STATE OF THE WORLD

# EarthEd

## *Rethinking Education on a Changing Planet*


THE WORLDWATCH INSTITUTE

CHAPTER 12

# All Systems Go! Developing a Generation of "Systems-Smart" Kids

*Linda Booth Sweeney*

Try this: Find a young person between the ages of four and twenty-four. Show them a picture of a cow and ask, "If you cut a cow in half, do you get two cows?" Even the four-year-old will shout, "No way!" Children understand that a cow has certain parts—hearts, lungs, legs, brain, and more—that belong together and have to be arranged in a certain way for the cow to live. You cannot have the tail in the front and the nose in the back.[1]

As adults, it is easy to miss this simple truth: a cow is a complex, living system, in the same way that the human body, a family, a classroom, a community, an organization, or an ocean is. A system is composed of parts and processes that interact over time—often in closed-loop patterns of cause and effect—to serve some purpose or function. Living systems, unlike a collection or "heap of stuff," share similar characteristics. In systems, it matters how the parts are arranged. That is why a cow cannot have the tail in the front and the nose in the back. And why a stomach does not work on its own, and the body does not work without a stomach. And systems often are connected to or nested within other systems (for instance, a person may be nested within a family, school, ecosystem, community, and nation).

## Making the Shift: Systems as Context

Sounds simple, right? But here is the challenge: much of today's education remains focused on discrete disciplines—for example, math, science, and English. Science is taught in one class. The bell rings. The student moves on

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to math and then, perhaps, to English—and never the twain shall meet. Such a fragmented approach reinforces the notion that knowledge is made up of many unrelated parts, leaving students well-trained to cope with obstacle-type or technical-based problems but less prepared to explore and understand complex systems issues. (See Box 12–1.) In medicine, for example, obstacle-type problems are those that can be clearly targeted and fixed, such as a broken arm or an acute disease, like appendicitis. A systems approach is more effective for chronic and complex diseases, such as diabetes, where the interaction of factors—lifestyle, family history, environment, etc.—also plays a role.

Issues such as climate change, economic breakdowns, food insecurity, biodiversity loss, and escalating conflict are matters not only of science, but also of geography, economics, philosophy, and history. They cut across several disciplines and are best understood when these domains are addressed together. Students and adults must be able to see such important issues as

**Box 12–1. Teaching Big Systems Ideas**

The following core systems ideas should be taught—where developmentally appropriate—across the grade levels:

- There are such things as systems. A system, unlike a collection or a "heap of stuff," is composed of parts and processes that interact over time to serve some purpose or function.
- Systems, as a whole, can exhibit properties and behaviors that are different from those of their parts.
- Simple systems can work in predictable ways; dynamic systems exhibit more complex and unpredictable behaviors.
- Although different, complex systems share similar patterns of behaviors such as "escalation," "boom and bust," and "limits to growth." These often are called "systems archetypes" or "kernel structures."
- Making systems visible, using tools such as connection circles, behavior-over-time graphs, causal-loop diagrams, stock-and-flow models, and computer simulations, helps students visualize, understand, and test ideas that are applicable throughout science, engineering, history, literature, and more.
- Constructing a simplified model of a system by defining a boundary in which it operates enables students to better understand and predict system behaviors.
- Change occurs through closed loops of cause and effect called feedback loops. There are two types of feedback loops: reinforcing (positive) and balancing (negative), which either amplify or control change.

systems— elements interacting and affecting one another. In the case of climate change, a systems view shows the link between politics, policy (for example, legislation related to carbon emissions and deforestation), the natural sciences (particularly forests, which help stabilize the climate by absorbing heat-trapping emissions from factories and vehicles), and a person's own consumption habits. Without a systems view, the complexity can be daunting, and the result is often policy resistance or, worse yet, polarization and political paralysis.

## When We Don't See Systems

It is no surprise, then, that we often find ourselves tinkering with complex systems without understanding the system—how the key parts of the system are interconnected, or how the interactions of all the parts produce the often puzzling or confounding behavior of the system. Consider, for example, road-building programs that are meant to reduce congestion but that end up increasing traffic, delays, and pollution. Or pesticides that are meant to kill crop-damaging insects but that also kill the "good" insects that are controlling the population of "bad bugs."

We get into trouble when the desire to make the problem go away outweighs the desire to understand the problem or opportunity. In the 1920s, local ranchers in the U.S. states of Montana, Wyoming, and Idaho called for the removal of wolves from Yellowstone National Park. Over the next seventy years, wildlife biologists and park rangers watched as the integrity, or "wholeness," of the Yellowstone ecosystem unraveled. Without a top predator such as the wolf, the populations of deer and elk grew unchecked, which led to overgrazing of shrubs and plants, decreasing the nesting areas for migrating birds, changing the habitat for beaver colonies, and so on.[2]

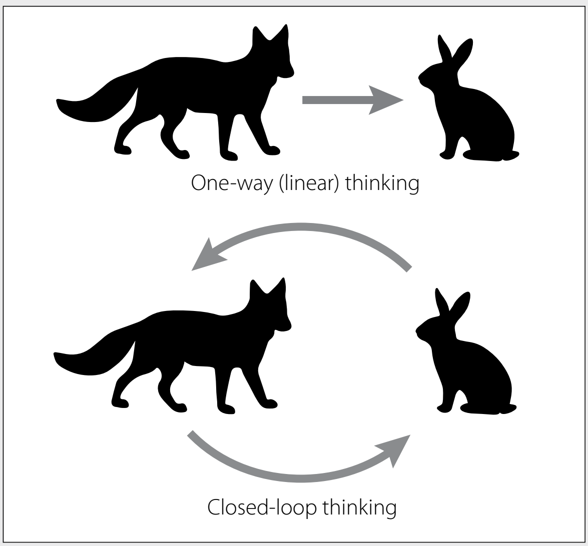
Professor John Sterman at the Massachusetts Institute of Technology argues that these examples of "policy resistance" arise because we do not understand the full range of feedbacks operating in the system. Moreover, in all of the above examples—increasing traffic congestion, the rise of pesticide-resistant bugs, unchecked population growth—these behaviors are not the result of a single event but are produced by the interaction among the elements or individual factors within a system. Or, as the old adage goes, "the whole is greater than the sum of its parts." In systems terms, we call these behaviors "emergent properties."[3]

Decision-making research shows that when adults are faced with dynamically complex systems—containing emergent properties, multiple feedback processes, time delays, nonlinearities, and accumulations—performance is systematically biased and suboptimal. When the scope of the research is broadened to children, studies show that both young people and adults find it difficult to trace causality beyond simple one-way connections, and most do not spontaneously "close the loop" when feedback exists. Said simply, we tend to think in straight lines—"Problem" leads to "Solution"—when, in reality, closed loops of cause and effect exist.[4]

In one study, ten- and eleven-year-old students were asked to describe the relationship between wolves and rabbits. Most participants immediately responded that wolves eat rabbits, end of story. With additional questioning, the students were able to identify the mutual interdependence between rabbits and wolves, commonly called a predator-prey relationship: a relationship that is not one-way or linear, but rather is made up of a closed loop of cause and effect, with births and deaths of one species affecting the population of the other. (See Figure 12–1.)[5]

In addition, we tend to think in terms of immediate outcomes over longer-term effects. Economists have even coined a term—"discount rate"—to designate the extent to which we reduce our concern for future consequences in comparison with current events. If you have a high discount rate, you ignore information about consequences that will manifest themselves more than a few years into the future. This perspective is particularly evident, and damaging, among elected politicians, but we all suffer from it. If people got cancer immediately from smoking, few people would become addicted to cigarettes. But, in this case, the consequence lies decades in the future, so most smokers ignore it and opt for the immediate pleasure of smoking. High discount rates can act against sustainable

**Figure 12–1. Linear versus Closed-Loop Thinking**



development efforts that aim to "meet the needs of the present without compromising the ability of future generations to meet their own needs."[6]

## Learning to Think About Systems

Enter the age of the Anthropocene, the term that many scientists are now using to describe the significant global impact that humans are having on Earth's air, water, and land—or, more specifically, on its interacting systems, including our atmosphere, hydrosphere, biosphere, geosphere, and cryosphere.[7]

How can education—whether in school, on a farm, in a lab, or at the kitchen table—enable the next generations to live sustainably and navigate the radical changes that they are inheriting in this human-dominated epoch? We do not need a specialized degree to answer this question. Common sense tells us that to understand human impact on Earth's systems, we need to understand *systems*. The question then becomes: how can young people develop systems-based skills and "habits of mind"—for example, discerning what is a system and what is not; looking for recurring patterns of relationships across subjects and situations; making systems visible through maps and models; anticipating how the functioning of a living system will change if a part or a process is changed (assuming that nothing stands in isolation); and looking for causes and consequences in a slew of interconnected systems, including families, schools, local economies, the environment, and more?

The good news is that systems education is happening in schools, nature centers, community meeting rooms, board rooms, and even on playgrounds. Perhaps the best way to look at the emerging state of systems education is through the lens of a constellation. Such a view reveals the brilliance of multiple points of light, including: the new face of Earth system science, the rise of "Education for Sustainability," pioneering systems-based curricula, the teacher as systems thinker, innovative out-of-school learning and application opportunities, and the growing demand for corporate and nonprofit "systems leadership." Here, we discuss several of these stellar exemplars, pointing the way toward more-comprehensive systems-based education for all.

## The New Face of Earth System Science

Historically, Earth science as a discipline has taken a back seat in U.S. schools. The more-talented college-track students often pass over Earth science classes, which are perceived to be less rigorous than the Nobel Prize-worthy subjects of physics, biology, and chemistry. But this picture is slowly changing, thanks, in part, to a growing recognition that an understanding of Earth's interconnected systems is critical to our planet's future.

According to the 2007 report *Revolutionizing Earth System Science Education for the 21st Century*, many U.S. states are reshaping their Earth science curricula, standards, and high-school science graduation requirements. These states are "revolutionizing their approaches to Earth science education by moving towards a '21st century' view of Earth science, with an increased focus on Earth as a system, use of new visualization technologies that reveal Earth's processes in powerful ways, recognition of Earth science as a cutting-edge domain of vital importance for our future, and responsiveness to the national call for workforce development."[8]

Since the formation of Earth system science as a discrete yet integrative field of study in the 1980s, the importance of this discipline was reinforced by the creation in 2000 of the Earth System Science Education Alliance (ESSEA). With additional support from the National Aeronautics and Space Administration and the National Science Foundation, ESSEA offers online programs for primary, and secondary, school teachers that are designed to improve the quality of geoscience instruction and to promote an understanding of Earth's interrelated systems. Worldwide, there also is growing interest in teaching "Big History," a systems-based perspective on the origins of Earth and on how humans have come to dramatically transform the planet. (See Box 12–2.)[9]

## The Emergence of Education for Sustainability

Spurred on by the United Nations Decade of Education for Sustainable Development (2005–14), schools, school systems, universities, and education departments in many U.S. states are now incorporating "Education for Sustainability" (EfS), also called "Education for Sustainable Development" (ESD), into curricula and instruction. There is a developing consensus both in the United States and globally that systems thinking is an essential element of sustainability education. Both EfS and ESD use systems thinking to empower "students to make decisions that balance the need to preserve healthy ecosystems with the need to promote vibrant economies and equitable social systems for all generations to come." U.S.-based organizations such as the Center for Ecoliteracy, the Center for Green Schools, the Cloud Institute for Sustainability Education, Facing the Future, and Shelburne Farms, as well as global institutions such as the United Nations Educational, Scientific and Cultural

## Box 12–2. Big History Teaches Systems Thinking and Transforms Worldviews

"Big History," a discipline first developed by historian David Christian, teaches the "origin story" of how humans came to be, based on our best science. A Big History course typically describes Big Bang cosmology, the creation of stars, and the dispersal of new chemical elements from dying stars, enabling the creation of planets. It covers the conditions for the emergence of life on Earth and eventually of our own species.

Many Big History courses identify the distinctiveness of our species as being our capacity for "collective learning," the ability to share ideas so efficiently that the information learned by individuals accumulates in our collective memory from one generation to the next. This creates a level of technological creativity that no other species has been able to match, enabling us to transform our biosphere. Big History also looks ahead, pondering whether humanity—and perhaps other intelligent species throughout the universe—end up growing in power faster than they grow in wisdom, never making it beyond "civilizational adolescence" to maturity, where they find balance with their planetary system and with themselves.

Big History is now taught in a broad range of high schools in Australia, the Netherlands, Scotland, South Korea, and the United States, among others. Its growth in popularity has been aided by the Bill Gates-sponsored Big History Project, which has developed a rich set of teaching resources that are freely available to high school teachers worldwide. The number of high schools with ongoing support by the Big History Project has increased from just a handful in 2012 to well over one thousand in mid-2016. The course is offered in a growing number of colleges as well, and even as an introductory lecture at the Presidio Graduate School (known for its MBA in Sustainable Management). Dominican University in San Rafael, California, has pioneered an undergraduate first semester "Introduction to Big History" course, followed by a broad array of liberal arts courses taught through the lens of Big History.

Learning Big History can transform a student's vision of humanity, which can lead the student to embrace sustainability values and behaviors. Students learn to think across multiple time scales. Their writing skills improve markedly as they learn to think more critically, using evidence to support their points. Perhaps most importantly, learning Big History teaches students to empathize with other peoples' perspectives.

—Dwight E. Collins, Professor Emeritus, Presidio Graduate School

—Russell M. Genet, Research Scholar in Residence, California Polytechnic Institute

—David Christian, Professor of History and Director of the Big History Institute, Macquarie University, Sydney, Australia

*Source: See endnote 10.*

Organization (UNESCO), the International Union for Conservation of Nature (IUCN), and the Swedish International Centre of Education for Sustainable Development share a common goal: for students to apply systems thinking to problem solving and decision making on the road to a sustainable future.[10]

These and numerous other groups provide professional development and coaching to improve teaching and learning for sustainability, working with faculty around the world to develop curricula, lessons, and projects that educate for sustainability. In the United States, at least twelve states and dozens of school districts have embraced policies that promote and support EfS, including California, Colorado, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, Vermont, Washington, and Wisconsin. Globally, the picture is even brighter. In many countries, including Australia, Brazil, Canada, Japan, the Netherlands, New Zealand, Sweden, and Switzerland, ESD is housed within ministries of education.[11]

In the state of New York, for example, the Putnam/Northern Westchester Boards of Cooperative Educational Services Curriculum Center has developed an EfS curriculum that provides multidisciplinary web-based materials to address the question: How are we all going to live well within the means of nature? The curriculum challenges students to think about issues that affect their future—all within the context of their existing curricula in math, language arts, science, social studies, and the arts. The program is being integrated in kindergarten through grade twelve (K–12) classrooms in the region.[12]

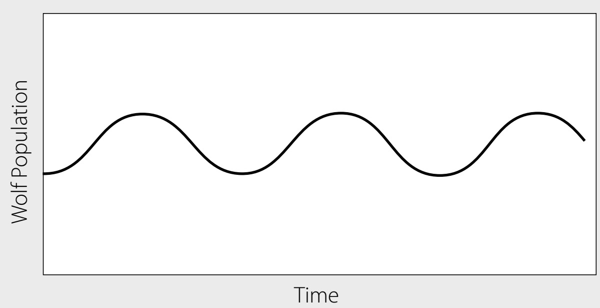
## K–12 Curriculum: Integration and Innovation

Educational standards can act as beacons for schools. Teachers and parents use them to make clear what students are expected to learn in each grade and subject. It is only in the last decade that "understanding systems" has begun to show up in state educational standards. The most recent U.S. science standards feature "patterns," "cause and effect," and "systems and system models," among others, as cross-cutting concepts. Although intended primarily to cut across science disciplines, these concepts also enable students and teachers to recognize recurrent features of complex systems across disciplinary boundaries.[13]

How might this look in a classroom? Imagine that you are a student in a fourth-grade science class. Your teacher tells you that ecosystems, like all dynamic systems, are made up of many cause-and-effect interrelationships. Walking through a national park, you may not be able to see how wolves and rabbits interact, but you learn that these two species are tightly connected in a predator-prey relationship and exist within a closed loop of cause and effect: any change in the circumstances of one species will ultimately influence the other, and vice versa.

You create a graph of the changing wolf population. The general pattern of behavior is one of oscillation, rather than of continued growth or decline. (See Figure 12–2.) Your teacher then asks, "Where else do you see this kind of up-and-down pattern of behavior?" Someone shouts, "Our thermostat!" Another says, "Hungry, eat, not hungry; hungry, eat, not hungry . . . ," and another asks "supply and demand?" The teacher explains: "This type of causal loop, known as a balancing feedback loop, returns a system (such as your household cooling system, your body, or an ecosystem) back to a state of equilibrium. By its very nature, balancing feedback works to self-regulate and self-correct systems, to bring them toward some goal or desired state and keep them there."

**Figure 12–2. Change in Wolf Population Over Time**




Similar cause-and-effect relationships can be introduced in history class. When presenting a unit on U.S. westward expansion, the teacher asks, "What set of interrelationships led to improved agricultural land, drawing settlers out west?" Students map out one set of causal connections, including increased railroad access and new technologies and inventions. They show how innovations such as the mechanical reaper and the steel plow helped convert open range into farmland, which enabled more settlers to work the land, which subsequently drove demand for further technologies that could increase the production and distribution of crops. As even more settlers headed west in search of farmland, driven in part by the promise of the Homestead Act, the amount of territory that was improved for agricultural use grew. In a case of reinforcing feedback, one change amplified another. The teacher then asks: "Where else do you see a similar pattern of behavior?" Students suggest the spread of a rumor or a virus. They are right.[14]

These students are now cued up to recognize these cause-and-effect patterns through analogy—or, more accurately, through "homologies": recurring structural similarities that surface in a wide variety of systems, from ecosystems and families to global politics and the Internet. As writer and cultural anthropologist Mary Catherine Bateson observes:

> Central to the study of ecosystems is the study of circular processes of self-regulation and self-correction. If children grasp the concept of self-regulating systems, they can apply it to systems of all kinds, including the functioning of their own bodies or families, schools or neighborhoods. When an abstract pattern has been recognized in a single memorable example, the possibility of multiple analogy is created. In this sense, ecology offers tools for thinking about why it is unwise to experiment with addictive drugs, about the course of family quarrels, or about damage done by racism.[15]

A compelling example of learning design that bridges disciplinary boundaries while inspiring innovative learning environments could be found in the classroom of Frank Draper. Draper was a longtime science teacher at Catalina Foothills High School in Tucson, Arizona, where he taught an honors, advanced field-science course for seniors. Over the course of his twenty-year teaching career, systems thinking concepts and tools transformed his science curriculum. As Draper notes: "Science, as it is generally taught in our country, is mostly a series of facts unrelated to each other in terms of dynamics and relationships."[16]

In his class, Draper integrated the sciences, combining anatomy, physiology, evolution, biogeography, ecology, geology, chemistry, and more into a unified understanding of how the natural world works. At any one time in his classroom, four labs would occur simultaneously, each involving one-quarter of the class and exploring similar self-regulating patterns found in different "systems": a cooling coffee cup, the thermodynamics of animal temperature, the feedback relationship driving cumulonimbus cloud buildup, and the impact of thermodynamics on plate tectonics. Students would spend a full class period on each of the four labs and then, on the fifth day, spend a portion of the class outdoors, trekking in the wild desert surrounding the campus. Classroom learning is, in Draper's view, ultimately about a "better understanding of the real world outside the classroom."[17]

Does this approach work? By the end of their high school experience, Draper says, the students who attended his class were able to explain the world "not as a series of discrete events, but as a rich, interconnected structure." He adds, "I have seen it so often: a systems-thinking worldview helps concepts make so much sense because they are retained better."[18]

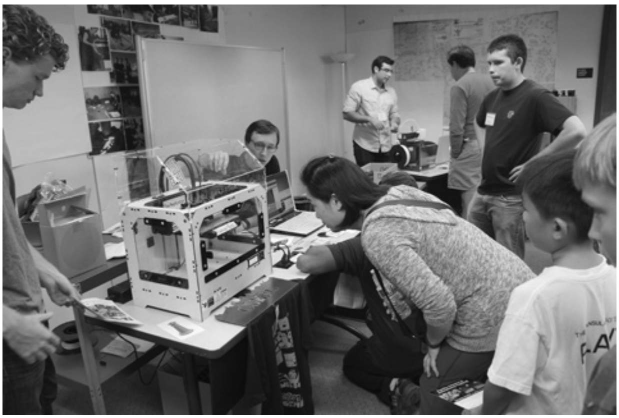
Educators report that the use of visual tools such as causal-loop diagrams and simulations helps to level the playing field, enabling students with different language skills to clearly communicate and make their thinking visible. According to the Pittsburgh-based Waters Foundation, a nonprofit organization dedicated to systems thinking education, "Systems thinking engages even the most reluctant students with a mix of visual, verbal and kinesthetic strategies, offering an 'in' for all types of learners. Its tools distill abstract ideas into a shared vocabulary that lets students express themselves with empowering precision. That lucidity also helps them connect classroom learning to the outside world and tackle challenges in their daily lives."[19]

## Applying Systems Thinking Beyond School

"Systems" as the context for learning is also appearing in a variety of out-of-school learning settings, including museums, after-school clubs, high school internships, and farms. In Lincoln, Massachusetts, educators at the Drumlin Farm Wildlife Sanctuary use a systems-thinking play kit with visiting children ages six to sixteen. The kit encourages the children to think deliberately about living systems in a farm setting and gives them a mental framework to apply in other contexts. Through games, discussions, and system-mapping activities using bendable wax-coated yarn, students explore the interconnections and dynamics surrounding a mobile chicken coop known as the Egg Mobile. Concepts such as feedback loops, time horizons, and stocks and flows are illustrated through a study of the relationships among elements of a farm pasture, including chickens, cows, soil, plants, and manure.[20]

At the university level, the Social System Design Lab at Washington University in St. Louis, Missouri, applies these same systems concepts and tools to social issues. Students become experts in developing simulation models of problems facing complex social systems. A resource for students, professionals, and researchers, the Design Lab builds the capacity of those who want to learn and apply system dynamics in order to understand and address specific problems within an organization and community. At the 2016 Changing Systems Student Summit—designed, led, and facilitated by youth leaders—students tackled the issue of gun violence in St. Louis. They used system dynamics concepts and tools to uncover the structures that underlie neighborhood gun violence, identifying and prioritizing leverage points for change and engaging and involving the stakeholders who have the power to influence broad institutional change.[21]

Finally, systems thinking is emerging as a partner to critical thinking, problem solving, and social innovation frameworks, such as in the area of design thinking. A promising trend is the spread of "makerspaces" (also known as Fab labs and hacker spaces) in libraries, museums, community centers, private organizations, and schools. Packed with craft and hardware supplies, electronics, and a variety of tools, as well as three-dimensional (3-D) printers, these do-it-yourself stations invite peer learning, knowledge sharing, and social innovation. The integration of a systems-thinking framework within makerspaces, in or out of schools, helps to address the limits of purely technical solutions and raises the question of context: in what context are the "inventions" being designed?


CSM Library

Demonstration of a 3-D printer at the College of San Mateo makerspace, California.

In the case of oysters in Baltimore's city harbor, the context is a living system. Oyster reefs play a valuable role in the harbor's overall health (health being an emergent property, shaped by the interaction among diverse elements within the system). Oysters help to filter waste and provide habitat for a variety of species, as well as offering other benefits. Yet pollution, dredging, overharvesting, and other human impacts have damaged the Chesapeake Bay's oyster population. In a 2016 FabSLAM event, organized by Baltimore's Digital Harbor Foundation, a team of middle schoolers tackled the challenge of a dwindling oyster population by creating 3-D-printed "reef balls"—perforated hollow spheres to which organisms can attach—to serve as oyster habitats.[22]

## Closing the Circle

Mythologist Joseph Campbell once said, "People who don't have a concept of the whole can do very unfortunate things." But the corollary is rarely considered: *People who understand the whole can do very fortunate things.* If we raise young people who have a concept of the whole—of how systems work—they will be geared toward seeing the systems around them and will not, by nature and training, see things in isolation. They will not stand for silos but will reach out over silos because they know better. They will be indignant when conversations become narrowly linear and will look for a wider variety of causal connections.[23]

So much in our culture forces us into compartments. But just as we teach kids not to be victims of advertising (see Chapter 13), we can teach them to see beyond the obvious, to see the systems all around us. We can awaken the innate systems intelligence in young people and encourage them to recognize what the Reverend Dr. Martin Luther King, Jr. described in his 1967 *Christmas Sermon on Peace*: "It really boils down to this: that all life is interrelated. We are all caught in an inescapable network of mutuality, tied into a single garment of destiny. Whatever affects one directly, affects all indirectly. . . . We aren't going to have peace on Earth until we recognize this basic fact of the interrelated structure of all reality."[24]

As systems become the context for learning, students will move beyond discrete lists to seeing patterns of interaction that more closely match the interdependent, complex world in which they live. This understanding, coupled with curiosity and stamina, has the power to unleash the vast human potential to navigate and ultimately transform the interlinked social, environmental, and economic issues generated by the Anthropocene.

2016); Pedro Noguera, Linda Darling-Hammond, and Diane Friedlander, *Equal Opportunity for Deeper Learning* (Washington, DC: Jobs for the Future, October 2015).

6. Author field notes, November 30, 2011.

7. King Middle School, "Past Expeditions."

8. Larry Rosenstock, Chief Executive Officer, High Tech High, San Diego, CA, personal communication with author, January 15, 2013.

9. Author field notes, October 27 and 28, 2011; Casco Bay High School, "Academics," https://cbhs.portlandschools.org/academics.

10. Author field notes, November 20, 2011; author interview, November 15, 2012.

11. Author field notes, September 28 and October 24, 2011; Avalon School, "What Is Project-Based Learning?" www.avalonschool.org/pbl.

12. Author field notes, November 24 and 25, 2011.

13. Michael Fullan and Maria Langworthy, *A Rich Seam: How New Pedagogies Find Deeper Learning* (London: Pearson, 2014), 2.

14. Ibid., 16.

15. Ibid., 19; Richard Elmore, "What Happens When Learning Breaks Out in Rural Mexico?" Education Week Blog, May 18, 2011.

16. European Schoolnet website, www.eun.org; Monica Martinez, Dennis McGrath, and Elizabeth Foster, *How Deeper Learning Can Create a New Vision for Teaching* (Washington, DC: National Commission on Teaching & America's Future (NCTAF), 2016); iTEC: Designing the Future Classroom website, http://itec.eun.org.

17. Common Core State Standards Initiative website, www.corestandards.org.

18. Sarah Jenkins et al., *The Shifting Paradigm of Teaching: Personalized Learning According to Teachers* (Washington, DC: NCTAF and Knowledgeworks, 2016).

19. XQ: The Super School Project, "Ten U.S. 'Super Schools' Awarded $10M Each for Reimagining Education," https://xqsuperschool.org/news/3150; Next Generational Learning Challenges website, http://nextgenlearning.org.

20. Box 11–1 from the following sources: John Dewey, "Self-realization as the Moral Ideal," *The Philosophical Review* 2, no. 6 (1893): 652–64; Joe Bryan, "Participatory Mapping," in Tom Perreault, Gavin Bridge, and James McCarthy, eds., *The Routledge Handbook of Political Ecology* (New York: Routledge, 2015), 249–62; TEMA, "Türkiye Su Varliklarina Yönelik Tehditler Haritasi," http://sertifika.tema.org.tr/_Ki/SuTehditleriHaritasi/.

## Chapter 12. All Systems Go! Developing a Generation of "Systems-Smart" Kids

1. Thanks to Frank Draper, former field science teacher at Catalina Foothills High School in Tucson, AZ, for this question.

2. Douglas Smith, *Decade of the Wolf: Returning the Wild to Yellowstone*, revised and updated edition (Guilford, CT: Lyons Press, 2012).

3. John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World* (Boston: Irwin/McGraw-Hill, 2000), 5–13.

4. Tina A. Grotzer and Belinda Bell Basca, *Helping Students to Grasp the Underlying Causal Structures When Learning About Ecosystems: How Does It Impact Understanding?* paper presented at the National Association for

Research in Science Teaching Annual Conference, Atlanta, GA, 2000; David W. Green, Explaining and Envisaging an Ecological Phenomenon," *British Journal of Psychology* 88, no. 2 (1997): 199–217; Peter A. White, "Naive Ecology: Causal Judgements About a Simple Ecosystem," *British Journal of Psychology* 88, no. 2 (1997): 219–233; Linda Booth Sweeney, *Thinking About Systems: An Empirical Investigation of Middle School Students' and Their Teachers' Conceptions of Natural and Social Systems*, unpublished doctoral dissertation (Cambridge, MA: Harvard University, 2004); Linda Booth Sweeney and John D. Sterman, "Thinking About Systems: Student and Teacher Conceptions of Natural and Social Systems," *System Dynamics Review* 23, no. 2–3 (2007): 285–311.

5. Figure 12–1 from PBS Learning Media, "Systems Literacy: Teaching About Systems," STEM professional development module for teachers, www.pbslearningmedia.org/collection/systemsliteracy.

6. Linda Booth Sweeney and Dennis Meadows, *The Systems Thinking Playbook: Exercises to Stretch and Build Learning and Systems Thinking Capabilities* (White River Junction, VT: Chelsea Green, 1995/2010); World Commission on Environment and Development, *Our Common Future*, Annex to United Nations General Assembly document A/42/427, Section IV-1 (New York: 1987).

7. Clive Hamilton, "Define the Anthropocene in Terms of the Whole Earth, *Nature*, August 17, 2016.

8. Martos Hoffman and Daniel Barstow, *Revolutionizing Earth System Science Education for the 21st Century, Report and Recommendations from a 50-State Analysis of Earth Science Education Standards* (Cambridge, MA: TERC Center for Earth and Space Science Education, 2007), 5.

9. Ibid. Box 12–2 from Melia Robinson, "Bill Gates Is Revolutionizing How History Is Taught, and We Went to a Poor NYC High School to See It in Action," *Business Insider*, January 7, 2015.

10. Jaimie Cloud, "Education for a Sustainable Future: Benchmarks for Individual and Social Learning," *Journal of Sustainability Education*, June 2016; The Center for Green Schools at the U.S. Green Building Council and Houghton Mifflin Harcourt, *National Action Plan for Educating for Sustainability* (Boston and Washington, DC: 2014), 4.

11. The Center for Green Schools at the U.S. Green Building Council and Houghton Mifflin Harcourt, *National Action Plan for Educating for Sustainability*.

12. Putnam/Northern Westchester BOCES Curriculum Center, Education for Sustainability website, www.pnwboces.org/EFS/efs_home.htm.

13. Next Generation Science Standards website, www.nextgenscience.org.

14. PBS Learning Media, "Westward Expansion: A Systems Approach to History," http://rmpbs.pbslearningmedia.org/resource/syslit14-ush-sys-westexp/westward-expansion-a-systems-approach-to-history.

15. Mary Catherine Bateson, *Willing to Learn: Passages of Personal Discovery* (Hanover, NH: Steerforth Press, 2004), 290.

16. Tracy Benson, James K. Doyle, and Frank Draper, *Tracing Connections: Voices of Systems Thinkers* (Lebanon, NH and Acton, MA: isee systems, Inc. and Creative Learning Exchange, 2010), 54–58.

17. Ibid., 54–55.

18. Ibid., 61.

19. Waters Foundation, Systems Thinking in Education website, www.watersfoundation.org.

20. Linda Booth Sweeney, *Healthy Chickens, Healthy Pastures: Making Connections at Drumlin Farm and Beyond* (Lincoln, MA: Creative Learning Exchange and Mass Audubon Drumlin Farm Wildlife Sanctuary, 2010).

21. Washington University in St. Louis, Social System Design Lab (SSDL) website, https://sites.wustl.edu/ssdl; Washington University in St. Louis, SSDL, "Changing Systems Gun Violence," https://sites.wustl.edu/ssdl

/changing-systems-youth-summit/changing-systems-gun-violence-2.

22. Steph Grimes, "3D Printing for Solving Baltimore's Problems," Digital Harbor Foundation, May 25, 2016; Digital Oyster Foundation website, http://digitaloysterfoundation.weebly.com.

23. AZ Quotes, "Joseph Campbell Quotes," www.azquotes.com/quote/796947.

24. Dr. Martin Luther King, Jr., "Christmas Sermon on Peace," delivered to the congregation of Ebenezer Baptist Church, Atlanta, GA, December 24, 1967.

## Chapter 13. Reining in the Commercialization of Childhood

1. Susan Linn and Josh Golin, "Save the Lorax, Shun the Stuff," *Huffington Post*, March 1, 2012.

2. Emma Brown, "The Lorax Helps Market Mazda SUVs to Elementary School Children Nationwide," *Washington Post*, February 28, 2016.

3. Susan Gregory Thomas, *Buy Buy Baby: How Consumer Culture Manipulates Parents and Harms Young Minds* (Boston: Houghton Mifflin, 2004), 109–35; Duncan Hood, "Is Advertising to Kids Wrong? Marketers Respond," *Kidscreen*, November 1, 2000, 15.

4. Dale Kunkel, "Children and Television Advertising," in Dorothy G. Singer and Jerome L. Singer, eds., *The Handbook of Children and Media* (Thousand Oaks, CA: Sage, 2001), 375–93; James Vincent, "Teens Can't Tell the Difference Between Google Ads and Search Results," The Verge, November 20, 2015.

5. Anup Shah, "Children as Consumers," Global Issues Blog, November 21, 2010; Juliet Schor, *Born to Buy: The Commercialized Child and the New Consumer Culture* (New York: Scribner, 2004), 21; Bruce Horovitz, "Marketing to Kids Gets More Savvy with New Technologies," *USA Today,* August 14, 2011, B1.

6. American Academy of Pediatrics Council on Communications and Media, "Media Use by Children Under the Age of Two," *Pediatrics* 128, no. 5 (October 2011): 1,040–45; Victoria Rideout, *Zero to Eight: Children's Media Use in America* (San Francisco, CA: Common Sense Media Inc., 2011), 44; Pooja S. Tandon et al., "Preschoolers' Total Daily Screen Time at Home and by Type of Child Care," *Journal of Pediatrics* 158, no. 2 (February 2011): 297–300; Common Sense Media Inc., *The Common Sense Census: Media Use by Tweens and Teens* (San Francisco, CA: 2015).

7. Debra Holt et al., *Children's Exposure to TV Advertising in 1977 and 2004* (Washington, DC: Federal Trade Commission, 2007); Jane Wakefield, "Children Spend Six Hours or More a Day on Screens," *BBC News*, March 27, 2015; Francisco Lupiáñez-Villanueva et al., *Study on the Impact of Marketing Through Social Media, Online Games and Mobile Applications on Children's Behavior* (Brussels: European Commission Consumers, Health, Agriculture and Food Executive Agency, 2016), 66.

8. Patrick Callan, "Fast Forward," *Kidscreen*, June 16, 2016.

9. Lily Hay Newman, "NY Cracks Down on Mattel and Hasbro for Tracking Kids Online," *Wired*, September 13, 2016; John Herrman, "Who's Too Young for an App? Musical.ly Tests the Limits," *New York Times*, September 17, 2016.

10. Campaign for a Commercial-Free Childhood (CCFC), "International Coalition to McDonald's: Keep Your Word and Ban Ronald McDonald from Schools," July 29, 2014.

11. T. Lobstein and S. Dibb, "Evidence of a Possible Link Between Obesogenic Food Advertising and Child Overweight," *Obesity Reviews* 6, no. 3 (2005): 203–08; Marjorie Hogan and Victor Strasburger, "Body Image, Eating Disorders, and the Media," *Adolescent Medicine: State of the Art Reviews* 19, no. 3 (2008): 521–46; Dimitri Christakis, "Virtual Violence: Council on Communications and Media," *Pediatrics* 138, no. 1 (July 2016); American Psychological Association, Task Force on the Sexualization of Girls, *Report of the APA Task Force*

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