

Education for Sustainable Development: A Systems Thinking Approach

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Abstract

The challenges of sustainability are adaptive challenges, and require the development of more effective mental models that support a transition to sustainability. Our ability to generate effective mental models is hampered by common deficient ways of thinking – and this deficiency is often shared by policymakers, private sector leaders and the general population. In this paper we provide an overview of these deficiencies and how systems thinking could provide the framework to answer to these challenges. We propose a set of skills, a visual language and technologies to increase our ability to learn systems thinking. Finally, we provide an overview of several educational initiatives currently showing promise at developing a sustainability-focused systems thinking capacity, as well as recommendations for additional educational approaches.

Key words: adaptive challenges, mental models, systems thinking, sustainability

1. Introduction

The complexity of challenges facing humanity today is growing exponentially. We are reaching the limits of the exponential growth model we have experienced since at least the Industrial Revolution. There is indisputable evidence that we must transform the systems that are responsible for overshooting our planet's limits, for example, those that are responsible for global emissions and impending climate catastrophe. Still, we see little global or national support for requisite policies. The combined challenge of addressing short-term objectives coupled with weak institutions of global governance makes formulating positive outcomes tough, especially when multiple issues such as security, prosperity or implementation of universal values still present a challenge. Available information is vast, confusing and often inconsistent or too complicated, making bottom-up action difficult.

We suggest that education for sustainable development is essential for creating needed change. It will facilitate a transformation to a more harmonious world that is developed taking into account inspiration from some principles of nature. Since we need to influence multiple “systems of systems,” we present a framework of Systems Thinking as an essential element of education. Systems Thinking provides principles and methods through which practitioners intervene in and learn about real world problem situations in order to bring about constructive change.

2. Sustainability Challenges and Our Mental Models

2.1 One cause of intractability: Sustainability challenges are *adaptive challenges*

Sustainable development challenges are far from routine – we suggest they are *adaptive challenges* (Heifetz & Linsky, 2002).

Technical (routine) *challenges* are common, but not necessarily simple: routine means there is a known solution/protocol to follow in order to resolve them. Running low on copy paper is a routine or technical challenge because we have a procedure for restocking. Physicians, when diagnosing a patient with brain cancer, have a range of treatments including surgery. This example is far from a “simple fix.” However, there is an established protocol for diagnosing and treating brain cancer.

Conversely, an *adaptive challenge* is a situation without an established protocol or procedure. Achieving global sustainability is the ultimate adaptive challenge. There is no single, unified, generic way to transition communities, regions or the planet toward a resilient, thriving future. What that future holds will be unique for each community – yet must be tied into the larger context. Each community will have its own culture, set of physical assets, resident skills, and desired future. The ability to think and communicate systemically will be an important capacity a community must have or develop in order to make the transition. In the absence of such ability, efforts may focus on low (or no) leverage activities and

they may lack coordinated and orchestrated sets of initiatives.

2.2 Adaptive challenges require fundamentally modifying our mental models

Determining our current sets of routines, protocols and technical solutions are mental models. Mental models are the set of assumptions we use – often unconscious, untested, implicit and incomplete – to make sense out of the world. We have mental models about our families, organizations, the global market, the environment and of course, what is sustainability is and how to achieve it. We use our mental models to assess what is happening, predict what might happen and choose how to influence our future.

Our mental models are frequently useful, or each of us would not have lived to our current age, nor would we have survived as a species (e.g., our mental models are responsible for the institutions and systems we’ve developed as humankind.) However, our mental models appear inadequate to address today’s adaptive challenges. All seem intractable. If mental models determine how we observe the world and take action, there must be something wrong with the mental models we apply to intractable, adaptive challenges.

Richmond and his colleagues at *isee systems*, the producers of the STELLA software, use a simple thought experiment called *Mature Trees* or its business equivalent *Rookie-Pro* to make the point that even when shown a set of six assumptions about what’s basically a supply chain problem, over 75% will fail to correctly mentally simulate the implications of those assumptions – how the system will react to a simple, single shock – even though these assumptions are far simpler than what you would observe in the real world (Richmond, 2001). The system is simpler than reality and the majority still gets it wrong. The implications are staggering, because if most of us cannot determine how a simple system will behave in the future without an intervention, how could we possibly know how a more complex system will behave if we try something to improve it?

An example

Our increasing economic activity currently leads to consuming natural resources at rates beyond their ability to regenerate (remain sustainable). To address this issue, many countries adopt an official policy to reduce the intensity of consumption while continuing to promote growth in GDP. Assuming each unit of GDP is responsible for consuming a specific amount of the resource: reducing the intensity means reducing the amount of consumption per unit of GDP.

There is a stock and flow map (Fig. 1) showing two reinforcing loops: one responsible for regenerating a resource and the other driving GDP growth. The flat line assumes the resource renews at 5% a year with no GDP growth: GDP is 1,000 and the annual amount of consumption per unit of GDP is 50. The steep decline curve assumes GDP grows 3% annually.

GDP growth is (desired to be) exponential – another reinforcing loop

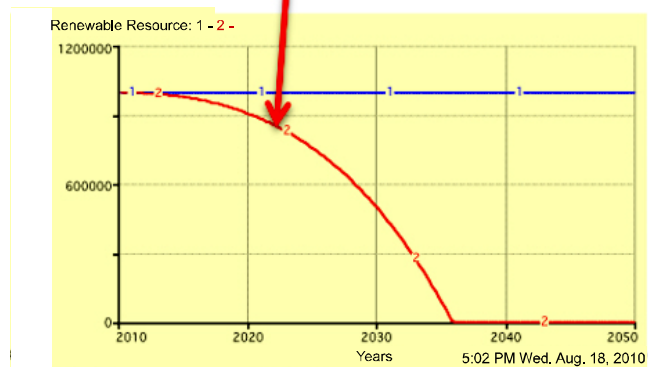
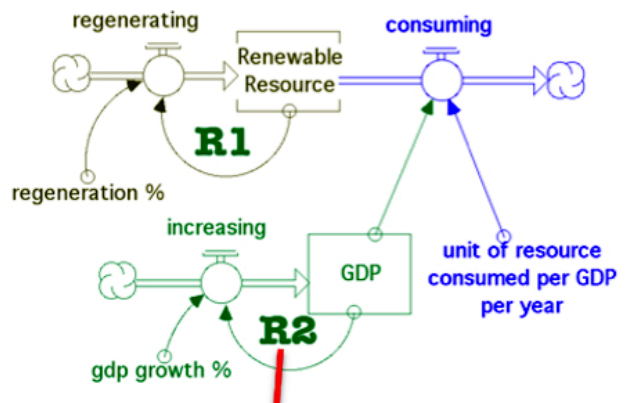


Fig. 1 Example of poor mental models: the relationship between GDP and consumption of a renewable resource.

Visualization using the mapping language of Systems Thinking: if the amount of GDP (the stock or rectangle) is growing with a reinforcing loop (R2), then the annual unit of resource consumed per GDP must decrease at roughly the same rate that GDP increases, which is a rapid and dramatic reduction. Reducing GHG emissions intensity while continuing to expect yearly exponential growth of GDP requires similar assumptions about dramatic (unrealistic) reduction of intensity.

Assuming that such growth is desirable, one way to keep the resource from running out is to reduce the intensity (consumption per unit of GDP). When asked how much this intensity should be reduced, many believe that a 20%-50% reduction in intensity would be sufficient. In fact, in this example, to ensure the resource is not depleted requires reducing intensity by 90% over 40 years!

Reducing greenhouse gas emissions intensity while continuing to expect yearly exponential GDP growth requires similar assumptions about a dramatic (unrealistic) reduction of intensity.

2.3 Our mental models are often inadequate due to several well-established “ways of thinking”

As demonstrated in the policy example of GDP and the intensity of resource use, we sometimes have great difficulty in developing useful mental models. Specific-

cally, people have several “ways of thinking” that lead to poor, ineffective mental models.

Common “ways of thinking”

In our mental models we tend to:

- 1) Focus on events instead of patterns (apply boundaries which are too narrow),
- 2) Apply spatial boundaries which are too narrow, as well,
- 3) Underestimate (ignore) inherent time delays,
- 4) Assume one-way causality (instead of feedback loops),
- 5) Avoid or skip simulating potential unintended consequences to our actions, and
- 6) Exclude non-physical realities.

Below we provide additional details on these common ways of thinking.

2.3.1 Focus on events instead of patterns (temporal boundaries too narrow)

From an early age individuals are taught to focus on events, usually something occurring right in front of them, in space and time. The ability to hyper-focus on the predator that has just leapt from the bushes and to act immediately has served humankind well. What distinguishes the human species from other animals is our ability to see patterns and make predictions. It is this higher level of cognition that must be utilized in today’s world, but it is something we must increase our ability to do effectively.

However, events often lead people to engage in reactive behavior while ignoring the historical background or series of events over time. What is needed is the skill to use events to stimulate long-term, “over time” thinking. Climate change could become recognized as a threat when weather events such as rising temperatures, rainfall or drought are seen in trends occurring over multiple years, or rather decennia. The rising impacts of industrialized farming could become apparent when over the years an increasing amount of animal-related influenzas strike.

Determining to what extent an organization is well-managed depends on the timeframe of the performance measures applied by management. Applying a longer time boundary often leads to better mental models regarding cause and effect and how to act. In Fig. 2, as the time frame expands, the management team is more likely to see the “commodity cycle” nature of their business and generate systemic solutions rather than reactive, cost-cutting policies.

Having temporal boundaries too narrow can have serious consequences. People tend to extrapolate the future from the present, or from a persistently too narrow time frame. All economic bubbles occur as a result of this: if housing prices are rising now and have done so for the past few years, we tend to believe they will continue to rise. If prices for oil have been falling, we believe they will continue to fall. One of the most significant assumptions that underpin much of our current economy is

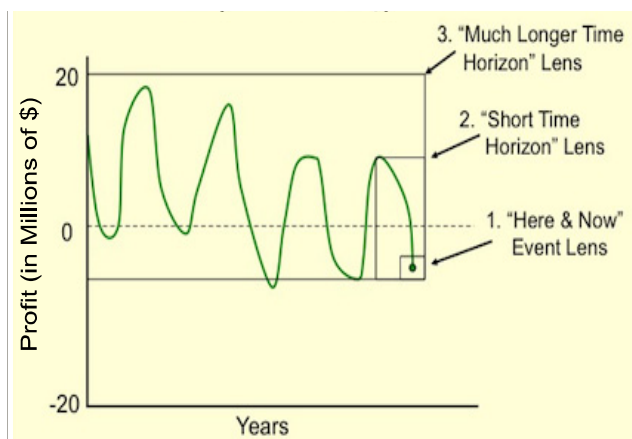


Fig. 2 Dynamic thinking: applying an “over time” perspective.

Different timeframes might be used by management. The actions these leaders might take will be dramatically different based upon which of the three perspectives they choose. With perspective 2, management would be “searching for those responsible.” Adopting perspective 3 would lead to “understanding industry dynamics and how can we adjust our organization.” The power of adopting a pattern-of-event perspective is transformative in guiding the strategies chosen by an organization’s leaders.

the belief that continued exponential growth within a world of physical limits is possible or even desirable.

“It makes sense that economies should follow rules analogous to those that govern biological systems. [...] But economists generally don’t see things this way, [...] because most current economic theories were formulated during an anomalous historical period of sustained growth. Economists are merely generalizing from their experience: They can point to decades of steady growth in the recent past, and they simply project that experience into the future” (Heinberg, 2010, p.5).

2.3.2 Underestimate (ignore) inherent time delays

Even when applying an “over time” lens, humans tend to mentally simulate time delays poorly. Sterman and Sweeney (2002) have demonstrated that a majority of subjects (students at MIT) cannot predict how long it will take for a decrease in carbon emissions rates to impact global climate temperatures, even when the assumptions are made very explicit. Ignoring time delays is a major inhibitor to understanding potential “worse before better” scenarios when implementing public policies or organizational improvements. Public sector managers avoid – and rightfully so due to the public’s understanding of dynamics – policies that might eventually improve situations if they know that in the short term they will contribute to worsening conditions (Soderquist, 2003). In many cases, decisions made today may take years before they have a desirable impact on the organization or system.

2.3.3 Apply spatial boundaries that are too narrow

We also miscalculate how the impacts of our actions spread over time, and are often unaware of how they impact across spatial dimensions. As the housing crisis

began to unfold, it became quite clear that due to the interconnected nature of the global economy, the United States housing bubble and subsequent collapse was able to impact economies all around the world. In the environment, emissions in China now impact the western United States— just as years ago it became understood that pollution from the Midwest was damaging ecosystems in New England.

2.3.4 Assume one-way causality (instead of feedback loops)

We also prefer creating a linear cause-and-effect theory to explain behavior. When asked the question, what creates a highly desirable country (Fig. 3), most people generate a one-way causality list. A desirable country occurs with good leadership, a skilled workforce, technology investments, a robust economy, strong education, effective public services, strong security and shared values Fig. 3(a).

However, reality includes feedback. As shown in the Fig. 3(b), technology certainly improves both education and security; It is also true that both of these sponsor and fund technology improvements. Skilled workers support a healthy economy, and a healthy economy provides more funding to educate a more skilled workforce.

2.3.5 Avoid or skip simulating potential unintended consequences to our actions

“To fix this problem, all we have to do is X – no problem!” states a policymaker. After a few experiences of the consequences of “no problem,” the public becomes more cynical in the future. This is because we have learned reality is filled with unintended consequences (and very few “no problems”). Unintended consequences often result from overlooking important feedback loops.

In the Simplistic Mental Model about increasing farm profitability, a balancing (B) loop works to keep profitability high (Fig. 4). If profits decrease, then the farmer increases fertilizer use (lbs/acre/year) and thus

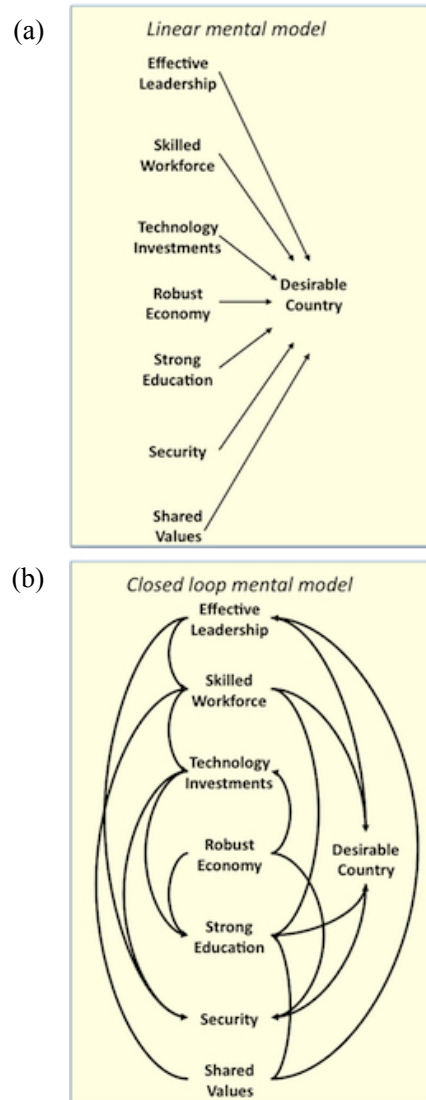


Fig. 3 What causes a country to be desirable? (a) Typical list-based, linear mental model and (b) one demonstrating closed loop relationships, feedback loops.

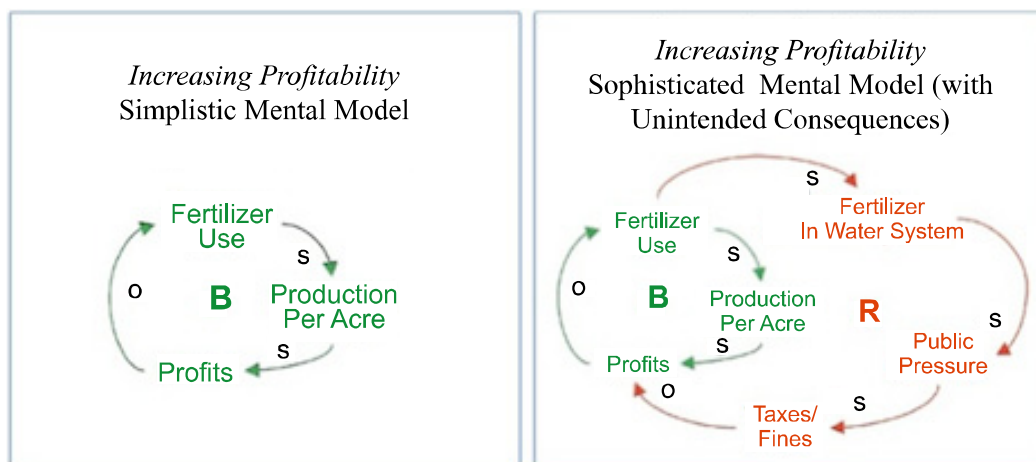


Fig. 4 Understanding unintended consequences of agricultural commodity systems: increased fertilizer use increases fertilizer in the water system – which come around to depress profitability through public pressure to increase taxes. The vicious cycle gets set in motion: low profits lead to increased fertilizer use, which lead to lower profits – and then more fertilizer use. Using a mapping approach helps anticipate and avoid problematic unintended consequences.

increase *production per acre per year* (the “o” means that as profits drop, fertilizer use goes in the opposite direction – up). Profits increase as more sales leads to more revenue for the same number of acres (assuming, of course, that the additional cost of fertilizer does not outweigh the increased revenue per acre).

However, often unintended consequences accompany increased fertilizer use. In the more Sophisticated Mental Model picture, another loop is activated: increased fertilizer use increases fertilizer in the water system – which come around to depress profitability through public pressure to increase taxes. The “R” indicates it is a reinforcing loop, meaning that it tends to go in the direction it is already going. In this case, the unintended consequence is that a vicious cycle gets set in motion: low profits lead to increased fertilizer use, which leads to lower profits – and then more fertilizer use (Sustainability Institute, 2003).

Using a mapping approach (*e.g.*, stock/flow maps or causal loop diagrams like shown here) will help anticipate and avoid problematic unintended consequences.

2.3.6 Exclude non-physical “realities”

In finding solutions to improve how systems behave, our formal models usually only include the things we can measure – we usually exclude “soft” variables like motivation, trust, knowledge and skills. Many disciplines, due to their mathematical and statistical nature tend to ignore these types of variables, even though most people will recognize that we already use (if only implicitly) these types of variables in decision-making. Managers know that these variables matter. Yet, they will often leave them out of the formal model used to describe organizational performance. From practice we know that environmental laws require public support to be effective. Therefore, using a mere “technical” or “legalistic” model for analyzing the environmental law’s effectiveness, while leaving out the public’s perception thereof, is not useful. This is why more recent management approaches (*e.g.*, the balanced scorecard) include variables such as morale, employee skills, and customer satisfaction. Public policy models need to include not only technical understanding of “the science,” but also public perceptions and knowledge – the human dynamics components required for effective engagement and implementation of policy.

3. Systems Thinking: An Integrated Framework for Collaboratively Building and Communicating More Effective Mental Models

Previous sections suggest that the elements of Systems Thinking can significantly enhance the capacity to develop and utilize mental models that can address the adaptive challenges we face. Specifically, Systems Thinking includes the following:

- Processes,
- Sets of skills, and

- Technologies.

When integrated into an overall framework, these can improve our ability to collaboratively surface and improve our mental models in a way that will help us better understand the world, and act more effectively in it.

3.1 Process

The systems thinking process (Fig. 5) applies a scientific method-based approach to building, communicating and applying understanding. Applying this process ensures we have enough confidence that our conclusions are credible and that any recommendations will be efficacious.

3.2 Set of skills

Richmond (2010) proposes a set of skills, that build our capacity to be better systems thinkers (what he often referred to as Systems Citizens), by addressing the inadequate “ways of thinking/being” described above. Additionally, the following skills (further defined in Fig. 6) support the process above:

- 1) Dynamic Thinking,
- 2) 10,000 Meter Thinking,
- 3) System-as-Cause Thinking,
- 4) Operational Thinking,
- 5) Feedback Loop Thinking,
- 6) Scientific Thinking,
- 7) Generic Thinking, and
- 8) Empathic Thinking.

3.3 Technologies

Unfortunately, we have difficulty learning systems skills when the impacts of our current “way of thinking” fall outside the narrow range of our experience. We cannot improve performance when we cannot link our actions to outcomes. Moreover we are just not good at mental simulation when the issues are dynamically complex – as adaptive challenges always are. For that reason, we need mental exercise equipment and training regimes to build our Systems Thinking skills. The technologies found to be effective are:

- 1) Stock and flow mapping: An operational mapping language to improve mental simulation;

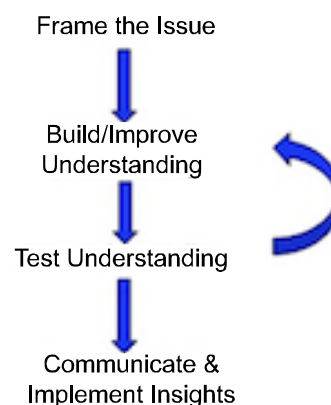


Fig. 5 The process of building and communicating ‘Systems’ understanding.

Activity	Skill	Definition
Framing (issues)	Dynamic Thinking	Look for trends/patterns of behavior – shift from “event focus”
	10,000 Meter Thinking	Take a Big Picture view (from the balcony)
	System as Cause Thinking	Mental models should contain only those elements whose interaction is capable of self-generating the phenomenon of interest.
Building Understanding (Mapping & Testing)	Operational Thinking	Explicit causal explanations for behavior – How does this work?!
	Feedback Loop Thinking	Move beyond linear thinking to circular causality – world is made up of feedback loop relationships
	Scientific Thinking	Applying scientific method to analysis – includes both mental and computer simulations
	Generic Thinking	Seeing the world composed of generic structures (e.g. some ecosystems and economic systems can be similar)
Communicating	Empathic Thinking	Expanding personal boundaries and creating ability to “understand” other perspectives/mental models

Fig. 6 Developing more useful mental models using systems thinking is accomplished by applying several Systems Thinking skills (Richmond, 2010).

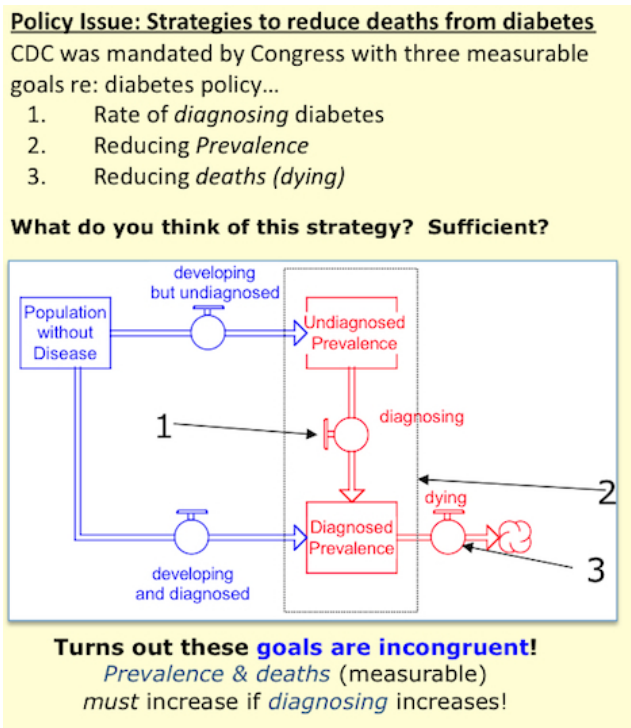


Fig. 7 The case of diabetes: operational mapping language improves mental simulation.

- 2) Computer simulation: Individual and collective mental exercise equipment to build mental simulation capacity; and
- 3) Microworlds and learning environments: Practice fields to generate profound shifts in thinking.

3.3.1 Stock and flow mapping: An operational mapping language to improve mental simulation

As shown in the example of GDP and the intensity of resource use, using a visual language that distinguishes between stock (conditions) and flows (activities) in a system helps to improve our ability to see time delays and feedback loops – and thus improves our mental simula-

tion capacity. Over time, as we develop proficiency in this language, we simultaneously increase our Systems Thinking capacity. However, just learning the language is insufficient: we need additional tools to supplement our mental simulation capacity as exemplified by Fig. 7.

In Fig. 7, the United States Congress requested the Center for Disease Control and Prevention to reduce the number of deaths resulting from diabetes complications. Specifically, it was requested to:

- a) Reduce the prevalence of diabetes;
- b) Increase the rate of screening to detect diabetes; and
- c) Reduce the annual incidence of diabetes-related mortality.

On the surface, these may seem like a perfect set of goals to address the diabetes epidemic in the United States. However, after developing a stock and flow map to represent these assumptions, it became clear that the goals were incongruent. Increasing the rate of screening will detect the Undiagnosed Prevalence (of diabetes) and therefore increase the Diagnosed Prevalence (of reported diabetes). Worse, the number of people who die from diagnosed diabetes will also increase because new cases have been added to the stock of *Diagnosed Prevalence*.

The goals are incongruent – impossible to achieve simultaneously. This example demonstrates the value of using an operational, visual language to map out public policy interventions in order to better mentally simulate their efficacy.

3.3.2 Computer simulation: Individual and collective mental exercise equipment to build mental simulation capacity

Having an operational, visual language is a necessary condition to improving the quality of our mental models. However, it is far from sufficient. Even if we can visually map the operational assumptions, individuals will have dramatically different mental simulations of those assumptions. This is illustrated in the following example.

HIV/AIDS policies and impacts

The stated goal behind many strategies to address the HIV/AIDS crisis is to ensure the fewest number of people will ultimately die from complications associated with the disease. In most cases, there are established programs with the expressed objective to provide life-extending pharmaceutical therapies. (In some cases, due to social and religious cultural stigmas, pharmaceutical treatments are the primary or only intervention.) On the surface, these would seem to hold promise in achieving the objective of reducing the total long-term mortality resulting from HIV/AIDS-related causes. But will they?

After developing an operational map (Fig. 8) to visualize the underlying structure of the epidemic's spread – with people moving from the Safe Population to the Risky Behavior Population to the Infected Population – it is easy to see where pharmaceutical policies will impact. They will slow the flow out of the stock of the Infected Population. What happens if the survival time increases?

Although initially the trend is improved over a base case (the straight line), over time more people die from the disease. This occurs because initially fewer people leave the Infected Population stock. However, this increases the number of becoming infected...and more become infected. Ultimately, even though it takes longer, those people die and the volume flowing out (through

dying) is even greater (line that eventually increases above the straight line) than under the base case.

Many people do not see this as the logical implications of the assumptions shown above. This is why computer simulation is often required. We are usually good at sketching assumptions, but have difficulty mentally simulating their implications. Computer simulation addresses this difficulty, and can improve mental simulation capacity.

Any strategies focusing solely on reducing the deaths of the currently infected could have the unintended consequence of creating more deaths – trying to be humane leads to more suffering. The best way to reduce deaths in the long term is to focus upstream and prevent people from entering the Infected Population stock in the first place. It's not that treatment shouldn't be done – it must be in order to reduce the suffering of those with the condition. However, without some upstream focus – prevention – short-term efforts to reduce suffering and deaths will backfire as more people will get the disease.

3.3.3 Microworlds and learning environments: Practice fields to generate profound shifts in thinking

Just as computer simulation can supplement, and improve on, our mental simulation of Systems Thinking maps, microworlds and learning environments can increase the effectiveness of simulation-based learning.

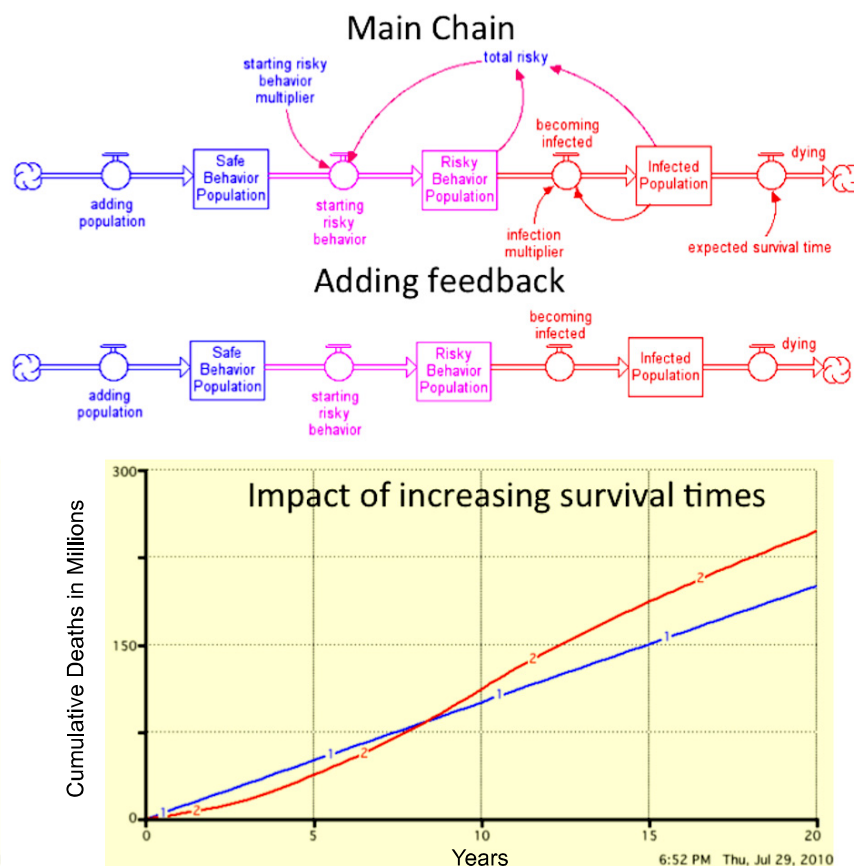


Fig. 8 A systems approach to total long-term mortality resulting from HIV/AIDS-related causes.

Becoming infected and starting risky behaviors are reinforcing loops. Slowing the rate of dying initially accumulates more Infected Population and ultimately the rate of dying increases.

These tools become practice fields that facilitate deep reflection on deeply held assumptions about the systems we are trying to improve.

As an example, a learning environment was developed by the Darden School of Business at the University of Virginia, Pontifex Consulting, and the Sustainability Institute for MBAs and undergraduates to deepen their understanding of the structural causes of commodity dynamics. Working as individuals and teams, through repeated experimentation by applying cycles of hypothesis/test/reflection, these students achieve a systemic understanding of the shrimp fishery and commodity systems in general. They are able viscerally to understand the Tragedy of the Commons, a systems archetype that occurs when stakeholders within a system are “harvesting” a commons – a resource shared by all. Individual incentives to maximize individual short-term profits in the system drive these stakeholders to overharvest in the long term.

3.4 Technologies – Summary

The operational mapping language (of stocks and flows), computer simulation, and learning environments/microworlds form a suite of powerful technologies for building Systems Thinking capacity.

4. A Critical Review: Perspectives on Possible Limitations

System Thinking as defined in this article comes from the field of system dynamics, and is one of several approaches attempting to apply a “systems framework” for improving social and environmental systems. There are several critiques of an approach based on system dynamics; some of the major critiques being

- 1) Intensity of time/resources,
- 2) The focus on theory and process instead of practice and action, and
- 3) Ignorance of social consequences.

4.1 Intensity of time/resources

Applying a Systems Thinking approach takes time. With complexity of issues accelerating, it can seem as if there is not sufficient time to apply Systems Thinking. Additionally, according to Jackson (1991) Systems Thinking has difficulty dealing with unanticipated occurrences during an investigation.

We agree that Systems Thinking reflection requires more time than typically seems available for problem-solving. However, one common “systems archetype” is “Fixes That Fail,” which results from applying a fix that has unintended consequences. Adequate systems reflection could better anticipate such consequences.

The inherent danger in taking this time is of course, that the problem situation may worsen or evolve into other situations. By taking sufficient time and re-evaluating during specific stages of the analysis, the temptation to short cut the analysis and miss out on important developments can be minimized.

4.2 Weakness in the process of issue generation

Systems Thinking analysis requires first identifying an issue for which to map, analyze and explore. Other systems approaches (e.g., soft systems) emphasize that lack of agreement on an issue within the system is part of the system, and include explicit practices for mapping/resolving such disagreements. (Lane & Olivia, 1994).

We recognize this as a limitation for certain problems or situations. Employing a more collaborative approach to Systems Thinking analysis can improve this agreement on the issue.

4.3 Ignorance of social consequences

Desired ends can only be achieved when social consequences are taken into account. A critique of Systems Thinking is that these social consequences such as power and conflict are seen as irrelevant and are often ignored (Lane & Olivia, 1994).

We agree that including assumptions concerning human rationality in a Systems Thinking analysis is challenging and has been described by others as realistic challenges in decision-making (Simon, 1957).

Numerous approaches at blending systems analyses (e.g., combining soft systems with system dynamics) have been proposed and by doing so, there is a potential to increase the likelihood that social concerns will not be overlooked (Salerno *et al.*, 2008).

5. Current Educational Initiatives to Build and Apply Systems Thinking for Sustainable Development

In order to increase the likelihood that policies will achieve a lasting impact on adaptive sustainable development challenges, public policy institutions, the private sector and all “global” citizens must develop their systems thinking capacity. Otherwise, it will be extremely difficult to generate higher leverage solutions supporting sustainability.

Described below are some current efforts in each of these spheres, as well as some suggested initiatives that might also facilitate movement toward a more sustainable future. They focus on different areas of society:

- Government and Public Policy Education,
- Private Sector Education,
- Youth Education, and
- Cross-sectoral approaches.

Not all are focused explicitly on sustainable development. Most programs focus on a subset of Systems Thinking skills, not the full range, and utilize several different delivery mechanisms: from face-to-face to online or distance-based learning.

5.1 Government and public policy education

5.1.1 Georgia Health Policy Center – legislator health certificate program

In 2008, the Georgia Health Policy Center (GHPC) developed and implemented an innovative state Legisla-

tor Health Certificate Program (LHCP). The purpose was to develop the capacity of leaders in both the state House and Senate to understand health content in ways that promoted systemic thinking and led to more sustainable health policy in the future. The program includes several “core content” sessions (e.g., health status, financing) plus additional “topical” sessions (e.g., childhood obesity, trauma). During each session, legislators learn Systems Thinking concepts and apply them to the session’s content through small group and large group discussion. Legislators use such tools as:

- a systemic framework for systems analysis of health policy,
- stock and flow maps, and
- learning labs, for example, on childhood obesity.

To date, the GHPC has successfully graduated two cohorts. They are currently developing additional training for those cohorts, while preparing for a third cohort. The childhood obesity learning lab has been used in the making of legislation. A final indicator of their success is the request of other states for GHPC to assist them in developing similar programs.

5.1.2 Sustainability Challenge Foundation

The Sustainability Challenge Foundation, located in the Netherlands designed the International Programme on the Management of Sustainability (IPMS), attracting individuals from around the world to focus on conflict management and to discover common interests behind the perceived from the outset contrasting demands of economic development and environmental protection.

5.2 Private sector education

Several private sector organizations have included some form of the concepts presented here in their leadership and management training courses. Some MBA & Sustainability programs also embed Systems Thinking training in degree programs or executive education. Two of the more notable executive education programs are run by MIT’s Sloan School of Management and the University of Virginia’s Darden School of Business.

5.3 Youth education

Notable organizations and initiatives are working to educate youth in the concepts of Systems Thinking and sustainability. Some examples include:

- Cloud Institute,
- K-12 System Dynamics in Education Project,
- The Waters Foundation, and
- Creative Learning Exchange.

5.3.1 US-China systems science learning project

The Vermont Commons School developed a relationship with Jiangsu Province’s Nanjing Educational Technology Center, the education technology hub serving all secondary schools in the capital city. Over the course of three years, the Vermont Commons School and its project partners collaborated with Nanjing area schools to co-create Systems Science curricula and case

studies in most core school subjects, which were documented within a web-based workspace. This project included several of the Systems Thinking organizations listed above, including The Waters Foundation and the Creative Learning Exchange.

5.4 Cross-sectoral education

Some of the more promising approaches apply a cross-sectoral approach. Several examples are presented in *The Necessary Revolution* (Senge, 2008). A few unique programs are described here.

5.4.1 Energy for Sustainable Development Policy Dialogue

The Energy for Sustainable Development Policy Dialogue is a capacity building activity of the Energy for Sustainable Development Initiative. Their key purpose is to promote active dialogue and exchange of ideas/options aimed at addressing key challenges related to energy for sustainable development. All stakeholders in the energy and development challenge are brought together in an online course to focus on a specific topic. Although not expressly developing the range of Systems Thinking skills presented here, the Dialogue does greatly enhance the capacity of Empathic Thinking.

5.4.2 Donella Meadows Leadership Fellows Program

The Donella Meadows Leadership Fellows Program has accelerated the shift to global sustainability by increasing the effectiveness of well-positioned sustainability leaders. Fellows learn to address social, economic and environmental issues at their root causes while benefiting from a national and international network of talented and supportive colleagues. Skills included are:

- Skillful learning within complex economic, social, and environmental systems, and
- Acting effectively in change processes involving multiple stakeholders with diverse goals and needs.

To develop these abilities, Fellows receive training, coaching and practice in Systems Thinking, reflective conversation and visioning.

The Fellows Program nurtures these qualities in a selected group over two-year cycles in on-the-ground projects. At present the Fellows Network consists of 74 sustainability Fellows and practitioners from 16 countries.

5.4.3 Sustainable Food Lab

The Sustainable Food Lab is a partnership among governments, NGOs and private sector organizations responsible for the production and distribution of food around the globe. Their efforts are program-focused (e.g., coffee supply chain) and while working on any program, participants learn and apply Systems Thinking concepts to develop deeper understanding of why the systems behave in ways they wish to change and where leverage points are for improving that behavior.

5.5 Recommendations

Each of the initiatives and programs mentioned above have successfully advanced the ability of participants to build and apply Systems Thinking to public policy challenges and in most cases associated with sustainable development. Programs showing the greatest impact on motivation and learning appear to be those that provide the concepts in conjunction with an issue of particular concern to participants. To that end, it is recommended that additional effort be made to develop training materials that can be delivered to groups already grappling with a sustainable development challenge, in particular regional sustainability. With enhanced Systems Thinking capacity, coordinated efforts such as Transition Towns or The Natural Step planning process (or any regional planning initiatives) can have tremendous impact on sustainability. The issues are at a scale that is both visible and manageable, and the stakeholders have the capacity to meet and engage in effective processes. Such groups would find that the tools described in this article would facilitate engagement in developing actionable, coordinated strategies.

6. Conclusion

This article presents the challenges we face in moving to the next level of sustainable development – meeting adaptive challenges requires learning “new ways of thinking.” What is needed is an increased capacity to build and apply systemic understanding of the nature of the systems we are trying to improve. Systems Thinking provides a process, a set of thinking skills and technologies that can improve our ability to develop that systemic understanding. Systems Thinking is often considered too time-intensive or over-theoretical, not focusing on action and lacking usefulness in real-world problem situations. Systems Thinking certainly should not be over-romanticized or seen as a theory that does provide the solution to every existing complex problem. It has proven, however, to be a rich and varied discipline and an invaluable tool to gain insights into complex problems and provide action-oriented solutions to adaptive challenges we face in global, national and local problem situations. Several local and international initiatives are currently working to build that capacity in various societal sectors. We recommend that more coordinated efforts to build Systems Thinking capacity be integrated into firmly established, inter-connected regional initiatives (e.g., Transition Towns) to increase the effectiveness of those initiatives and to spread more quickly through the social fabric. The time to undertake this challenge is now.

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