FEATURE

The End of Economic Expansion Requires Compression Thinking

by Robert W. "Doc" Hall

Global crises are squeezing us from all directions, and with or without our participation, change will occur. To implement the sort of changes that will allow civilization to prevail rather than merely endure requires a resourcefulness and ingenuity beyond any the world has ever employed. In this article, Doc Hall introduces the concept of "Compression" as an invitation to learn more effectively both as individuals and organizations, rethink our perpetual devotion to old ideals, and welcome the shift in thinking that must be our first and immediate step.

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TOOLBOX

Core Resources of Paradigm-Change Facilitation

by Christoph Hinske

Large-scale problems require paradigm-shifting change processes. Whether facilitators are tackling climate change, organizational transformations, poverty reduction, or ecosystem degradation, they must be capable of partnering with others to lead fundamental shifts rather than simply surface-level fixes. "Paradigm-change facilitation" is a body of work aimed at identifying, illuminating, and accessing the inner stances and core abilities that allow us to realize transformational processes together.

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Modeling for What Purpose?

by Jay W. Forrester

Models are present in everything we do. One does not have a family or corporation in one's head. Instead, one has observations about those systems. Such observations and assumptions constitute mental models, which are then used as the basis for action. System dynamics models have little impact unless they change the way people perceive a situation. They must relate to and improve mental models if they are to fill an effective role.

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THE END OF ECONOMIC EXPANSION REQUIRES COMPRESSION THINKING

BY ROBERT W. "DOC" HALL

The term "Compression" refers to the end of economic expansion as we currently know it, that is, ongoing growth enabled by the practices of the Industrial Revolution and powered mostly by fossil fuels. High-consumption industrial societies created many benefits we'd like to keep, but also huge problems that we cannot put off dealing with. To respond effectively to the "squeeze" we've put on the Earth's resources and ecological viability, we also need to "compress" our work processes and products to make them less wasteful of human and natural resources. To meet these challenges, our organizations will need to engage in high rates of learning and achieve unprecedented levels of performance. The key to this major revolution is within each of us.

Our 21st-Century Challenges

In an age of Compression, all of these forces act at once. To get our minds around the enormity of this fact, not only do we need systems thinking, we need a system for systems thinking. This kind of thinking is not normal in today's organizations. We have to learn it, and to learn it, we have to practice it.

Without taking a systems approach, well-intentioned, intelligent people grab for magic solutions to our environmental messes, such as seeding the oceans with iron to sequester carbon, creating sulfuric clouds in the sky to reflect solar heat, or pumping CO_2 into the ground for storage. Because they have faith in technology, they jump on these ideas, seemingly unaware that the unintended consequences of such actions could be catastrophic. But it's easy to see how each of these actions could backfire. Most of our messes today are the unintended consequences of past "solutions."

Global Objective in Compression

To begin to approach this confluence of issues more systemically, we propose setting a measurable baseline objective:

By the year 2040, create a quality of life around the globe that is equivalent to that of today's industrial societies while consuming less than half the energy and less than half the virgin raw materials as were consumed in the year 2000, with near-zero toxic releases.

OUR 21ST CENTURY CHALLENGES

The figure shows an arbitrary classification of our 21st-century challenges: Finite Resources, Precarious Environment, Excessive Consumption, Pushback from the Have-Nots, the inability to address the foregoing complex challenges without Self-Learning Work Organizations, and Complexity. These challenges are all interconnected. Each covers more sub-categories than anyone can fathom.

The circle at the center represents self-learning organizations, needed to cope with the big global challenges imperiling us and arbitrarily categorized in the other four circles. Black–Impending global shortages of petroleum, water, rare earths, phosphorus, maybe even arable soil. Green–An environment made precarious by a long list of threats from coral reef bleaching to endocrine disruptors; climate change is only one aspect. Yellow–An economic system in industrial societies that fosters excess consumption of resources. Red–Pushback from people displaced or left out of the current system for using global resources (resource wars, crowded third world slums, etc.).

To achieve this objective, people in both advanced and less-advanced economies must learn to make much better use (and reuse) of resources. The truth is, though, that these standards can't be uniformly applied to every part of the world. Those barely surviving can hardly consume less than they currently do. Because industrial economies consume significantly more materials and energy than other

economies, the cuts in those regions need to be deeper. Fortunately, they also have more innovative technological research with which to meet this tough goal. These kinds of initiatives are starting to become reality, not vague hope. For example, several years ago, the British Parliament enacted the Climate Change Act of 2008, setting timetables toward an 80 percent reduction of greenhouse gas emissions by 2050.

Of course, to achieve these goals, we need to go beyond basics like reduce, reuse, recycle. We currently have too few inventive, innovative organizations with business models that allow them to be viable while processing less material and energy, not more. A transformation is unlikely to occur by gradually raising performance bars through regulation, with governments coercing the reluctant to meet minimum standards. Instead, we need to create what I call "Vigorous Learning Enterprises."

Vigorous Learning Enterprises

What is a Vigorous Learning Enterprise? *Vigorous* implies that an organization "does" something. It's not strictly academic or social. Those most critical are in mining, agriculture, food processing, manufacturing, utilities, healthcare, police, fire, justice, and so on. They either process large amounts of energy and material (and are thus gatekeepers of our consumption), or they provide services that are crucial to the quality of life. A rough estimate is that 30-40 percent of the American workforce is engaged in such work—a high percentage, but not everyone.

Learning is the act, process, or experience of gaining knowledge or skill. In an organizational setting, it includes process learning, innovation, and organizational learning.

Enterprise is used in many senses, but the intent here is analogous to the supply chain: several tiers of customer organizations going out and several tiers of suppliers feeding in, plus feeder educational institutions, consultants, advisors, banks, auditors, and the like.
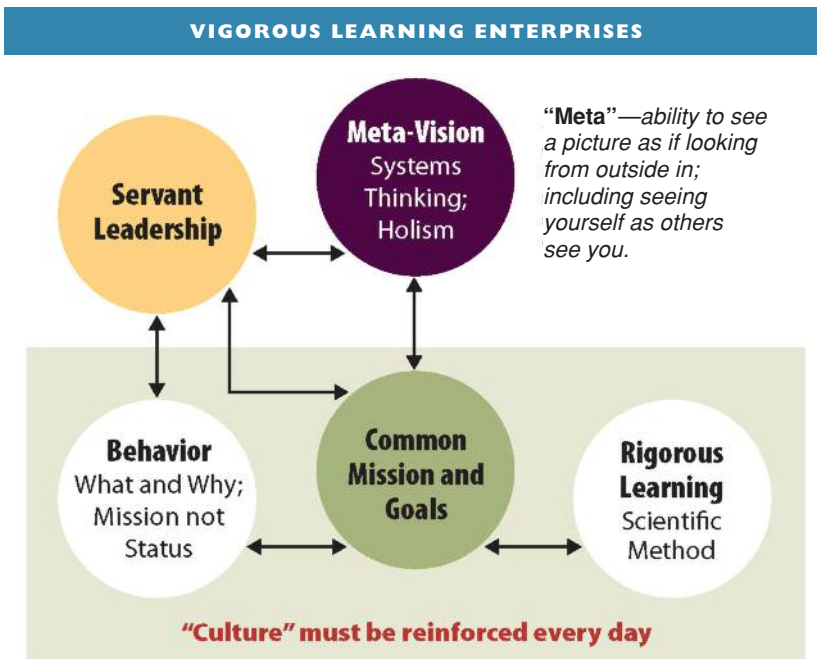
Here are some principles and practices for Vigorous Learning Enterprises:

1. They are mission-driven. Serving a social need or mission has to trump all other objectives, including growth, profit maximization, job creation, and personal aggrandizement. The turning point for leaders is realizing that their organization must support nature; nature does not exist to support or enrich them. That shift changes the emphasis from what we *get* to what we *do*. The actions by BP and other companies involved in the Gulf oil blowout illustrate why this change in focus is important. Attempting to limit liability—the basis of corporate charters—is a dysfunctional way of dealing with such problems.

2. They look at their physical processes. When we move away from focusing on what we *get*, we can more objectively look at physical processes: how our customers act, what our workers do, and how our business models operate. When we identify our primary customers' real needs, we recognize that anything else is waste. Lean thinking identifies waste as what a customer will not pay for. In Compression Thinking, we go a step further and identify waste as any unnecessary use or destruction of resources, things that nature should not have to "pay for."

3. They expand their cognition (meta-vision). By expanding our view, we can both improve local processes and anticipate effects far removed in time and distance.

4. They extend the concept of "waste." The concepts of eliminating waste that are a part of lean today are typically confined to a few elements of

VIGOROUS LEARNING ENTERPRISES

Meta-Vision Systems Thinking; Holism

Servant Leadership

"Meta"—*ability to see a picture as if looking from outside in; including seeing yourself as others see you.*

Behavior What and Why; Mission not Status

Common Mission and Goals

Rigorous Learning Scientific Method

"Culture" must be reinforced every day

Vigorous Learning Enterprise features are an amalgam of best practices seen in real organizations over a 20-year period.

• Meta-Vision, or keen, broad system insight, especially by leaders.

• Common mission and goals related to Compression, that unifies effort.

• Systems and structure for rigorous learning built into regular work for everyone, not for just a few people.

• Behavior for learning; ability to subdue personal infighting to concentrate on problems and issues.

• Servant leadership, putting the mission, organization, and development of it people before personal gain or ego.

All this is possible, but so contrary to instinct that this culture needs a built-in mechanism that reinforces behavior almost daily.

operations and never applied to full life cycles. By expanding the definition of "waste" to include materials, energy, space, and unproductive behaviors, we can define elimination of waste as doing whatever is necessary by the lowest energy process we can devise. Low energy use is usually associated with low use of all resources.

5. They value quality over quantity. This new kind of organization values quality over quantity; provides service, not promotions to buy more "stuff"; does it right the first time; and emphasizes prevention over remediation. As Yogi Berra might say it, "Fix it before it happens."

6. They avoid "model myopia." We need to learn to look at what really goes on in our organizations without the prejudice of model blinders, including all the financial ones. We've hitched our guidance systems to obsolete measurement models. Even customer-centered lean operations typically conflict with accounting models. Physical measurements of what we do are far from perfect, but they beat self-referencing measures based only on human valuations, which is what market-derived dollar measures have been.

7. They develop rigorous structures for learning. Systems structured on the basics of the quality movement are a good start, but few manage to spread throughout the entire organization. Also, sustaining the behavior is challenging, especially when issues are "wicked," meaning that people perceive them from different tunnel visions or conflicting spheres of interest. To make a new culture "stick," the organization needs codes of conduct with daily reinforcement built in, or human nature will take over and undermine the system. In this sense, we're really trying to elevate our level of civility, at least in our work settings.

8. They create "tribal cohesion." We must create a sense of cohesion—trust and confidence—across work enterprises, including suppliers and customers, while minimizing "tribal rivalries." These arise from more than ethnic and religious differences. They include functional silos, intellectual property divides, and races for reward and recognition. Rivalry and competition are instinctive, but cohesion is vital for true information sharing to occur. Everyone has to be confident that all share a common allegiance to a universal mission. No working organization today functions at the level of a vigorous learning enterprise, but some of our best organizations have mastered big chunks of the skills and culture required. These rigorous organizational cultures demand the highest levels of professionalism. Is this impossible? No. Is it difficult? Yes.

New Business Model

One of the most counterintuitive aspects of coping with Compression is the need to rethink the business model so that an organization can be viable without focusing on selling more, more, more. DTE Energy (Detroit) is one of the more aggressive utilities in helping customers reduce their energy usage. By doing so, the company reduces costs for its clients, many of whom are struggling financially, and eliminates the need to expand its energy capacity. An overview of how DTE helps customers save energy is available at www.dteenergy.com/businessCustomers/saveEnergy. PortionPac Chemical in Chicago also has a business model that foreshadows those of the future. PortionPac primarily produces cleaning chemicals, but it sells few of these products directly. Instead, it provides service contracts, so customers pay for clean buildings, not cleaning products per se. After signing on a customer, PortionPac trains the client's cleaning personnel in methods that are designed to minimize the use of detergents and other chemicals. (Excess cleaning chemicals are a major source of problems for sewage plants and of pollution in waterways.) Over six months or so, a new client's use of cleaning chemicals usually drops by 40-50 percent. The less product PortionPac ships, the higher the margin it earns on the service contract.

This approach makes conventional business sense, but PortionPac is also on a mission to increase the respect given to cleaning personnel, who are usually poorly paid and whose role in an organization is often ignored. The goal is for cleaning personnel to contribute to reducing or eliminating the pollution a company generates, and thereby reducing the pollution of whole cities or regions. Cleaners see what others don't, so PortionPac can help clients examine their waste streams to see ways to reduce waste of materials and toxic releases.

DTE Energy and PortionPac are on the way to becoming Vigorous Learning Enterprises. By placing a strong emphasis on developing people and, in turn, expecting extraordinary performance, these organizations clash with current assumptions both for business and government.

Mission First

Think of the organization's primary purpose as performance to mission, not maximizing profit, soaking up employment, serving as an owner's personal fiefdom, or other ulterior motives. Making this shift is obviously the big hurdle. However, transforming working organizations, as wild as that idea may seem, has more promise than trying to shift public policy. Working organizations are not democracies, with everyone doing as they please. For good or bad, companies, nonprofit hospitals, and military units are disciplined organizations.

People's behavior changes when the environment in which they function changes. If companies change what they do and how they do it, the working culture slowly changes with it. No other avenue of social change seems to offer this possibility.

But to spearhead such a change, leaders of a working organization must absorb the thinking and work on a sequence of change that moves the company in a direction that can deal with Compression. Leaders start with themselves, becoming role models of the discipline and behavior they expect from others. That's servant leadership, not status-based leadership. Probably the most succinct description of servant leadership comes from the military: Mission first. Troops second. Me third.

Sometimes control-oriented leaders of no-nonsense organizations regard concepts and methods for open dialogue and self-initiative as "permissive management." But a Vigorous Learning Enterprise is the opposite. Leaders demand that all employees develop themselves, individually and collectively, into the very best of what they are capable. Leaders become teachers, mentors, and role models—rather than central decision makers who stand in the way of learning—to create a top-performance organization.
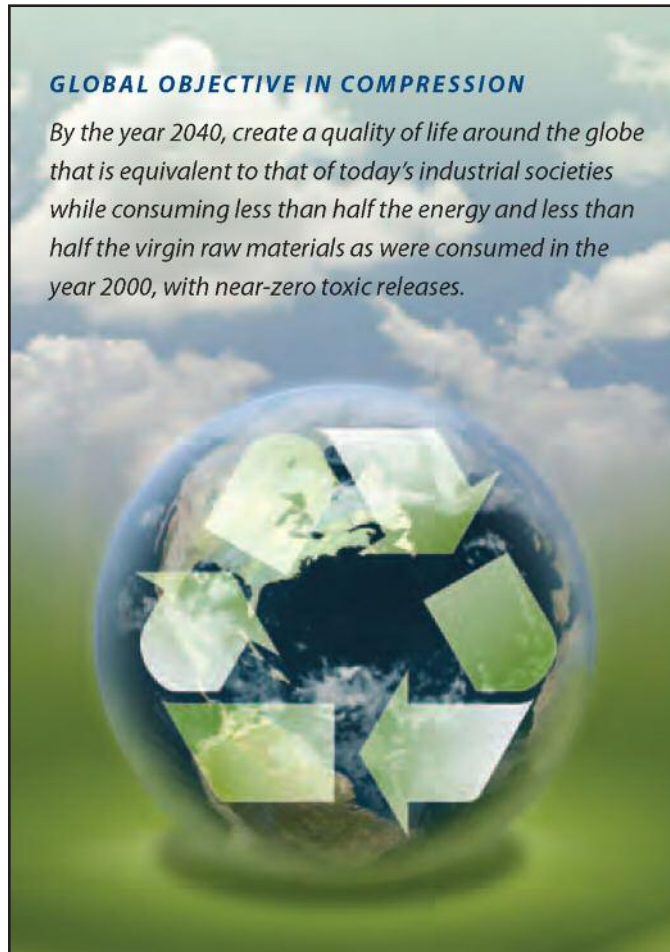
> **Leaders become teachers, mentors, and role models—rather than central decision makers who stand in the way of learning—to create a top-performance organization.**

The human challenge—rapidly changing ourselves and our organizations—is the greatest one we face, but it's the key to meeting all other challenges. Compression compels us to have same spirit of the race to put a man on the moon, but with a lot more of us actively participating in this common mission. This time, the stakes are even higher. ◙

Robert W. "Doc" Hall is the author of *Compression: Meeting the Challenges of Sustainability Through Vigorous Learning Enterprises* (Productivity Press, 2010), Professor Emeritus, Indiana University, and one of the founding members of the Association for Manufacturing Excellence. To learn more about Compression, visit www.compression.org.

GLOBAL OBJECTIVE IN COMPRESSION

By the year 2040, create a quality of life around the globe that is equivalent to that of today's industrial societies while consuming less than half the energy and less than half the virgin raw materials as were consumed in the year 2000, with near-zero toxic releases.

CORE RESOURCES OF PARADIGM-CHANGE FACILITATION

BY CHRISTOPH HINSKE

Large-scale problems require paradigm-shifting change processes. Whether facilitators are tackling climate change, organizational transformations, poverty reduction, or ecosystem degradation, they must be capable of partnering with others to lead fundamental shifts rather than simply surface-level fixes. For more than a decade, I have worked with and studied the capacities required for leading this kind of change, culminating in my graduate work in global change management, in which I interviewed successful pioneers in this work in the US and Germany (see "Research Process").

These pioneers helped me formulate responses to four questions:

1. How can we enable people to enact fundamental change?

2. How can we liberate the enormous possibilities that global change processes offer?

3. How can we change ourselves in order to be authentic when facilitating these paradigm-shifting processes?

4. How can we shape our organizations toward higher performance?

I will characterize the sum of these responses as "paradigm-change facilitation," a body of work aimed at identifying, illuminating, and accessing the inner stances and core abilities that allow us to realize transformational processes together. Although this process is highly specific to each person and situation, we can generalize the steps (see Paradigm-Change Process).

The four steps for supporting fundamental change are:

Accessing—access our inner resources and the individual parts of the system

Interrelating—study and/or create interrelationships among those parts

PARADIGM-CHANGE PROCESS

1—ACCESSING

2—INTERRELATING

3—LEARNING

4—INSPIRING
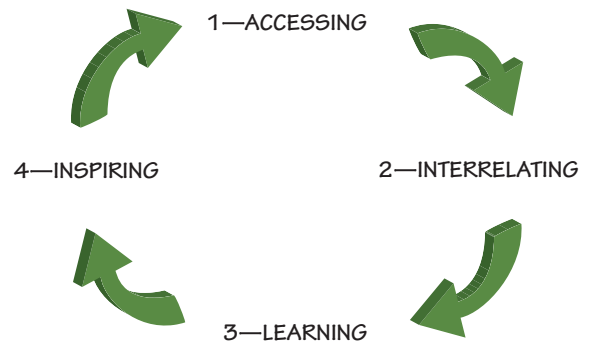
Real transformation starts with the ability to make paradigm changes within ourselves by following an iterative, four-step process.

TEAM TIP

To fundamentally change the system you are in instead of making surface-level fixes, you and your team members must reinvent yourselves at every moment based on the inner stances and core abilities described in this article.

Learning—learn to be changed by the parts and their interrelationships

Inspiring—dissolve ourselves into the system and change it from within by starting to ask for and listen to its essence

Inner Stances and Core Abilities

I define "inner stances" as the mindset and attitude with which one approaches a particular situation. These filters shape the logic behind our daily actions. They shape the way and the intensity with which we relate to others as well as to the content within which we're operating. I define "core abilities" as the skills, methods, and tools used to create a setting where paradigm shifts are likely to happen—a setting in which entirely new ideas, intentions, and perspectives come into reality.

> I define "core abilities" as the skills, methods, and tools used to create a setting where paradigm shifts are likely to happen.

Before I describe these inner stances and core abilities, I invite you to take about three minutes to reflect on four questions. To do so, you will need to imagine that you are in a position to facilitate a paradigm-shifting process. You will refer to these answers at the end of this article:

1. What is the inner stance with which I enter the room when I am facilitating a paradigm-shifting process?

2. What inner stance allows me to connect to the other stakeholders?

3. What inner stance enables me to activate and make full use of my innate and trained core abilities?

4. What inner stance allows me to maintain the creative tension as we think out of the box and enact something genuinely new?

In my research, I found that successful, paradigm-changing practitioners seem to have certain inner stances and core abilities:

Inner stances

1. Being present with mindful passion

2. Creating reality out of an attitude of letting go to let come in

3. Knowing that one does not have to merely like but must love and integrate other belief systems

4. Being an interdependent part of our surroundings

Core abilities

1. Learning and perceiving information

2. Creating trusting relationships

3. Enabling a holistic worldview

4. Contextualizing the facilitation process with the characteristics of human development

Experiencing Inner Stances

The first stance, being present with mindful passion, includes a willingness and ability to develop, train, crystallize, and act mindfully out of one's innate purpose. Practitioners who successfully realize paradigm-level change tend to work with a high level of concentration while remaining detached from the situation. Passion brings the focus, while mindfulness reminds the practitioner that there is not just one truth to be defended, rather an infinite number of truths worthy of being integrated. This perspective increases the facilitator's ability to overcome doubts, accept ambiguities, and bridge different opinions.

One way to practice this stance in everyday live is by aligning one's will (intentions) with one's feeling (relationships, emotions) and thinking (cognition) during a facilitation process. I perceive the "O Process" of the Ecosynomics framework as well as the "U Process" of the Presencing framework as powerful approaches to achieve this kind of alignment. They also help to create shared understanding on the levels of willing, feeling, and thinking. By consciously applying the principles of the O as well as the U Process, we can build our ability for authenticity and mindful presence.

The three other stances are letting go to let come in; dislike the system, but love it; and be an interdependent part of it. When we are humble and have a welcoming and loving attitude toward both "enemies" and "friends," we are more likely to see ourselves as learners and not as knowers of the situation. This objectivity and curiosity allows us to serve the process out of a conscientious and exploratory mindset and thus support emergence of a new future.

Letting go of one's own ideas and realizing a loving attitude does not mean that we always have to like our counterparts; we are merely making a

THE CORE RESOURCES FOR PARADIGM FACILITATION		
Process	**Inner Stances**	**Core Abilities**
Accessing	Do not like it, but love it	Contextualizing the facilitation process with the characteristics of human self-development
Interrelating	Being present with mindful passion	Ability to create trustful relations
Learning	Letting go, to let come in	Learning and perceiving information
Inspiring	Being an interdependent part of the system	The art of integrated thinking

conscious decision to embrace their world in a neutral and appreciative way. In the facilitation process, this means not imposing our own ideas or serving any specific interests, but rather fostering a holistic and interrelated awareness toward others and the process. By cultivating this stance, we prevent our self-interest from blocking any emerging possibilities, ideas, or products. This attitude enables the practitioner to ask for and listen to the essence of how the system (and its individual parts) makes sense of the topic at hand.

Experiencing Core Abilities

The first core ability, learning and perceiving information, requires an intrinsic willingness to constantly gain and improve our basic skills. It requires learning, experiencing, and internalizing relevant models, concepts, and tools derived from evidence-based scientific and spiritual levels of human existence. One way to do so is by organizing learner-centered study workshops with colleagues or friends. In this protected space, people are more likely to learn how to apply relevant concepts, theories, and models of change in a way that will *serve* the purpose rather than letting them *be* the purpose of the intervention. In addition, by integrating emotionality and mindfulness, practitioners can find peace and sovereignty in dealing with conflicts and ambiguities.

The second core ability, creating trusting relationships, strengthens the social fabric as a whole. While teaming and trust-building methods support this process, the practitioners I interviewed focused on two main drivers: a sense of humbleness and a high level of self-awareness. Paradigm-change facilitators must remain uninfluenced by power and authority, and be able to relate to and support the individual members of the group, so that they can gain clarity about their own intentions, become a trusted part of the process, and avoid taking action independently.

To build self-awareness, try to sense your own boundaries and limitations. By being clear about yourself and your abilities, gifts, and limitations, you can see the larger system much more clearly. As a result, the practitioner can support the group in understanding its organic structure, different subgroups, and inherent common purpose. I was amazed to find that even though all the practitioners I met were highly experienced professionals, they never perceived themselves as superior to others.

The third core ability, enabling a holistic worldview, requires thinking in interdependencies and grasping how and why different parts of a system come together to accomplish a common goal. In this kind of thinking, no single part of the system alone can achieve the function or purpose of the system as a whole.

Paradigm-change practitioners seek to discover and highlight individual and groups mental models. They bring assumptions to the surface and create a common understanding of reality as it is, not as it is assumed to be. This ability to combine systems thinking with the knowledge of group dynamics helps the stakeholders to appreciate each other's different backgrounds, enabling them to form new agreements and partnerships.

One possibility for cultivating this ability in everyday life is to study and apply systems thinking. To complement this study, practice actively putting yourself in a position of being an "in-betweener,"

In facilitating paradigm change, the practitioner acts as a vehicle for fundamental shifts in thought and action.

switching between different concepts and cultures. For example, go to a meeting or party that doesn't interest you and try to internalize why it may appeal to someone else. Try not to have one fixed viewpoint, but switch, interrelate, and interconnect between different cultures and perspectives. Attempt to develop a feeling for when to apply which model, concept, or tool in order to integrate rather than separate.

The fourth core ability, contextualizing the facilitation process within the characteristics of human development, requires an in-depth knowledge of how people change and grow. It is not enough to understand the concepts; practitioners must also work on their own personal development as well. They need to be able to process knowledge "spatially"—understanding how actions and decisions affect somebody in remote areas—and "temporally"—understanding how actions and decisions will impact people in the near and distant future. To help develop this perspective, the following questions could serve as a daily training: "How many hands has this product I am holding in my hands touched?" "What might those people have done to have this job and what are their dreams for the future?" and "How are those dreams connected to me, the consumer of this product?"

Observations from My Path

I have witnessed many colleagues and close friends involved in paradigm-change processes (see "Case Study" on p. 9). These practitioners gained their diverse working knowledge in leadership and management positions in the three sectors of civil society, economics, and politics. Those who have been successful demonstrated an extraordinarily high level of self-awareness and perceived themselves as global change agents. They participated in facilitation processes with curiosity and humbleness

A global company struggled to maintain its position as a market leader in communication and strategy consulting. Due to lack of new opportunities to develop their full potential, innovative employees, who are the company's main resource, started to leave. Moreover, long-time clients reported that the company's credibility and its innovative spirit had declined. Worse still, the competition in the field increased.

In order to address these challenges, a group of employees was trained to act as internal change agents following the four-step approach of Paradigm-Change Facilitation:

Accessing – By taking adult development tests, team members became aware of their own mental models, biases, and feelings toward their co-workers. They also trained their core abilities. They mapped abundance- and scarcity-based realities as well as the "system of emotional relationships" within the company.

Interrelating – Based on the analysis, the team members created working hypotheses of how to strengthen the existing positive relationships among company employees. They tested those in one-on-one dialogues and small-group discussions.

Learning – Every team member kept a "change diary" to note down the key learnings and their implications. In reflective learning sessions, they challenged their own mental models. By adjusting their hypotheses, they became more open to change themselves.

Inspiring – The change agents transformed their hypotheses into high-leverage intervention points, strategies, and actions. After that, they dissolved themselves back into the system and took part in the proposed actions.

Results of those interventions included a company-wide Innovation Day, new training modules, modified organizational processes, and more of "out-of-the-box" business models, and in turn increased employee satisfaction. Even though the project is still in process, it has already been observed that innovative employees now have more ways to work to their full potential and are thus more likely to remain in the company.

toward the past, present, and future, as well as with regard to the visible and non-visible parts of the system. I have been deeply impressed by their ability to think, feel, and act during an intervention while maintaining a learning instead of a knowing mindset. They demonstrated great rational, emotional, and spiritual skills. All of them showed a good working knowledge of multiple levels of human interaction and personal development concepts. They combined these with the principles and tools of empowerment, trust, mission, and passion.

Coming Back to Your Starting Point

To return to the propositions described above, I invite you to take out your notes from the short reflection you made at the beginning. To what degree do your notes correlate with the four stances and four core abilities I suggest?

In facilitating paradigm change, the practitioner acts as a vehicle for fundamental shifts in thought and action. This approach invites practitioners to understand that they are not using tools and methods to realize change, but that real transformation starts with the ability to make paradigm changes within ourselves. At the heart of this belief is the willingness of all participants in the process to recall the inner stances and core abilities that enable them to reinvent themselves at every moment.

What daily exercises do you take part in to transform your own mindset so you can shape your organization toward higher performance? Here are some practices I learned during my research:

• When lying in bed at night, reflect on how you responded to the situations you encountered, how you learned from them, and how you tried to change the larger context.

• Reflect on the degree to which you are using yourself as a vehicle for change.

• Paint, write, or model the inner stances from which you seek to inspire change in the existing structures.

By following these and other practices, you are likely to improve your ability to lead fundamental change rather than working just on surface-level fixes. ◘

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MODELING FOR WHAT PURPOSE?

BY JAY W. FORRESTER

System dynamics does not impose models on people for the first time—models are already present in everything we do. One does not have a family or corporation or city or country in one's head. Instead, one has observations and assumptions about those systems. Such observations and assumptions constitute mental models, which are then used as a basis for action.

The ultimate success of a system dynamics investigation depends on a clear initial identification of an important purpose and objective. Presumably a system dynamics model will organize, clarify, and unify knowledge. The model should give people a more effective understanding about an important system that has previously exhibited puzzling or controversial behavior. In general, influential system dynamics projects are those that change the way people think about a system. Mere confirmation that current beliefs and policies are correct may be satisfying but hardly necessary, unless there are differences of opinion to be resolved. Changing and unifying viewpoints means that the relevant mental models are being altered.

Unifying Knowledge

Complex systems defy intuitive solutions. Even a third-order, linear differential equation is unsolvable by inspection. Yet, important situations in management, economics, medicine, and social behavior usually lose reality if simplified to less than fifth-order nonlinear dynamic systems.

Attempts to deal with nonlinear dynamic systems using ordinary processes of description and debate lead to internal inconsistencies. Underlying assumptions may have been left unclear and contradictory, and mental models are often logically incomplete. Resulting behavior is likely to be contrary to that implied by the assumptions being made about underlying system structure and governing policies.

System dynamics modeling can be effective because it builds on the reliable part of our understanding of systems while compensating for the unreliable part. The system dynamics procedure untangles several threads that cause confusion in ordinary debate: underlying assumptions (structure, policies, and parameters), and implied behavior. By considering assumptions independently from resulting behavior,

there is less inclination for people to differ on assumptions (on which they actually can agree) merely because they initially disagree with the dynamic conclusions that might follow.

If we divide knowledge of systems into three categories, we can illustrate wherein lie the strengths and weaknesses of mental models and simulation models (see "Three Categories of Information"). The top of the figure represents knowledge about structure and policies; that is, about the elementary parts of a system. This is local non-dynamic knowledge. It describes information available at each decision-making point. It identifies who controls each part of a system. It reveals how pressures and crises influence decisions. In general, information about structure and policies is far more reliable, and is more often seen in the same way by different people, than is generally assumed. It is only necessary to dig out the information by using system dynamics insights about how to organize structural information to address a particular set of dynamic issues.

The middle of the figure represents assumptions about how the system will behave, based on the observed structure and policies in the top section. This

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THREE CATEGORIES OF INFORMATION
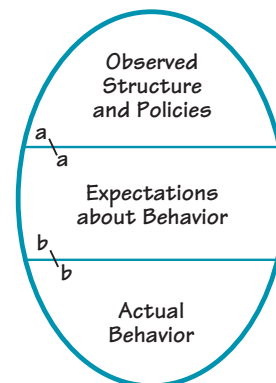
There are three categories of information about a system: knowledge about structure and policies; assumptions about how the system will behave based on the observed structure and policies; and the actual system behavior as it is observed in real life. The usual discrepancy is across the boundary a-a: expected behavior is not consistent with the known structure and policies in the system.

middle body of beliefs are, in effect, the assumed intuitive solutions to the dynamic equations described by the structure and policies in the top section of the diagram. They represent the solutions, arrived at by introspection and debate and compromise, to the high-order nonlinear system described in the top part of the figure. In the middle lie the presumptions that lead managers to change policies or lead governments to change laws. Based on assumptions about how behavior is expected to change, policies and laws in the top section are altered in an effort to achieve assumed improved behavior in the middle section.

The bottom of the figure represents the actual system behavior as it is observed in real life. Very often, actual behavior differs substantially from expected behavior. In other words, discrepancies exist across the boundary b-b. The surprise that observed structure and policies do not lead to the expected behavior is usually explained by assuming that information about structure and policies must have been incorrect. Unjustifiably blaming inadequate knowledge about parts of the system has resulted in devoting uncounted millions of hours to data gathering, questionnaires, and interviews that have failed to significantly improve the understanding of systems.

A system dynamics investigation usually shows that the important discrepancy is not across the boundary b-b, but across the boundary a-a. When a model is built from the observed and agreed-upon structure and policies, the model usually exhibits the actual behavior of the real system. The existing knowledge about the parts of the system is shown to explain the actual behavior. The dissidence in the diagram arises because the intuitively expected behavior in the middle section is inconsistent with the known structure and policies in the top section.

These discrepancies can be found repeatedly in the corporate world. A frequently recurring example in which known corporate policies cause a loss of market share and instability of employment arises from the way delivery delay affects sales and expansion of capacity (see "Underinvestment in Capacity"). Rising backlog (and the accompanying increase in delivery delay) discourages incoming orders for a product (B1) even while management favors larger backlogs as a safety buffer against business downturns. As management waits for still higher backlogs before expanding capacity, orders are driven down by unfavorable delivery delay until orders equal capacity (R3). The awaited signal for expansion of capacity never comes because capacity is controlling sales, rather than potential demand controlling capacity (B2).

When sales fail to rise because of long delivery delays, management may then lower price in an attempt to stimulate more sales (B4). Sales increase briefly but only long enough to build up sufficient additional backlog and delivery delay to compensate for the lower prices. In addition, price reductions lower profit margins until there is no longer economic justification for expansion (R5). In such a situation, adequate information about individual relationships in the system is always available for successful modeling, but managers are not aware of how the different activities of the company are influencing one another.
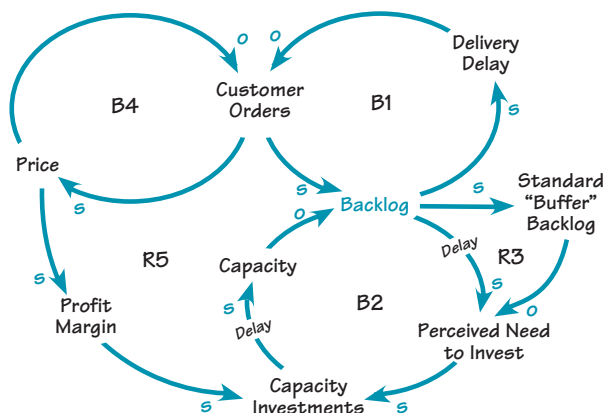
Lack of capacity may exist in manufacturing, product service, skilled sales people, or even in prompt answering of telephones. For example, airlines cut fares to attract passengers. But how often, because of inadequate telephone capacity, are potential customers put on "hold" until they hang up in favor of another airline?

System dynamics models have little impact unless they change the way people perceive a situation. A model must help to organize information in a more understandable way. A model should link the past to the present by showing how present conditions arose, and extend the present into persuasive alternative futures under a variety of scenarios determined by policy alternatives. In other words, a system dynamics model, if it is to be effective, must communicate with and modify the prior mental models. Only people's beliefs—that is, their mental models—will determine action. Computer models must relate to and improve mental models if the computer models are to fill an effective role. ◻

UNDERINVESTMENT IN CAPACITY

Rising backlog dampens customer orders because of increasing delivery delay (B1). However, if management is reluctant to invest in capacity expansions until the backlog reaches a certain level (Standard "Buffer" Backlog), orders will be driven down until demand equals capacity (R3). The awaited signal to expand capacity never comes, because capacity is controlling sales rather than potential demand controlling capacity (B2). If management tries lowering price to stimulate demand (B4), the resulting lower profit margins will further justify a delay in capacity investment (R5).

Jay W. Forrester, professor emeritus at the Massachusetts Institute of Technology and former director of the MIT System Dynamics Group, is the founder of the field of system dynamics.

FROM THE FIELD

Full STEAM* Ahead: Camp Snowball 2013

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*STEAM = Science, Technology, Engineering, Art+Design, Mathematics

To thrive in a changing world, our kids need to think in systems . . . and act for a healthy future. Camp Snowball brings together students, parents, educators, and business and community leaders to build everyone's capacity for learning and leading in the 21st century.

Camp Snowball objectives:

• To develop educators' capacity for teaching systems thinking and/or sustainability to their students

• To empower students to become leaders in their schools and communities by exposing them to these powerful ways of thinking and acting

• To develop local teams that are working to implement these tools and perspectives in their own school systems

• To build local community support for schools by engaging business and government leaders, educators, parents, students, and community members in jointly creating the conditions for ongoing innovation

• To foster relationships and create long-term connections for regional, national, and international learning communities to continue this work beyond the conference

• To learn directly from school systems and others who are accomplishing demonstrable, measurable results

• To elevate awareness of the positive outcomes of these approaches locally, nationally, and internationally

Who should attend

Camp Snowball is designed for both individuals and teams. The organizers encourage communities and school systems to put together diverse teams that include:

• Educators—Teachers and Administrators
• Students
• Community Members
• Staff and Volunteers from Youth-Service Organizations
• School Board Members
• Parents
• Business and Government Leaders

By building critical mass and building local capacity, a community can reinforce learnings from Camp Snowball and substantially increase the chance that new approaches will be adopted once Camp Snowball is over.

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