NOTES AND INSIGHTS

Minding the abstraction gap: approaches supporting implementation

Laura J. Black[a]* and Donald R. Greer[b]

Abstract

Regardless of insights gained from building and analyzing dynamic models, the only strategies people can act on are those in their heads. The strategies people internalize are related to their perceived capacities to act—the verbs they believe they can do. If we want others to implement model-informed policies, then we must connect model abstractions with new situated, concrete actions stakeholders can take. We can emphasize opportunities to act with SD representations, navigating levels of abstraction cleanly, identifying flows as verbs, and choosing variable names that signal who is acting. By drawing on social-science theories as we offer our grammar of accumulations, activities, and relationships in the language of actions accessible to stakeholders, we help connect experiential understandings to richer, dynamic explanations people can internalize and so discover situated steps to implement policies informed by modeling.

Keywords: implementation, implementation science, model abstractions, system dynamics representations, verbs

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Introduction

The transition from system dynamics analysis to insights implementation is a critical path toward achieving meaningful societal impact. This transition lies at the essence of leveraging system dynamics for social good, a goal that resonates deeply in our community. Accordingly, some have called for more attention to implementation (e.g. Größler, 2007; Randers, 2019; Wheat, 2010). These calls for research often emphasize questions about which system representations are more effective under certain circumstances (Randers, 2019) or highlight the importance of modeling and analyzing structures to implement policies (Snabe & Größler, 2006; Wheat, 2010). While some acknowledge "contextual experts must be involved in the modeling process" (e.g. Wheat, 2010, p. 429), the focus often remains on models and other system dynamics representations of analysis, rather than on ways to engage the people who have a role in implementing the insights. If we want others to implement model-informed policies, we must help them connect insights arising from abstract system dynamics representations of their problem to concrete actions they can take to address it, to the verbs they can do in that particular situation.

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Engaging stakeholders in system dynamics

Marvin Weisbord, author of *Discovering Common Ground* and books on "future search" conferences,[i] proposed that society's learning curve advances through large oscillatory waves as new methods move from expert-only uses to use by "everybody" (Weisbord, 1992; Weisbord & Janoff, 2010). For example, he suggested that at the beginning of the 20th century experts like Frederick Taylor solved manufacturing problems, and by the 1950s and 1960s Deming's Total Quality Management invited everyone on the manufacturing line to solve problems. We propose that a similar trajectory may be unfolding in system dynamics. Jay Forrester, Jorgen Randers, Dennis Meadows, and Donella Meadows typified "experts improving whole systems" (Weisbord & Janoff, 2010, p. 2), as they developed the World Dynamics model, wrote *Limits to Growth* (Meadows et al., 1972), and testified before the U.S. Congress. With seminal scholarship on group model building (Andersen et al., 1997; Richardson & Andersen, 1995; Vennix, 1996), we saw an effort to engage stakeholders directly in understanding the grammar of stocks and flows as applied to their "messy" problems. Hovmand's *Community Based System Dynamics* (2014) further adapted system dynamics methods to broader constituencies and participants in very large social settings. This shift holds hope for implementation, as developing stakeholders' collective capacities to learn from system dynamics mapping, modeling, and simulation through direct involvement in group and participatory modeling can help them translate dynamic insights into actions that address their important challenges.

Hovmand's participatory modeling work in a variety of community contexts, along with his exploration of philosophical theories, led him to propose two continua of assumptions with which people may approach an effort to solve a complex problem: the subjective–objective approach to knowing, and the radical change–regulation view of society (Hovmand, 2014, pp. 44–48). In the quadrants formed by the intersection of these continua, he identified four types of problems: Learning (radical change–subjective), Transformation (radical change–objective), Coordination (regulation–subjective), and Analysis (regulation–objective). Those working on Analysis problems take the world as given and assume that information with which one constructs a model has objective validity, emphasizing identification of root causes and leverage points, rather than on building consensus on the problem, developing others' skills to address the problem, or altering structures giving rise to the problem (Hovmand, 2014, p. 45). Analysis has long dominated conversations among system dynamicists (see Figure 1). Analysis is usually aimed at experts, often academic experts; even expert executives who hold authoritative control over others may encounter organizational challenges in implementing analysis-informed policies to achieve real change.

More broadly, if implementing insights arising from dynamic model analysis must involve actions by people who are not experts, we must continue to consider how to engage "everybody" in our rather technical representations. We can also expand our representation repertoires and narratives to account for more

[i]Future search conferences have similarities to participatory modeling sessions but are more far-reaching in the range of stakeholders to "get the whole system in the room," not equipped with the grammar of stocks and flows, and almost always focused on a particular geographic region.

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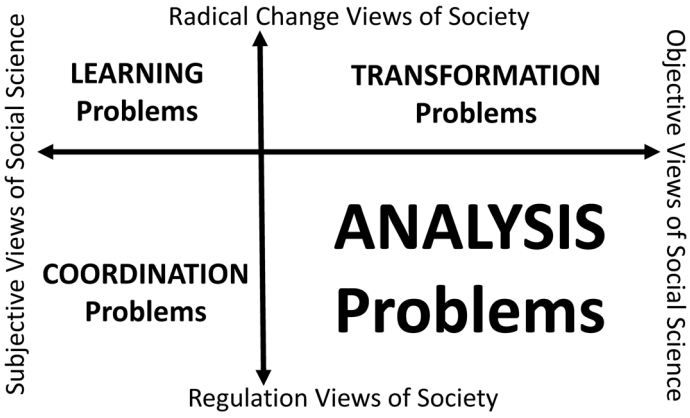

Fig. 1. Distorted view of Hovmand's continua of perspectives on epistemology (how we know what we know) and society (its stability or malleability) and the problem spaces formed by their intersection

subjective and change-focused perspectives, as stakeholders may aim for addressing problems related to coordination, learning, or transformation (see Hovmand's other quadrants in Figure 1). While we often start a system dynamics initiative by exploring stakeholders' (often diverging) perspectives on a messy problem, we must also consider how to end an initiative only when we have helped stakeholders carry dynamic insights back to their tangled situation with ideas and agreements for actions they can actually do from their respective positions in the problem space.

Navigating between concrete and abstract understandings

Unless we are undertaking theoretical research (DeGooyert & Größler, 2018), when we use system dynamics to gain insight into a complex domain, we start with the problem as understood and experienced by the people inhabiting the problem space. We receive lots of information, often not well organized, with reports from multiple people experiencing different aspects of the problem as it relates to what they seek to accomplish individually and collectively. Philosopher and theologian Bernard Lonergan called this "experiential understanding" of a problem, "how things relate to me" (Lonergan, 1957, Chap. 6). Lonergan asserted that insight advances as we move from "how things relate to me" to "how things relate to other things," from experiential understanding to explanatory understanding. He further asserted that the ability to apply a theory practically in a specific situation *also* requires insight. Figure 2 graphically portrays the notion that insights arise from—and are the only paths for—navigating between concrete and abstract planes.

The system dynamics method (e.g., Martinez-Moyano & Richardson, 2013; Richardson & Pugh, 1981; Sterman, 2000) provides great tools for abstracting from complex situations. We sift qualitative and quantitative data to identify reference modes in key variables and use the grammar of accumulations (stocks) and activities (flows) and information links to identify causal hypotheses for structures generating problematic behaviors-over-time. Manipulating and analyzing our abstractions, we learn about the system modeled, how things relate to other

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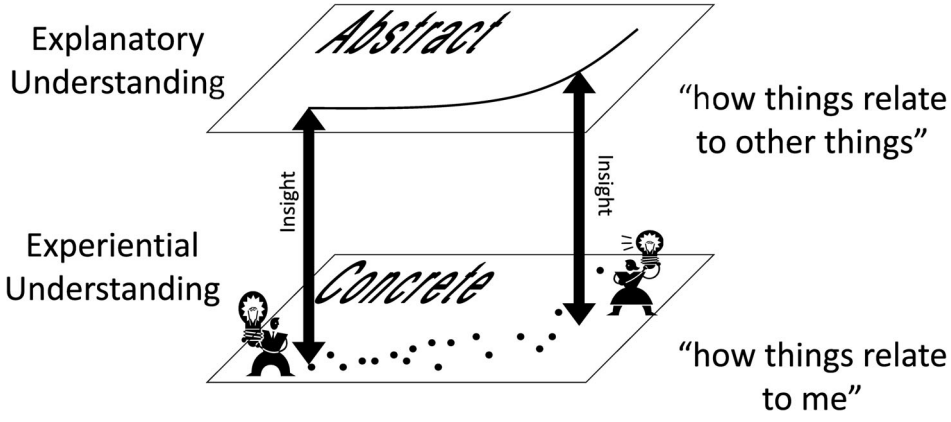

Fig. 2. Graphical depiction of Lonergan's idea that insight grows as people move iteratively between experiential understanding and explanatory understanding

things; Lonergan called this explanatory understanding "the realm of science" (1957). Research training generally, and system dynamics training specifically, focuses on how to abstract from rich, messy situations to clear, clean conceptualizations, often in terms that connect with others' academic research. Synthesizing policy insights in *model terms* is often the end of the process for us. We receive far less training in methods to move the other direction, creating insight from abstract understanding by resituating it in the realm of concrete actions and experiences. The system dynamics community must learn to produce and share these insights as well, if we hope that people will act on the insights generated by dynamic modeling.

Another lens for moving between concrete and abstract realms is the ladder of abstraction proposed by Hayakawa (1990). He suggested that language can be visualized as different rungs on a ladder, with the most concrete language on the bottom rungs and words growing increasingly abstract with each rising step. For example, the latitude and longitude coordinates 44°27′38″ N, 110°49′41″ W denote a specific point on the earth's surface, a physical reality. You may know this location as the Old Faithful Geyser. We could also refer to it as a predictable geothermal feature, Yellowstone National Park's most tourist-visited site, a U.S. National Park treasure, or an international travel destination, as we move up a ladder of abstraction. As a university English teacher, Hayakawa wanted his students to not only navigate levels of abstraction gracefully but also to think critically about meaning as they sifted information and news reports in the 1930s while war was taking shape in Europe. Hayakawa pointed out that, while abstraction is an "indispensable convenience" (we can point to one thing that defines Old Faithful Geyser, but imagine trying to point to one thing that completely defines "work"), once someone is confused by our language, seeking to clarify through higher levels of abstraction leads only to a muddle (Hayakawa, 1990, pp. 86–89). We can clarify and explain only by traveling *down* ladders of abstraction. That suggests we cannot leave our analysis on the abstract, theoretical plane but must explore ways to evoke lower levels of abstraction as we strive to articulate policies in ways that can be undertaken by the only ones capable of acting, the clients, stakeholders, decision-makers, and the people they, in turn, engage.

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Bridging the gap—highlighting action opportunities with language

We can consider that, no matter how elegant and parsimonious a model may be, it may be useless to an actor unless she can bridge the gap between the variables and relationships represented in that model and her messy, experiential context. We propose that bridging the gap between model insight and implementation may be aided by clarifying language to make insights more accessible to stakeholders in three ways:

- Naming variables in stakeholders' words;
- Naming inflows and outflows as verbs; and
- Choosing verbs to indicate the actors altering the rates (and respecting their volition).

Additionally, as we work with system dynamics representations, we can draw on boundary-object approaches and other social science theories to socially construct agreements focused on concrete actions stakeholders can take.

Naming representation variables in stakeholders' words

Unlike some modeling methods, system dynamics affords great flexibility in naming stocks, flows, and other variables. While we strive for clarity and parsimony, naming variables (and causal diagram loops) in stakeholders' terms helps ground abstract representations in their own ways of talking about their lived experiences. According to Lave (1988), representations play a critical role in cognition and problem solving. She asserts that what we look at significantly shapes how we view a problem and the cognition we can bring to bear on solving it. Because what we look at affects how we can *think* about a problem, we infer that system dynamics representations also affect how we can think about *acting* to address a problem. How we name elements of system dynamics representations may significantly influence what actions, and the degree to which any actions, are viewed as feasible, and in what time frame and by whom.

Naming flows as verbs

In Dynamo, one of the first programming languages of system dynamics, variables bore names indicative of how they were to be used in equations. Consider the World Dynamics model (Forrester, 1973): flows are named as nouns—"Capital investment generation," for example. Taking action on "capital investment generation," identifying something a single individual can *do*, may require some translating, perhaps many layers of translation, to move it into words that a person recognizes as activities *he* can do. Donella Meadows strived to do this interpreting, rendering insights from *World Dynamics* (Forrester, 1973) and *Limits to Growth* (Meadows *et al.*, 1972) into short, easily digested stories in plain language, the words of everyday actions she published as "The Global Citizen" syndicated newspaper column, writings later compiled in a book of the same name (Meadows, 1991). Indeed, the fact that the World Dynamics model variable

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"Pollution generation" is fairly easy for us to connect with many of our daily doings (such as reducing plastic use and recycling aluminum cans) is largely a tribute to *The Global Citizen*'s successful translations of highly abstracted nouns into actionable terms of everyday life.

Mead (1934) asserted that meaning is recognized in how people act, which is directly observable; meaning is both constructed and lived out in the verbs people execute. As modelers we can seek to bring stakeholders' verbs into our representations and articulate policies, especially policies considered for implementation, in verbs accessible to them. Since the only way to alter system dynamics accumulations is through the flows, when we talk about implementing policies identified through modeling and analysis, we are talking about altering activities represented as inflows and outflows in our models. Because the action opportunity lies with the inflows and outflows, careful attention to how we name flows, or variables affecting flows, can emphasize their verb-nature and in turn underscore the opportunities for action they present, for implementation relies on what stakeholders *do*, their verbs.

We can also ask stakeholders to articulate policy insights in phrases that focus on their perceived capacities to act (see also Richardson, 2024, this issue). Verbs are inherently complex, resolving multiple possible relationships among nouns (Gentner, 1978). As a trivial example, think of a verb to connect the nouns "boy," "girl," and "book." In choosing a verb, we decide whether the boy reads a book to the girl, the girl hits the boy with a book, or the girl and boy together write a book. The act of wording possible policies as verb phrases doable by stakeholders therefore invites them to engage deeply with the causal relationships among multiple constructs in the model, as they put into words their understandings from the abstract plane and resituate them as actions in the concrete plane. Moving from the abstract to the concrete requires us to consider how to navigate down ladders of abstraction, adding back nuance, while noting that nouns at low abstraction require verbs different from those at high abstraction. Further, different stakeholders have access to different verbs because they have different opportunities to act. Blumer (1986, pp. 70–73) insisted that the joint action required to address complex problems involved people acting on a shared goal, not in lockstep, but from their respective positions.

Choosing verbs signaling the actors

Naming flows as nouns in stock-flow maps, a common practice (see, for example, Sterman, 2000, Chap. 6) can be helpful in emphasizing their rate-nature and in pointing the modeler to equation formulations with consistent units. Since most stakeholders seldom look at equations, however, and often spend time examining the map view, naming rates for storytelling relevant to stakeholders can help them recognize actions to implement what they are learning. The linguistically balanced diagram in Figure 3(a) leaves ambiguous who is doing the action or altering the rate. While Figure 3(b), depicting the organization's possible actions, and Figure 3(c), reflecting the employees' perspective, do not exhaustively account mathematically for all of the employees who may exit through a particular flow (*Retiring*, for example, can include employees who retire because of their own sense of timing, those who retire because they find incentives compelling,

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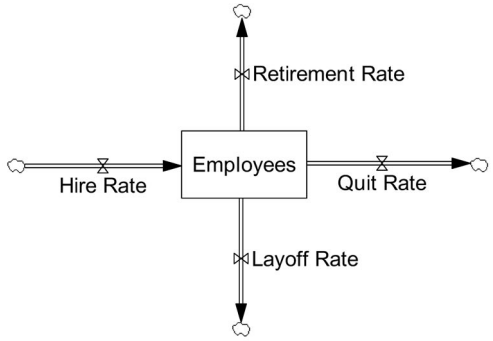
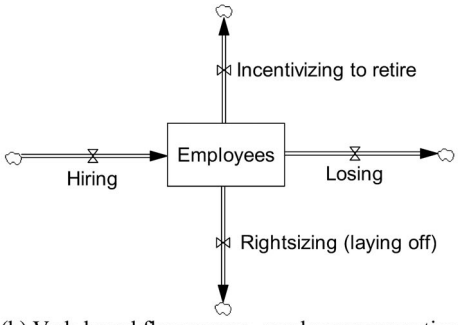
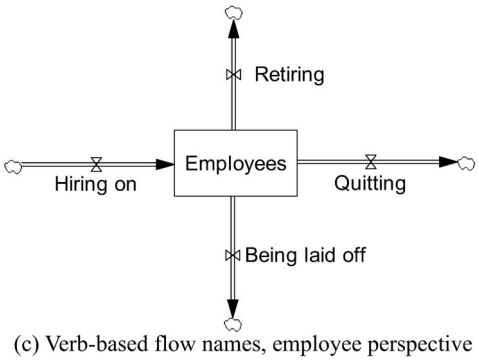


(a) Noun-based flow names based on rates (equations)



(b) Verb-based flow names, employer perspective



(c) Verb-based flow names, employee perspective

Fig. 3. Different representations of flows changing the stock of Employees

and those who are "forced" to retire), the present-participle approach to naming flows, or variables affecting flows, can emphasize the stakeholders' perspective and perceived locus of control for modifying an accumulation level.

More from social science theories

Asking stakeholders to articulate policies in their own verbs gives people opportunities to engage in sensemaking, which is inherently social and ongoing and action-focused (Weick, 1995). Weick's theory of sensemaking, drawing on Blumer's and Garfinkel's work as well as that of other social theorists, supports

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the attention to verbs described above. Garfinkel asserted that people discover the nature of their situation *as they act* in it (Garfinkel, 1967, also cited in Weick, 1995, Chap. 1). "Sensemaking is clearly about an activity or process" (Weick, 1995, p. 13). Enactment, a key property of Weick's sensemaking, "is first and foremost about action in the world, and not about conceptual pictures of that world" (1995, p. 30). Furthermore, asking stakeholders to explain the possible range of consequences of implementing model-informed policies in situated terms leads to storytelling, with themselves and their social identities as expressed in the problem space as actors. Such storytelling can advance collective sensemaking by aiding social cohesion as people explore novel approaches (Bietti et al., 2019) to causally address the problem.

While many undertaking participatory modeling use boundary-object approaches in constructing system dynamics representations (Black, 2013; Black & Andersen, 2012), these approaches can inform efforts to implement modeling analysis insights as well. Visual representations function as boundary objects (Carlile, 2002; Star & Griesemer, 1989) to the extent they are sufficiently concrete (tangible or realistic), portray dependencies among those involved, and remain transformable by all as conversations about the representations reveal new questions and understandings. By listening carefully to stakeholders' language and asking questions to understand their terms, we help participants "see" themselves in the system. By giving them the pens to draw, starting with hand-drawn rather than computerized graphics (because messy hand-drawn graphics invite "fixing" and further refinement), and by unabashedly altering our own representations based on stakeholders' input, we help stakeholders iteratively move from "how things relate to me" to "how things relate to other things." While using system dynamics representations as boundary objects unfolds on the abstract plane, repeatedly linking the more abstract images to their experiential understanding can help stakeholders move with insight from model-informed policies to the plane in which they can take concrete actions.

Strategies for solving problems emerge from "framing contests" (Kaplan, 2008), and framing focuses on understanding the problem, proposing a solution, and motivating people to act on it (Benford and Snow, 2000). Stakeholders bear the challenge of constructing and agreeing on framings that help not only themselves but also others outside the original initiative to make sense of proposed actions to address the problem. Mental and computer-based simulations catalyze conversations about steps to remediate the problem, as well as expand perspectives on possible consequences of those solutions (which, in turn, often create other challenges). Therefore, analysis must lead not only to articulating policies as doable verb phrases but also to introducing possible frames for stakeholders to speak and act in ways that resonate emotionally and make *more* sense of existing frames in the problem context (Lakoff, 2010). We have seen generative conversations emerge when we asked stakeholders to meet as groups to talk about how to move key variables in desired directions (Steinbruner, 2002). This invites stakeholders to carry abstract representations back to the concrete realm and discuss situated actions that can shift problem dynamics in the direction they hope.

Problems persevere because we draw on tried-and-true repertoires of actions (Steinbruner, 2002) that ensure they are never really solved. Argyris (1990) asserted that, when we do not achieve the results we desire with our actions and conversations, we recognize "error," or mismatches between our intentions and

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results. He described single-loop learning as focused on modifying our actions in hopes of reducing errors and achieving outcomes closer to our intended results. When that does not work, however, a more effective, though more difficult, strategy centers on reconsidering the *values* governing our actions, double-loop learning (Argyris, 1990). The *process* of building explanatory understanding—systemic understanding that shows connections among events or elements that seem far removed in place and time—casts our actions in a broader context, and usually over longer time horizons than we customarily consider. The process can therefore bring into the realm of choice new possibilities for action and broader action strategies, what we might call verbs that reveal what we value in the long term. When we expand our action strategies, we consider verbs we deemed infeasible before, effectively increasing our capacities to act. Reconsidering the values with which people view a situation introduces new verbs to the action repertoire, expanding the collection of verbs they believe they can do.

This boon to problem solving, though, can still remain abstracted from the situation giving rise to the problem. Stakeholders (with our help, we hope) must resituate solution strategies, with new verbs, in space and time. Navigating down ladders of abstraction to the plane of actual activity, therefore, does not simply reverse-translate explanatory understanding into the same old experiential-understanding verbs. It requires articulation of new verbs in light of an expanded view of cause and effect and a broader view of values, perhaps in newly constructed frames of what is happening in the problem space and why.

Coda

When we taught strategic planning and scenario planning to people working full-time in humanitarian aid organizations, we reminded students that the only strategy that people can act on is the *one in their heads*. Regardless of what is published on the organization's website or what sits in the big binder at headquarters, people act from their respective positions only on their own internalized understanding of the organization's plans. Likewise, people do not implement models or modeled polices. They implement their understandings of modeled policies. How do we get model insights implemented? The approaches described here center on navigating between concrete and abstract planes and rendering system dynamics representations in stakeholders' terms focused on their capacities to act. Inviting stakeholders to interact iteratively with each other and with system dynamics representations assists in socially constructing agreements on how to act jointly, with insight. We hope others in the system dynamics community will share their approaches and experiences, as collectively we use system dynamics' powerful representations and what we understand about social processes of cognition and sensemaking to support the people who implement change.

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Biographies

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