,* rather than one-way, streets. From this perspective, the Eastern, dynamic notion of "causeffect" supplants the Western, static construct of "cause and effect."

NOTICING UNINTENDED CONSEQUENCES

Shifting from Straight-Line to Closed-Loop Thinking increases the likelihood that you will achieve and sustain the results you intend. The "ongoing-process" orientation associated with Closed-Loop Thinking raises your awareness of unintended consequences. Instead of seeing only the direct consequences of implementing your strategy, organizational change initiative, or process redesign, you'll begin to anticipate unintended outcomes and the associated closed-loop relationships they so often set in motion.

For example, nearly every failed organizational change effort is traceable to a spiral of resistance, often ignited by *unintended consequences.* Typically, these impacts strengthen the credibility of an initially small, but passionate, nucleus of people who are resisting the change. As a result, other people who previously felt neutral about the change begin to join the ranks of the resistors. As these ranks swell, resistors can further intensify their recruiting activity—thereby fueling the backlash. Becoming aware of, and then avoiding, such undesirable unintended repercussions is key to identifying high-leverage interventions.

Because Closed-Loop Thinking helps you stop seeing problems, issues, or situations as things you "fix" once and for all, it also helps you sustain *intended* consequences. Consider personal relationships. As many of us have learned, you don't just develop a strong relationship with someone and then live happily ever after. You must continually work on nourishing the relationship if you want to sustain it. The same is true for teams and organizations—they don't remain "great" just because they once attained this status! Greatness, like the strength of a personal relationship, is something that results from consciously—and continually—nourishing a web of circular relationships.

Most people would quickly cite good people, vision and alignment, strong leadership, and attention to customers as factors that create great organizations. But if a great organization does not continue to attract and retain good people; to evolve, adapt, and realign vision; to strengthen its leaders; and to pay ever-closer attention to its customers, all the reinforcing spirals that produced its greatness will begin to spin in the opposite direction—producing an accelerating collapse.

CLOSING THE CIRCLE

Closed-Loop Thinking is one of the easiest skills to develop because opportunities for honing the talent are so abundant. Just read the headlines or listen carefully to conversations, meeting chatter, and TV/radio dialogues. You'll find Straight-Line Thinking everywhere! When people explain a phenomenon by positing a causal relationship, they usually will identify a cause (frequently more than one) and a resulting effect. You'll hear that video games cause youths to behave more violently, that advertising leads kids to smoke, and that condoms promote sexual activity. You're less likely to hear about the return linkages that make circles: How adolescent predilections for violent activity inspire video game companies to produce more blood-spattering titles; how the money that young smokers pay for cigarettes underwrites the advertising that seduces their friends; or, how the fact that kids are having sex fuels the demand for condoms.

To hone your Closed-Loop Thinking skills, just listen carefully whenever causality is at issue. Begin with the one-way causal link that's being articulated, and then simply close the loop!

Closed-Loop Thinking helps you supply the connections that link stocks with flows to form feedback loops in your model. The shift from one-way to two-way causality moves you from a static to a dynamic or "ongoing-process" view of how the world works. Such a view is critical to identifying high-leverage initiatives capable of both creating and sustaining the consequences you desire. ◘

QUANTITATIVE THINKING

Operational and Closed-Loop Thinking skills help you to structure your models. Quantitative Thinking helps ensure that these models yield reliable results. As we saw in the "Operational Thinking" and "Closed-Loop Thinking" sections, a stock-flow/feedback-loop structure makes explicit your assumptions about how the variables in your model influence one another. Clarifying your understanding of these relationships provides a strong basis for mental simulation. Quantification lets you move beyond mental simulation to the more rigorous testing of assumptions afforded by computer simulation.

But even before you simulate, the discipline inherent in the quantification process itself has important benefits. Specifically, it increases clarity and boosts the level of rigor in the thinking process you are using to build your model. It roots out inconsistencies and ambiguities that might otherwise remain masked beneath the visual facade of a stock-flow diagram. Quantitative Thinking can thus take your systems thinking capabilities to the next level.

ASSIGNING NUMBERS TO YOUR ASSUMPTIONS

Quantitative Thinking means outfitting your structural assumptions with numbers. This comes down to: (1) providing numerical values for constants; (2) choosing initial magnitudes for stocks; and (3) specifying numerical values for graphical function relationships.

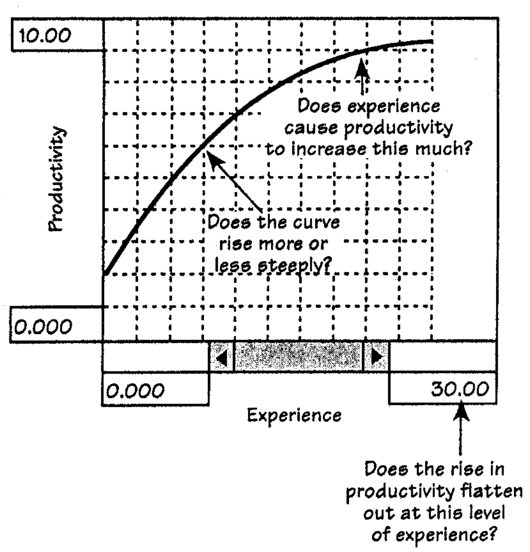
Quantitative Thinking does involve numeration, but not necessarily measurement. There's an important distinction! You can *quantify* virtually anything, but you can *precisely measure* very little. Nevertheless, much time in business is spent "sweating the numbers." Analyses often do not move forward until all the numbers are in and have been verified and reverified for accuracy.

If accurate numbers cannot be secured, the associated variables often are left out of the analysis. Relegated to "second-class citizen" status, they become "factors to be considered," or simply "nonquantifiables."

But can you ever measure, say, the strength of your relationship with a significant other? Can you ever gauge the numerical magnitude of an organization's commitment to a particular change initiative? Is it possible to assign a precise number to a customer's trust or degree of loyalty? Most people would probably answer "no" to all three questions. Yet it *is* possible to quantify such things. Here's one way: A value of 0, in each case, means "none of it." A value of 100 means "as much as it's possible to have." Numbers between these extremes also have a conceptually rigorous meaning.

Quantifying offers substantial benefits. But before elaborating on them, it's worth pausing to consider whence the passion for numerical precision emanates. Clearly, this enthusiasm is rooted in the Western scientific tradition, where the credo is: *To know, one must accurately measure.* But the real driving force behind the thirst for numerical accuracy probably springs from a deeper, less intellectual, need: the desire to feel "in control." We tend to feel "out of control" when we can't predict the future. Precise numbers therefore become something we feel we must have in order to accurately forecast what the future will bring—and in so doing, restore our sense of control.

SPECIFYING GRAPHICAL FUNCTION RELATIONSHIPS



Experience is quantified in years, from 0 to 30. Next, a group would ask: How does productivity grow with increasing years of experience? In this illustration, productivity of a fully experienced, 30-year veteran is assumed to increase about 4.5-fold over a complete novice (0 years' experience).

Unfortunately, no one has succeeded in translating more precise numbers into more accurate predictions. Even if someone managed this, any actions they took as a consequence of the resulting clairvoyance would alter the very future they had just finished predicting! This, in turn, would only serve to re-create the uncertainty they were seeking to avoid! Systems thinking's antidote to this irony is to develop System-as-Cause Thinking skills. As we saw, the essence of the System-as-Cause perspective is that we can feel more in control by understanding the relationships that govern a system's capacity to respond and adapt than we can by laboring to predict the future.

IDENTIFYING LEVERAGE POINTS FOR CHANGE

By yielding improved model structures—prior to simulating—and also by enhancing the reliability of simulation results, quantifying increases the likelihood of discovering effective leverage points for change.

Before simulating on a computer, you produce a set of numbers and some numerically specified relationships. Doing so increases the level of rigor in your thinking process, yielding a more operational and internally consistent model structure. For example, quantification discussions often reveal that one or more elements in a stock-flow chain have inconsistent time units or units of measure. Such dimensional inconsistencies (e.g., product quality flowing into a stock of customer satisfaction) or inconsistencies in time units (e.g., one flow in units/hour, another in units/week) often reveal inconsistencies or differences in the mental models underlying the stock-flow structure.

Specifying graphical function relationships also can help surface and resolve implicit differences in mental models (see "Specifying Graphical Function Relationships"). For example, while discussing "learning curves," people usually agree that productivity rises as experience accumulates. However, deep disagreements can emerge as to how quickly it rises, or what maximum will be achieved.

Quantification can also pay big dividends during simulation. Without quantifying, we must rely on mental simulation to identify leverage points and derive solutions. Add quantification and a computer can help.

Computer simulation always "tells the truth" about what dynamics are implied by the set of structural assumptions in your model. This does not mean that the simulation results will bear any resemblance to what will actually occur in the real system. But it does mean that the results accurately reflect the structural assumptions that have been made—something that cannot be rigorously verified through mental simulation.

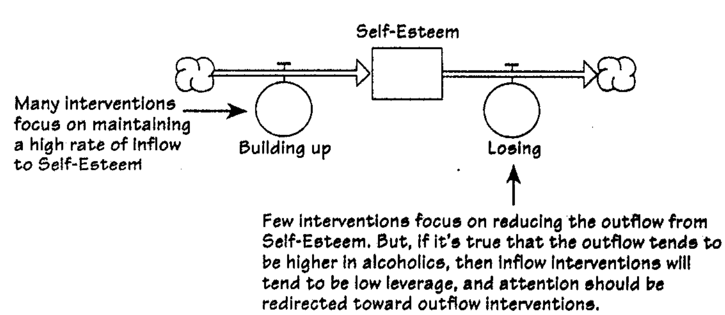
For example, through the quantification of self-esteem, computer simulations revealed a high-leverage intervention point in the field of addictive behaviors that had not been previously identified by researchers (see "Self-Esteem Intervention").

HONING THE SKILL

You can develop your Quantitative Thinking skills to a degree without working with computer-simulatable models. However, to refine the skill, computer simulation is essential. Here's a valuable exercise that does not require a computer but that can prepare you for computer simulation: First, select any two-variable relationship. Make one variable the "driver" of the other, and place it on the horizontal axis of a grid. Then, place the "driven" variable on the vertical axis. Next, determine a numerical scale for each axis. Finally, sketch in a curve that you feel captures the relationship between the two variables. For full value, do the exercise with a group! You'll be amazed at how much light the resulting, highly focused discussion will shed on the relationship in question.

Quantitative Thinking is an important step along the continuum of rigor in your thinking. Virtually anything can be quantified, though only a few things can be precisely measured. The discipline associated with the quantification process leads to much sounder models—even if no precise measurement is involved. The process also yields models that can be simulated on a computer—leading to results you often can feel more confident about. ◘

SELF-ESTEEM INTERVENTION



Oftentimes, as in this example, depicting structure using stocks and flows greatly facilitates identification of high-leverage points.

SCIENTIFIC THINKING

The first six systems thinking skills are best used while you are constructing models. The final skill, Scientific Thinking, is most applicable *after* you have constructed a model. Scientific Thinking is vital for ensuring that models deliver on their ultimate promise: to help build a better, shared understanding of a system for the purpose of improving its performance.

TESTING MODEL STRUCTURE AND ROBUSTNESS

Science proceeds by discarding falsehood, not by proving truth. Yet much of the effort surrounding models used in organizations—whether the models are of the mental or the more formal, mathematical variety—seeks to prove that a model is "true." People use statistical techniques to demonstrate how closely a model's outputs track actual historical results. A close match (or "fit") between model-generated and actual data is used to establish the "validity" of a model. We can think of the mindset behind this widespread approach to validation as Proving-Truth Thinking. By contrast, Scientific Thinking seeks to systematically build confidence that a model is useful for developing insights into how to improve performance.

Rather than leading to statistical tests that measure "goodness of fit," Scientific Thinking involves testing two other qualities of a model: face validity, which relates to model structure, and robustness, which has to do with model behavior. Face-validity tests assess how well the structure of a model matches the structure of the reality the model is intended to represent. For example, does the way decisions are made in the model reflect the way they are made in the real system? Do the physical infrastructures in the real system, such as supply chains and customer categories, have corresponding infrastructures in the model? Does the model capture the key perceptual and physical delays, such as the time it takes the market to recognize a change in the quality of a product, that characterize the real system?

Robustness tests assess how realistically a model behaves when subjected to extreme conditions. The question is always: Does the model exhibit behavior that the real system would exhibit under similar conditions? If not, the model lacks robustness.

THE BENEFITS OF SCIENTIFIC THINKING

If we can establish that the elements and relationships that make up the structure of a model coincide with same in the real system, and that the model generates patterns of response that parallel those exhibited by the real system, then we know that the model looks and behaves somewhat like the reality it is intended to represent.

In addition, differences between the model's structure and response patterns, and those of the reality it represents, can actually be valuable. Such differences suggest where the limits to our confidence in the model should lie. Showing that a model closely "tracks history" cannot provide the confidence that comes from matching its look and response to reality.

So what else does embracing Scientific Thinking buy us? To fully answer this question, we must understand what Proving-Truth Thinking is intended to deliver, and how it goes about trying to deliver it. People who embrace the "goodness of fit" approach to model validation hope that a model that tracks history well will also predict the future well. The presumption is that, with knowledge of "what will happen," the organization can prepare some sort of response that will let it capitalize on future events.

Unfortunately, there is a large fly in the predict-and-prepare "ointment." Virtually all models that are designed to forecast the future assume that the relationships that have governed historical performance will continue to exist and operate in the same way in the future. But if the organization intends to use the forecast to prepare a response to future events, that response itself (by definition) will produce a change in the relationships that have operated in the past! Once such a change occurs, the historical correlations no longer exist—thereby rendering invalid the statistical bases for the forecast.

Scientific Thinking offers a way out of this trap because, rather than seeking to *predict* the future, it seeks to identify levers for *creating* the future. For example, using robustness tests to evaluate the causal relationships governing an organization's performance under stress can reveal leverage points that often remain masked during "normal" times. And, models that show a high degree of correspondence between their structural relationships and those operating in reality can suggest new patterns of performance that may emerge after we implement changes to prevailing relationships.

HONING THE SKILL

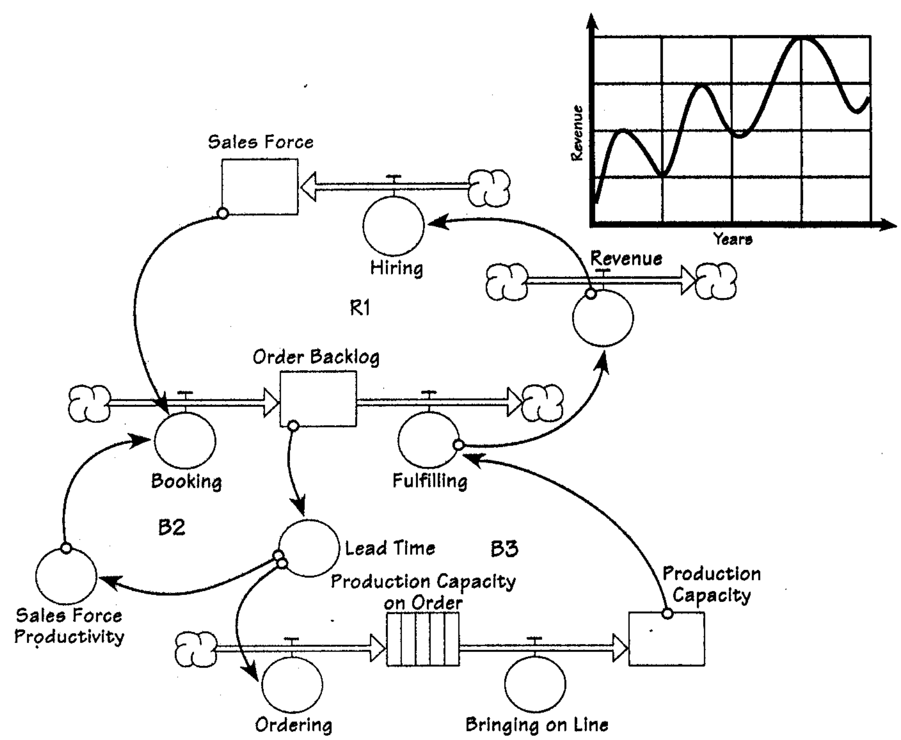
Perhaps the best way to sharpen your Scientific Thinking skills is to revisit the battery of spreadsheet or regression analysis–based models that constitute the analytical artifacts of most organizations' planning efforts. Begin by taking a closer look at the structural relationships within these models. Do they contain a representation of how key decisions are made? If so, does the representation reflect how these decisions are *actually* made, or has some theoretical (usually "optimizing") assumption been invoked? Does the model take into account real constraints to the decision-making process—such as limited time, limited budgets, limited information, delays, and distortions? After examining a model's structural assumptions, try subjecting it to a few robustness tests. For example, discharge half the employees, cut competitor price to 10 percent of yours, double the cycle time associated with some key process, or reduce the overall level of economic activity by 50 percent. Do the resulting model-generated behavior patterns make sense? If not, why not? If yes, what can you learn?

AN EXAMPLE

One of the best products of Scientific Thinking is a model constructed in the 1960s by Jay Forrester. Insights provided by the model continue to be highly relevant to companies today—even those in emerging industries such as telecom and e-commerce. A simplified representation of the basic model's structure appears in "The Structure of the Market Growth Model." This model does not rely on specific numerical data from any particular organization, nor does it track history. Rather, it generates a generic pattern of "growth with repeated crises" that has characterized the actual performance of high-fliers in industry after industry. The model also reveals some counterintuitive leverage points for flattening these downturns. For example, one analysis using extensions of the base model suggested that pricing policy could serve as a key intervention. When told this, most executives—given the opportunity to "play with" price—cut it. However, as the model shows, doing so actually exacerbates the instability, leading to sharper downturns! Under many circumstances, leverage lies in judiciously increasing price—a decision that leads to both higher profits and greater market share.

Scientific Thinking helps us to shift from a "predict-and-prepare" mindset to a "what can we do to improve performance under a range of possible conditions?" view of the world. Consistent with the thrust of the previous six thinking skills, Scientific Thinking focuses responsibility for performance on those within the organization rather than on "outside forces" over which we have little control. ◘

THE STRUCTURE OF THE MARKET GROWTH MODEL



The market growth model consists of three loops: a reinforcing loop (R1) that drives growth and two balancing loops (B2 and B3). The dynamic interplay of the three loops produces the "growth with repeated crises" pattern of behavior over time depicted in the graph.

INDEX TO THE SYSTEMS THINKER

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