CORNELL
POLICY REVIEW

Learning Systems Thinking at the Graduate Level

ABSTRACT:

Systems thinking is increasingly popular and has been applied in different fields. We explain that four simple rules underlie the plurality of systems thinking methods, and that these rules can be effectively taught and learned in a reasonable amount of time. Seeking to augment our work with teaching the four simple rules of systems thinking—DSRP or making distinctions and recognizing systems, relationships, and perspectives—to a diverse array of audiences, we offered a brief course on systems thinking for public policy students with no previous exposure to the field. These students read our book and applied DSRP to their ongoing research, with the result being 10-minute TED-style talks and the papers in this special issue. Students applied systems thinking to a wide array of problems, and they reported finding DSRP transformative for their work. We discuss implications for future research on the utility of relatively brief exposure to systems thinking rules for those who work on complex problems in and outside academia.

INTRODUCTION

As a field of study, systems thinking attempts to more fully understand and thus propose better solutions to the wicked problems we face.[1] Wicked problems are complex, interdisciplinary problems characterized by high stakes and uncertainty and involving competing interests. In a study of faculty from across disciplines, Cornell professors were

asked to identify the most pressing crises facing humanity and then rate how solvable and how important those crises were.[2] Faculty chose “climate change and its effect on ecosystems” as the most important and “loss of civil liberties in the US under the guise of fighting terrorism” as the most solvable. Significantly, the crises deemed most important and pressing were also rated as being the least readily solved, and those most easily solved were ranked as having lesser importance.[3]

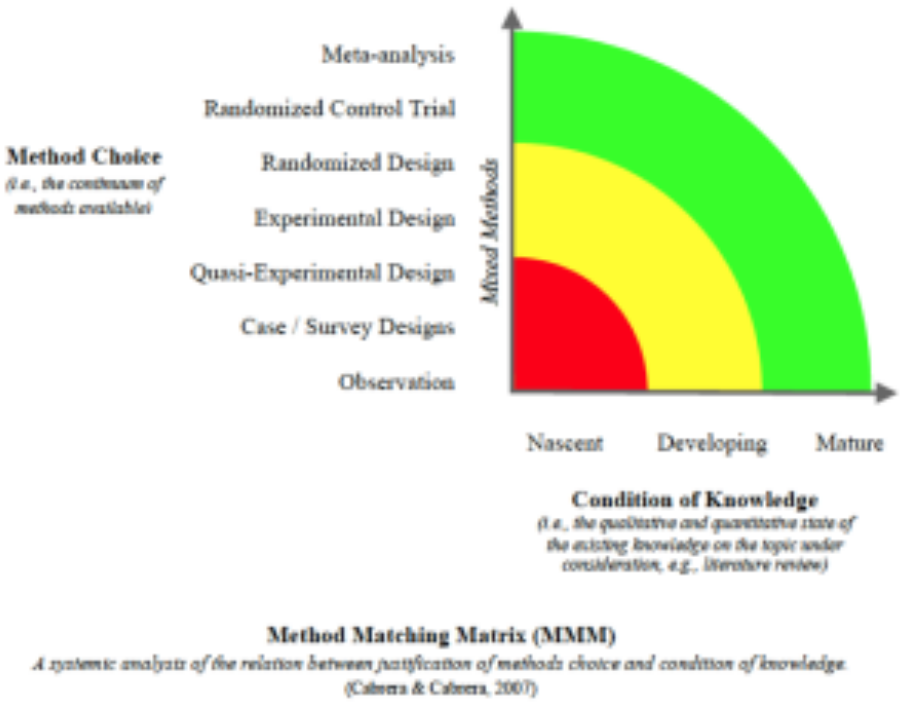
After multidimensional scaling and cluster analysis of the results, the 216 identified crises could be reduced to 7 crisis areas: environment and resources, health and disease, education and technology, influence, social institutions, human nature/perspective, and economics and poverty. But the greatest take-away from the research was that the “meta” crisis is one of perception (i.e., thinking). As we argue in the book that was the subject of this course, “[w]icked problems result from the mismatch between how real-world systems work and how we think they work.”[4] Wicked problems—complex ones not easily solved—are the purview of systems thinking and the subject of the papers in this issue.

A CASE STUDY IN SYSTEMS THINKING

Our work has focused on making systems thinking publicly accessible,[5] beginning in the field of primary education[6] and business.[7] We have built an extensive knowledge base on the process and outcomes of teaching systems thinking to students, businesses, and other organizations. Offering an abbreviated course on systems thinking through the Cornell Institute for Public Affairs gave us the opportunity to introduce systems thinking as an analytical method to policy professionals, and to see how systems thinking influenced their ongoing work on a diverse array of policy-relevant issues.

While systems thinking has been applied in a variety of fields such as education,[8] public health,[9] evaluation,[10][11] and organizations,[12] we know less about its application in the social sciences and public policy arenas. There is a need to study the effects on policy-oriented scholarship of offering advanced students a brief introduction to systems thinking. Accordingly, this course and its effects on the work of public affairs students can be viewed as a case study—the mode of study most appropriate when the state of knowledge in a field is relatively low (see the method matching matrix in Figure 1 below).[13] The method matching matrix presents a systemic analysis of the relation between justification of methods choice and the condition of knowledge in any field. The y-axis in Figure 1 represents a continuum of research methodologies, ranging from observational techniques; case studies or surveys; quasi-experimental designs that lack randomization; experimental designs; randomized control trials; and meta-analysis that reviews, analyzes, and synthesizes existing research. Mixed methods are research designs that combine more than one of these methodologies and mix quantitative and qualitative analysis. The x-axis generally describes the amount of knowledge society has in a particular area or about a particular phenomenon.

Figure 1: Method Matching Matrix



Method Matching Matrix (MMM)
A systemic analysis of the relation between justification of methods choice and condition of knowledge
(Cabrera & Cabrera, 2007)

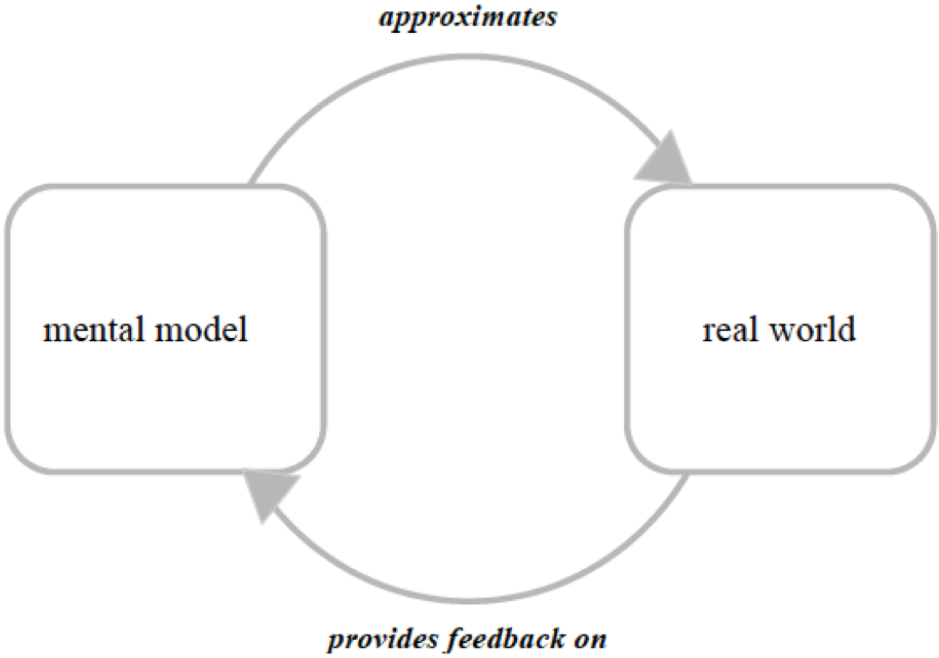
WHAT IS SYSTEMS THINKING?

There are myriad valid frameworks for systems thinking—what many in the field call a "plurality"[14]. But while many systems thinkers have attempted to identify isomorphic patterns that are universal to this plurality of frameworks, none has succeeded in isolating patterns that are as acceptable to the physicist and chemist as they are to the political scientist and economist, let alone of practical utility to the layperson. Today, a theory called DSRP has been accepted by many scholars in the field of systems thinking as universal across systems thinking frameworks. DSRP is an acronym that stands for distinctions, systems, relationships, and perspectives. Preeminent systems thinking historian Gerald Midgley explains it this way: "We have had 100 years of systems research giving rise to literally hundreds of different methodologies… When I saw DSRP, I realized that it broke systems thinking down to the bare essentials: a set of thinking skills. … [S]o it provides a framework for organizing the field."[15]

Because systems thinking originated to promote awareness of our cognitive biases—in our pursuit of both science and a more civil society—systems thinking is by its nature a metacognitive act.[16] Metacognition is the term scientists use for "thinking about one's thinking" or being aware, reflecting upon, and challenging one's thinking. But metacognition has increasingly evolved to denote more specialized and specific awareness of the cognitive structures that give information meaning—the cognitive structures we use and reuse every day to transform information or data into actionable knowledge.

Mental models (sometimes referred to as schema) are the cognitive structures that we build in order to describe or predict the world around us, regardless of what discipline that world "resides in." These mental models are constantly subjected to external pressures based on feedback from our environment (i.e., the real world). It is through this fundamental process that our mental models become (one hopes) increasingly accurate approximations of the real world. This process (see Figure 2) captures the basic procedure of systems thinking, but also of science and human learning.

Figure 2: Feedback Between Mental Models and the Real World



Mental model describes, summarizes, predicts, and leads to behavior in the real world. Real-world consequences inform adaptation (selective effect on viability and on competition among mental models).

Our Mind Builds Mental Models in Four Ways

It is helpful in discussing mental models and DSRP to understand more about how the brain works. The human brain weighs approximately 3 pounds and contains an estimated 100 billion neurons with 100 quadrillion connections between them. Its primary function is to structure data, or process information of any and every sort. Everything around us is information: everything in our environment, on Google, in books; everything people say or do. When your brain performs this structuring, it transforms that information into useable knowledge. Another word for structuring information is "thinking" or cognition.

As previously stated, the building blocks (or rules or patterns) of cognition and systems thinking are four-fold: distinctions, systems, relationships, and perspectives (DSRP). The

mind makes distinctions between things or ideas, organizes things or ideas into part-whole groups, relates ideas and things, and looks at ideas or things from different perspectives. Even though the four patterns are very simple, the brain is very complex—it can do these four things simultaneously and mix and match them to create intricate patterns of thought. We elaborate the DSRP rules below.

The first building block (or rule, or pattern) of systems thinking is distinctions: to make a distinction between an identity (any thing, including any idea) and an "other" (that which is not the identity). Essential to understanding any thing is how we draw or define the boundaries of that thing (or system of things). The boundary we draw while defining a thing simultaneously defines what is not the thing (i.e., the "other"). Important for considering policy issues is the related understanding that all thoughts and ideas have distinct boundaries. This means that making one thought or idea the focal point occurs at the expense of other ideas. While making distinctions simplifies our thinking, it inevitably introduces biases, unless the thinker consciously applies the distinctions rule (i.e., considers the "other").

The second rule of DSRP is systems, which entails ordering ideas into systems of parts and wholes. Every thing or idea is a system due to the fact that it contains parts. Meaning-making is essentially the process of organizing different ideas into part-whole configurations. It is important to be aware that each system can be seen as a part of some larger system. Here the distinction rule comes in, because thinking requires that we make a distinction as to where we stop zooming in to see more and more parts or zooming out to see larger and larger wholes. More generally, thinking entails splitting things up or amassing them together. All things, ideas, and phenomena exist in systems of context. In order to truly understand any phenomenon, we must both analyze the parts separated from the whole and the whole generalized from the parts.

The third rule, relationships, involves identifying relationships of action and reaction among things and ideas. Action and reaction refer to the mutual effects among things. We can have at best a very limited understanding of any thing or system of things unless we examine how the parts are interrelated. Relationship types include feedback, causation, correlation, inputs/outputs, influence, direct/indirect, etc. Being aware of the innumerable relationships or linkages that surround and embed us not only helps us understand physical systems, but also facilitates metacognition and deeper understanding of social dynamics and the interrelation between our thoughts, feelings, and motivations. These metacognitive phenomena are all obviously critical to emotional intelligence, as well.

Finally, the perspectives rule states that we view phenomena from different vantages. Fundamentally, perspectives are constituted by two related elements: a point (from which we see) and a view (that which is seen). Any time we draw a system's boundary, identify its parts, relate those parts, or make any distinction whatsoever, we invariably do so from a particular perspective (often unconsciously).

Employing these four universal rules or structures allows us to build but also deconstruct systems of infinite complexity. While for clarity's sake we enumerate the rules singly, it is

critical to understand that they do not operate in isolation. We can't authentically take a different perspective without first making distinctions. Any system of parts could be organized in different ways—by grouping them differently. We won't get far trying to understand a part-whole system without delineating the relationships it contains. D, S, R, and P are simple rules, but they add up and combine to produce systems of great complexity. Systems thinking frequently operates in the realm of complexity, and DSRP provides straight-forward, practical tools to approach complex situations and problems. Now that we have reviewed the four rules, we can elaborate their usage by systems thinkers.

Three Things Systems Thinkers Do

In our research with K-12, undergraduate and graduate students, and the general public over the last decade, three patterns emerge that show us the *specific* things systems thinkers do, irrespective of topic or context. These habits or actions are also evident in the papers that follow.

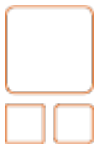
1. They are metacognitive. Systems thinkers are cognizant of their thinking processes and understand that we constantly construct and evolve knowledge into mental models that are approximations of reality. They habitually do the following:

- Factor mental models into the discussion of things, thereby calling into question accepted constructs, providing new constructs, and making explicit the evolving and approximate nature of mental models (versus the static permanence of facts);
- Contemplate the often invisible mental models that lead to visible behavior of actors or agents;
- Think about complex adaptive systems (CAS) and look for the rules followed by independent agents that collectively lead to large-scale emergent phenomena; and
- Struggle through the intricacy of complex mental models to identify leverage points or to organize them in a new way that causes the models to be simpler and easier to comprehend.

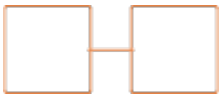
2. They use the four building blocks of systems thinking (DSRP). All of the papers used DSRP to guide their analyses.

- Systems thinkers make distinctions (identity-other) between and among things and ideas. They consciously use distinctions to challenge existing norms, labels, and definitions and to identify biases in the way information is structured.

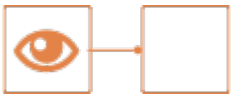
- Systems thinkers know that changing the way ideas are organized changes meaning itself. They constantly consider *context* by asking "what is this a part of?" in order to see how things fit into larger wholes than is normally done.



- They identify relationships (action-reaction) between and among things and ideas. Systems thinkers use relationships to show dynamical interactions between things and ideas, including feedback loops to show reciprocal relations.

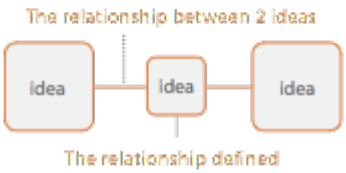


- They look at ideas from different perspectives (point-view) and understand that every time we make a distinction (including identifying relationships and systems), we are doing so from a particular perspective. Systems thinkers use perspectives to rethink distinctions, relationships, and/or systems. They move beyond human or animal perspectives (i.e., "perspectives with eyes") by taking conceptual perspectives (i.e., seeing a phenomenon from the perspective of an idea or thing).



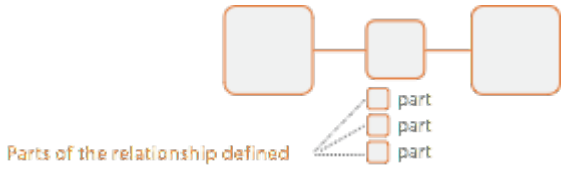
3. They Mix and Match the Four Building Blocks. Even though the four patterns or building blocks (DSRP) are quite simple, the brain is rather complex: it utilizes D, S, R, and P simultaneously and in combination to create intricate thought patterns. Systems thinkers frequently mix and match in the following ways:

- Combine R and D: make a relationship a distinction, which means defining relationships as ideas or things rather than just noting connections between objects (i.e., "R-things");

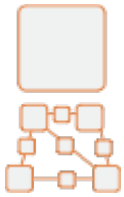


- Combine R, D, and S: after distinguishing relationships, "zoom into them" by deconstructing them into part-whole systems (i.e., RDS, which means relate two

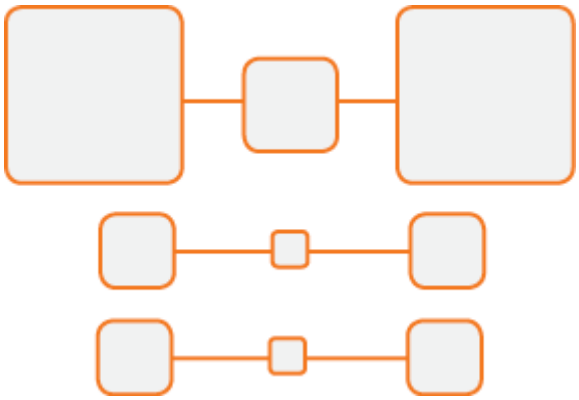
things, distinguish or identify the relationship, and systematize or recognize its parts as belonging to a system);



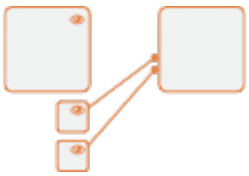
- Combine R and S (intra-system): see the organization of parts and the interrelationships between parts (i.e., “part parties”) in a novel way;



- Combine R and S (inter-system): use relational channels or “R-channels” to compare the relationship between two wholes by comparing the relationships between their parts;

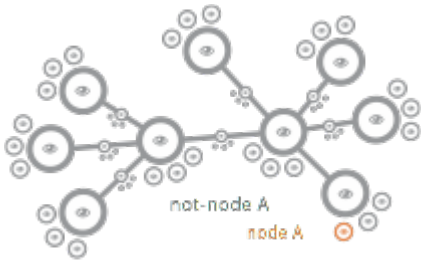


- Combine P and S: break down perspectives into sub-perspectives in order to avoid the homogenous perspective thinking error (i.e., assuming any group is characterized by a single perspective);



- Combine P, S, and D: see that distinct objects or ideas can be grouped/related in various ways according to a perspective, and thereby avoid thinking errors brought about by categorizing; and

- Combine P, S, R, and D: realize every complex topic or phenomenon is a massively relational, perspectival network where: (A) every edge (line indicating a relationship) could be a distinguished node (the object connected by a relationship); and (B) where every node must be distinguished, could be a system in and of itself, could be a perspective (point or view), and could be related to or the relationship between other elements.



ABOUT THE SPECIAL ISSUE

The papers that follow are the work of graduate fellows in policy analysis—incorporating a diverse array of policy interests and topics—who were exposed to a short course on systems thinking. The instructional aspect of the course involved reading the book *Systems Thinking Made Simple*[17] and 17.5 contact hours. Students were then asked to apply what they learned to their policy topic of choice, with particular attention paid to the ways in which systems thinking changed or did not change their analytical approach. The result was a 10-minute "TED-style" talk and a short paper for this special issue. The rationale for the course and its assignments was quite simple. Systems thinking as a field is quite popular and makes many claims as to its promise. We wanted to examine that promise, specifically with respect to the advanced work of graduate students in public policy.

In order for systems thinking to deliver on its promises, it should be three things:

1. Applicable to a wide variety of topics and interests (i.e., transdisciplinary);
2. Teachable and learnable in a reasonable period of time; and
3. Demonstrably impactful and useful.

All three are important, because the promise of systems thinking is predicated on its being universally applicable for deeper understanding and solving of problems across the disciplines. But this application needs to come at a reasonable cost (in terms of learning) and demonstrable impact. We were particularly interested in graduate students because they are investing their time in learning but also have many competing demands for their limited time. They are also the policy makers and innovators of the future. What models should they spend their time learning that will have the greatest impact? We knew that systems thinking showed promise, but we wanted to see how much. We argue that systems thinking is interdisciplinary and even universal. As noted in the first criterion, it

must therefore be applicable to many different domains. Granted these papers all employ policy approaches, but the areas of application (from animal conservation to poverty to climate change) are quite diverse.

The second criterion relates to how much time is necessary to master the approach. We all know that some methodologies and approaches take as much time to learn and master as the topic of study to which they are applied. While systems thinking is something one can take a lifetime to master, it must also be possible to teach and learn relatively quickly for the above reasons. Obviously, less time spent for more impact is better. As a group, students learned the four simple rules of systems thinking in an expedient manner. (The 17.5 total contact hours were composed of approximately 9 hours instructional time, 2.5 hours practice time, 5 hours of student presentations, and the remainder spent on course logistics). Due to the brief nature of the course, multiple students noted the need for additional time to apply systems thinking to real-world problems and to practice using DSRP. As one student wrote: "I would have loved if this was a full semester course. My only wish from this course is that we would have had more time to practice applying DSRP to more issues, including non-policy issues. The book has excellent examples, but practice improves skill! I imagine I will be using DSRP for the rest of my time in academia, even as a Ph.D. student after my masters!"

The third requirement—"useful and impactful"—can be assessed through student reflections (described below) on how systems thinking changed their work, as well as through reading their work itself or watching their presentations. Utility and impact are often comparative in that we are measuring how useful or impactful something is relative to some other thing. In this case, students named a variety of analytical models that they used in examining their topics prior to learning systems thinking. These include SWOT, SOAR, SCOPE, pros/cons analysis, gap analysis, cost/benefit analysis, mind maps, Ishikawa diagrams, and system dynamics. A significant number of students (see Table 1) reported DSRP was more valuable, useful, transformative, and worthy of recommending than these other forms of analysis. DSRP doesn't replace these forms of analysis *per se*, but it can be used to increase the sophistication and systemic skills with which these analyses are performed.

Table 1: Comparison of DSRP and other analytical models of policy students (N=11)

	More	Same	Less
Compared to other approaches or frameworks I've learned, DSRP is _____ valuable.	91%	9%	0%
Compared to other approaches or frameworks I've learned, DSRP is _____ useful.	73%	27%	0%

Compared to other approaches or frameworks I've learned, I think DSRP will be _____ transformative.	91%	9%	0%
Compared to other approaches or frameworks I've learned, I would recommend DSRP _____.	82%	18%	0%

Requirements 2 and 3—"can be learned reasonably quickly" and "demonstrable impact and utility"—create a return on investment (ROI) relationship upon which this case study was premised. So what exactly was the ROI for these public policy students? The preliminary data below reflects students' perceptions of the utility of what they learned.

100% of students agreed or strongly agreed with the following statements:

- Learning DSRP was useful to me as a graduate student.
- I can construct and deconstruct policy-level systems better as a result of DSRP.
- I will recommend DSRP to my colleagues.

91% of students agreed or strongly agreed with the following:

- I would seek out more training in DSRP.
- I understand HOW I think, as a result of learning DSRP.

Finally, 73% agreed or strongly agreed that "In the future, I will use DSRP in every analysis I do."

While the papers that follow contain sufficient detail to better understand the wicked problem each policy fellow was addressing, the focus of each paper is on the ways in which students approached the problem differently as a result of a short course in systems thinking. Thus, the specific topics—all fascinating and important—are merely a medium for the application of systems thinking. This is an important distinction, because as policy students or scientists it is not our ability to solve a problem that matters most but our consistent ability to better understand and solve problems over the course of a lifetime. So the transferability of these skills—across academic and nonacademic domains—is most important.

We also caution you not to view novel, implementable solutions to each of the addressed problems as constituting litmus tests for the ROI of systems thinking. This was a short course and the time to focus on the problems selected was measured in hours, not weeks. Solving the issue of poverty in Panama or traffic in Delhi will likely take some time. Accordingly, the litmus test should be whether novel thinking was applied to the problem through the use of systems thinking.

Students appeared to find the idea of the mismatch between our mental models and how the world actually works to be a powerful idea. In fact, many students critiqued their own

mental models of the problems they have been studying for some time. Specifically, students reported deriving the greatest utility from advanced applications of the systems rule and from deep understanding of mental models and their relation to real-world conditions. For example, 73% rated the following systems thinking skills as being most useful (a 5 on a 5-point scale):

- After distinguishing relationships, zooming into them by deconstructing them into part-whole systems (i.e., RDS);
- Consideration of a wider context of my issue (e.g., how things fit into larger wholes than is the norm); and
- Factoring "mental models" into the analysis and discussion of things (e.g., questioning accepted constructs and providing new constructs).

The next most highly rated skill in terms of usefulness was "contemplating the often invisible mental models that lead to visible behavior of actors or agents." This emphasis on mental models extended to students' introspection into their own mental models of the problems they were addressing, sometimes in ways that entirely transformed their approaches to the problems. With regard to the four patterns, students rated D, S, R, and P about equally in terms of their importance for their analyses.

CONCLUSION

An increasingly popular area of study, systems thinking includes an immense and diverse array of theories, methods, and approaches, yet four simple rules (DSRP) underlie the entirety of the field.[18] This case study was designed to explore the promise and return on investment of learning systems thinking. DSRP provides all thinkers—graduate policy scholars and everyday citizens alike—invaluable analytical tools for understanding, explaining, and ultimately crafting solutions to all sorts of problems across substantive realms. We have previously taught DSRP to preschoolers and to advanced practitioners and entrepreneurs in an array of formal and informal settings.

The authors of the articles in this special issue—advanced public policy students with no previous exposure to systems thinking—read a book and took an abbreviated course on systems thinking. Given the utility of this treatment for their work, what would be required to permanently alter the course of their study and future scholarship (and that of other advanced scholars)? To build upon the insights we gained from this course, we will be doing more formal research involving fellows who receive online training and in-person support to apply systems thinking to their ongoing research. This effort is part of the USDA-NIFA funded ThinkWater program that is teaching systems thinking to individuals of all ages to increase their understanding of and caring about water issues in our country.[19]

This case study significantly contributes to the level of knowledge about the application of DSRP to (1) the work of advanced scholars with significant constraints on their time; (2) a diverse array of substantive topics; and (3) policy-relevant issues. In addition, teaching DSRP to the subjects of this case study—public policy students—gave us the

opportunity to prepare future decision makers to be more aware of their own thinking, more open to many perspectives, and more innovative in seeking solutions to critical problems. This case study has implications for future efforts to teach systems thinking to advanced scholars in higher education—from undergraduates to mid-career professionals to senior professors. It represents a promising start and an invitation for additional research.

The application of DSRP yields more than analytical and problem-solving skills. Most significantly, the conscious application of these rules also generates a number of highly desired skills, including emotional intelligence (e.g., the ability to collaborate with others, to empathize) and an array of IQ-type skills (e.g., enhanced critical thinking and problem solving).[20] These qualities generally contribute to the development of prosocial individuals, which is valued not only in the policy arena, but in all aspects of life.

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13. This study was not designed as a formal treatment and there were not “controls,” except in the sense that these students applied systems thinking to issues on which they had previously worked, allowing them to address how learning systems thinking altered their approach and analysis. ↑
14. Derek Cabrera, “Systems Thinking” (Ph.D diss, Cornell University, 2006); Cabrera and Cabrera, *Systems Thinking Made Simple*; Gerald Midgley, ed., *Systems Thinking* (Thousand Oaks, CA: Sage Publications, 2003). ↑
15. Gerald Midgley, “An Introduction to Systems Thinking for Tackling Wicked Problems.” Lecture presented at Systems Thinking v.2.0 conference, Cornell University, Ithaca, NY, December 3, 2014. ↑
16. Derek Cabrera, Laura Cabrera and Erin Powers, “A Unifying Theory of Systems Thinking with Psychosocial Applications,” *Systems Research and Behavioral Science* 32, no. 5 (September/October 2015): 534-45. ↑
17. Cabrera and Cabrera, *Systems Thinking Made Simple.* ↑
18. Cabrera and Cabrera, *Systems Thinking Made Simple.* ↑

19. ThinkWater is funded by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Agreement No. 2011-51130-31148. ↑
20. Cabrera, Cabrera, and Powers, “A Unifying Theory of Systems Thinking with Psychosocial Applications.” ↑