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Evaluation Community of Learning, Inquiry, and Practice about Systems (ECLIPS) Resource Document: Generic System Structures Potentially Relevant to SEEs Evaluations (Working Document)

Introduction

This document provides information about generic systems structures (also referred to as system archetypes) taken from Meadows (2008) and Anderson and Johnson (1997)[1]. The information in the tables is quotes from these documents. The causal loop diagrams are taken from Anderson and Johnson (1997).

Space is provided for you to indicate the relevance of this archetype to the situation that you are evaluating; H = high relevance; M = medium relevance; L = low or not sure. This document is intended to help STEM education evaluators look at their project in light of these frequently observed system structures that can indicate systemic problems or opportunities.

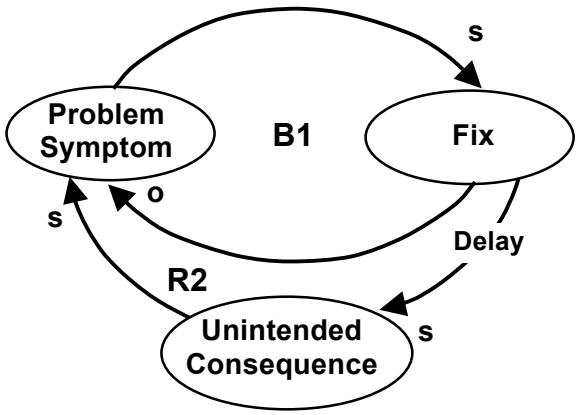
[1] The statements in regular typeface about problem-generating structures, traps, and ways out are all quotes from Meadows, D. (2008). *Thinking in systems.* White River Junction, VT: Chelsea Green Publishing Company. All statements are found in chapter 5 except for *Limits to Growth* which is drawn from pp. 59-61.
Statements in italics are from Anderson, V., and Johnson, L. (1997). *Systems thinking basics: From concept to causal loops.* Waltham, MA: Pegasus Communications, Inc.

I. Fixes that Fail (Policy Resistance)

Problem-Generating Structures	The Trap	The Way Out
The system is intractably stuck, producing the same behavior every year. Policy resistance comes from the bounded rationalities of the actors in the system, each with his/her/its goals. *The "Fixes that Fail" archetype states that a "quick-fix" solution can have unintended consequences that exacerbate the problem. It hypothesizes that the problem symptom will diminish for a short while and then return to its previous level, or become even worse over time.*	Each actor monitors the state of the system with regard to some important variable (e.g., income, price) If there is a discrepancy, each actor does something to correct the situations. Usually the greater the discrepancy between the goal and the actual situations, the more emphatic the action. The goals of the subsystems are different from and inconsistent with each other. When various actors try to pull a system stock toward various goals, the results can be policy resistance. Any new policy, especially if it's effective, just pulls the stock farther from the goals of the other actors and produces additional resistance, with a result that no one likes but that everyone expends considerable effort in maintaining.	Let go. Bring in all the actors and use the energy formerly expended on resistance to seek out mutually satisfactory ways for all goals to be realized—or redefinition of larger and more important goals that everyone can pull toward together. Find way to align the various goals of the subsystems.

Causal Loop Diagram I:

Fixes that Fail



Relevance to Your Evaluation

II. Rule Beating

Problem-Generating Structures	The Trap	The Way Out
Wherever there are rules, there is likely to be rule beating, i.e., evasive action to get around the intent of a system's rules—abiding by the letter but not the spirit of the law. Produces the appearance of following rules.	Rules to govern a system can lead to rule beating—perverse behavior that gives the appearance of obeying the rules or achieving the goals but that actually distorts the system. Becomes a problem only when leads a system to large distortions, unnatural behaviors.	Design, or redesign, rules to release creativity not in the direction of beating the rules but in the direction of achieving the purpose of the rules.

Causal Loop Diagram II:

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III:

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Success of A

Success of B

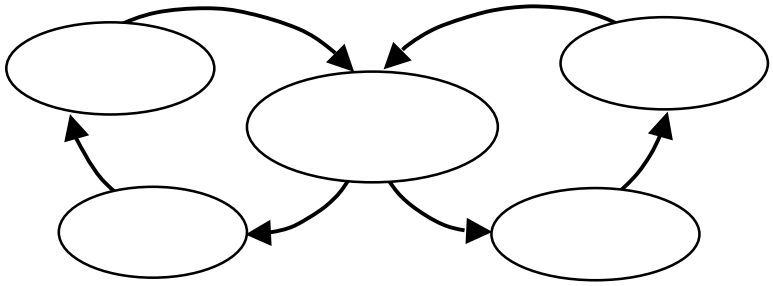
Relevance to
Your Evaluation

s R1 Allocation to A instead of B R2 s

III. Success to the Successful—Competitive Exclusion

Resources to A s o Resources to B

Problem-Generating Structures	The Trap	The Way Out
Using accumulated wealth, privilege, special access, or inside information to create more wealth, privilege access, or info . When winners of a competition receive, as part of the reward, the means to compete even more effectively in the future. *The "Success to the Successful" archetype states that if one person or group (A) is given more resources than another equally capable group (B), A has a higher likelihood of succeeding. The archetype hypothesizes that A's initial success justifies devoting more resources to A, further widening the performance gap between the two groups over time.*	If the winners of a competition are systematically rewarded with the means to win again, a reinforcing feedback loop is created by which, if it is allowed to proceed uninhibited, the winners eventually take all, which the losers are eliminated.	Diversification, which allows those who are losing the competition to get out of that game and start another one; strict limitation on the fraction of the pie any one winner may win (antitrust laws); policies that level the playing field, removing some of the advantage of the strongest players or increasing the advantage of the weakest; policies that devise rewards for success that do not bias the next round of competition.



IV. Seeking the Wrong Goal

Problem-Generating Structures	The Trap	The Way Out
The most powerful ways to influence the behavior of a system is through its purpose or goal. It's the direction setter of the system, definer of discrepancies that require action, indicator of compliance, failure, or success toward which balancing feedback loops work.	System behavior is particularly sensitive to the goals of feedback loops. If the goals—the indicators of satisfaction of the rules—are defined inaccurately or incompletely, the system may obediently work to produce a result that is not really intended or wanted. Systems produce exactly and only what you ask them to produce. Be careful what you ask them to produce.	Specify indicators and goals that reflect the real welfare of the system. Be especially careful not to confuse effort with result or you will end up with a system that is producing effort, not result.

Delay
Symptomatic Solution
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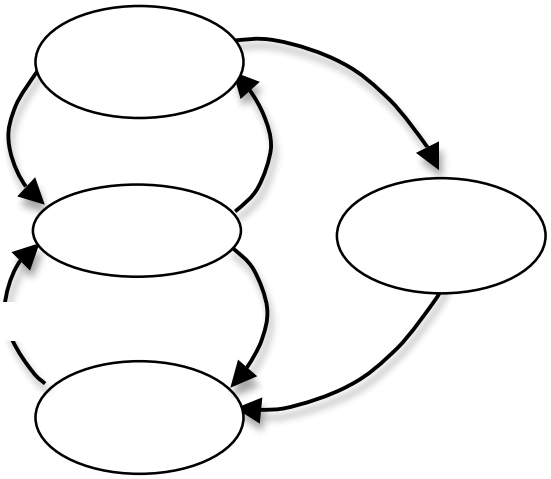
Relevance to Your Evaluation
Problem Symptom
B1
s
o
R3
Side-effect
o
B2
s
Fundamental Solution
o

V. Shifting the Burden to the Intervener—Addiction

Problem-Generating Structures	The Trap	The Way Out
Dependence of an industry of subsidies fits here, reliance of farmers on fertilizer; a stock is maintained by an actor adjusting inflow or outflow and then comparing stock to goal when stock has been artificially adjusted Substance dulls perception or policy hides the underlying trouble, drug of choice interferes with actions that could solve real problem. *The "Shifting the Burden" archetype states that a problem symptom can be resolved either by using a symptomatic solution or applying a fundamental solution. The archetype hypothesizes that once a symptomatic solution is used, it alleviates the problem symptom and reduces pressure to implement a more fundamental solution. The symptomatic solution also produces a side effect that systematically undermines the ability to develop a fundamental solution or capability.*	Shifting the burden, dependence, and addiction arise when a solution to a systemic problem reduces (or disguises) the symptoms, but does nothing to solve the underlying problem. If the intervention designed to correct the problem causes the self-maintaining capacity of the original system to atrophy or erode, then a destructive reinforcing feedback loop is set in motion. The system deteriorates; more and more of the solution is then required. The system will become more and more dependent on the intervention and less and less able to maintain its own desired state.	Dependence of an industry of subsidies fits here, reliance of farmers on fertilizer; a stock is maintained by an actor adjusting inflow or outflow and then comparing stock to goal when stock has been artificially adjusted Substance dulls perception or policy hides the underlying trouble, drug of choice interferes with actions that could solve real problem.



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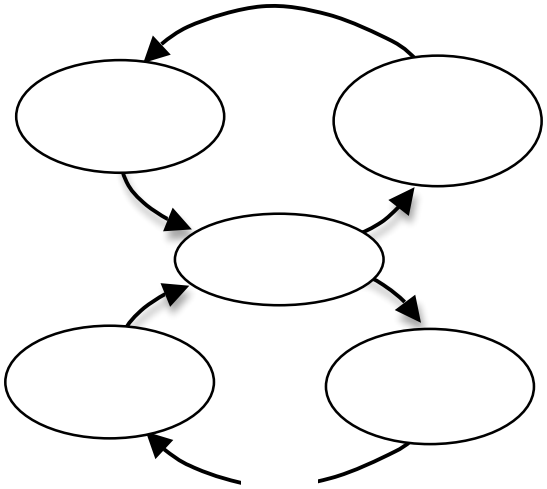
Relevance to
Your Evaluation

VI. Drift to Low Performance (Eroding Goals)

Problem-Generating Structures	The Trap	The Way Out
Some systems not only resist policy and stay in a normal bad state, they keep getting worse. *The "Drifting Goals" archetype states that a gap between a goal and an actual condition can be resolved in two ways by taking corrective action to achieve the goal or by lowering the goal. It hypothesizes that when there is a gap between the goal and the actual condition, the goal is lowered to close the gap. Over time, the continual lowering of the goal will lead to gradually deteriorating performance.*	Allowing performance standards to be influenced by past performance, especially if there is a negative bias in perceiving past performance, sets up a reinforcing feedback loop of eroding goals that sets a system driving toward low performance.	Keep performance standards absolute. Even better, let standards be enhanced by the best actual performances instead of being discouraged by the worst. Use the same structure to set up a drift toward high performance. (Set absolute standards.) (The better things get, the harder I'm going to work to make them even better instead of: The worse things get, the worse I'm going to let them get.)

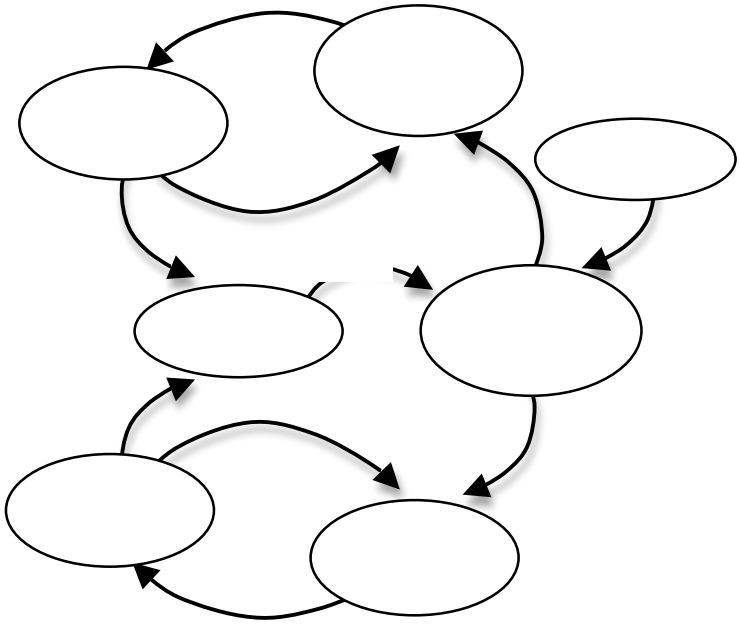


B3 s s Relevance to Your Evaluation
Net Gains for A B4 Resource Limits
A's Activity R1

VII. Tragedy of the Commons

Problem-Generating Structures	The Trap	The Way Out
This comes about when there is escalation, not just simple growth, in a commonly shared, erodible environment. The resource must be not only limited, but erodible when overused. *The "Tragedy of the Commons" archetype identifies the causal connections between individual actions and the collective results (in a closed system). It hypothesizes that if the total usage of a common resource becomes too great for the system to support, the commons will become overloaded or depleted, and everyone will experience diminishing benefits.*	When there is a commonly shared resource, every user benefits directly from its use, but shares the costs of its abuse with everyone else. Therefore, there is very weak feedback from the conditions of the resource to the decisions of the resource users. The consequence is overuse of the resource, eroding it until it becomes unavailable to anyone.	Educate and exhort the users, so they understand the consequences of abusing the resource. And also restore or strengthen the missing feedback link, either by privatizing the resource so each user feels the direct consequences of its abuse or (since many resources cannot be privatizing) by regulating the access of all users to the resource.

Delay
Gain per Individual Activity
Total Activity
B's Activity R2
Net Gains for B



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Activity by A
A's Threat Results to A
s
Results of A Relative to B
o s
B's Threat Results to B
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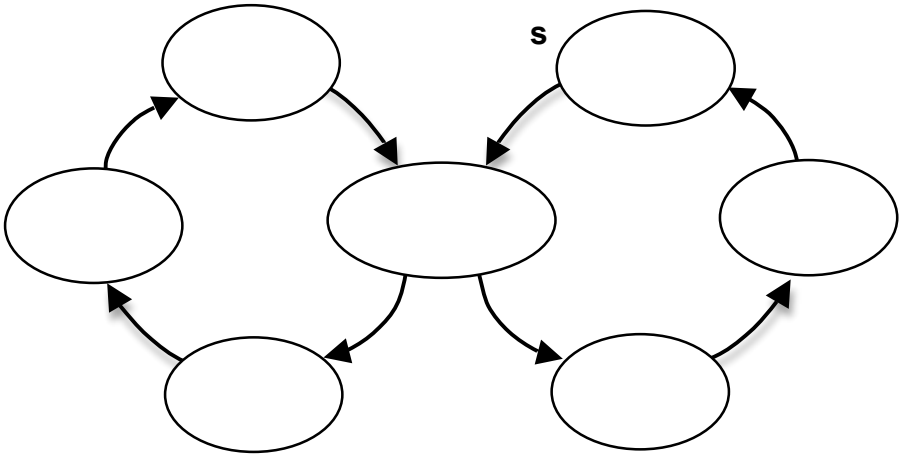
Activity by B
s
Relevance to Your Evaluation

VIII. Escalation

Problem-Generating Structures	The Trap	The Way Out
"I'll raise you one" is the decision rule that leads to escalation—a reinforcing loop set up by competing actors trying to get ahead of each other; goal of one part of system or actor is not absolute but related to the state of another part of the system/another actor. *The "Escalation" archetype occurs when one party's actions are perceived by another party to be a threat, and the second party responds in a similar manner, further increasing the threat. The archetype hypothesizes that the two balancing loops will create a reinforcing figure 8 effect, result in threatening actions by both parties that grow exponentially over time.*	When the state of one stock is determined by trying to surpass the state of another stock—or vice versa—then there is a reinforcing feedback loop carrying the system into an arms race, a wealth race, a smear campaign, escalating loudness, escalating violence. The escalation is exponential and can lead to extremes surprisingly quickly. If nothing is done, the spiral will be stopped by someone's collapse—because exponential growth cannot go on forever.(not just keeping up but keeping ahead of Joneses)	The best way out of this trap is to avoid getting in it. If caught in an escalating system, one can refuse to compete (unilaterally disarm), thereby interrupting the reinforcing loop. Or one can negotiate a new system with balancing loops to control the escalation. (This seems to be the case more in personal, political power struggles)



IX. Limits to Growth

Problem-Generating Structures	The Trap	The Way Out
In physical, exponentially growing systems, there must be at least one reinforcing loop driving the growth and at least one balancing loop constraining the growth, because no physical system can grow forever in a finite environment. Nonrenewable resources are stock-limited. Renewable resources are flow-limited. *The "Limits to Growth" archetype states that a reinforcing process of accelerating growth (or expansion) will encounter a balancing process as the limit of that system is approached. The archetype hypothesizes that continuing efforts will produce diminishing returns as one approaches the limit.*	Possible behaviors for this renewable resource system (see page 71): • overshoot and adjustment to a sustainable equilibrium • overshoot beyond that equilibrium followed by oscillation around it, and • overshoot followed by collapse of the resource and the industry dependent on the resource.	Arrange the structures and conditions to reduce the probability of destructive behaviors and to encourage the possibility of beneficial ones. *[Note from Anderson and Johnson (1997): ... a reinforcing process of accelerating growth (or expansion) will encounter a balancing process as the limit of that system is approached. The archetype hypothesizes that continuing efforts will product diminishing returns as one approaches the limit.*