Wicked Problems and the Systems Thinking Skills We Need to Solve Them

This past year, my husband and I bought a house. When we purchased the home, we knew it needed some work. Six months later and that original list of problems to tackle has now multiplied. We often joke that we are starring in our own version of Tom Hanks's *The Money Pit*.

Those of you who have built or remodeled a home are, no doubt, shaking your heads in sympathy (those of you in my part of the country probably mumbled "bless her heart" by the end of the second sentence). You know what we know: projects that first present themselves as simple, straightforward tasks, can oftentimes become complex, ever-changing beasts. Problems can be wicked. The quick and dirty definition of a wicked problem is a problem without a specific solution. Horst Rittel and Melvin Webber described a wicked problem as containing the following characteristics:

- It is difficult to define or explain. Sometimes, the only way to understand a wicked problem is to try to solve it.
- It has no end. The solution then becomes this is the best we could do with the time and resources we have.
- Solutions are weighted by whether these are *better* or *worse*, not *right* or *wrong*.
- Another thing about solutions: it is impossible to list every possible one.
- Trial and error cannot exist. Each time the problem solver tries out a solution, it changes the nature of the wicked problem.
- It is a unique problem. While it might be similar to other problems you have faced, the factors are different enough that a prepackaged solution will not work.
- The reasons why a wicked problem exists may be identified or described differently depending on the lens of the person examining it. This variability will also impact how the potential solutions are identified and weighted (1973).

A key characteristic of wicked problems is that they do not exist independently. They actually grow out of other problems. Because of this characteristic, Steve Eastbrook prefers to describe them as "*dilemmas* to which we can respond, rather than problems that we can solve" since "any attempt to solve them will give rise to further, unanticipated problems" (2014, p. 24).

What qualifies as a wicked problem? Here are just a few examples: homelessness, debunking misinformation spread on the Internet, obesity, the tax code, climate change, poverty. At first glance these seem like distant, adult dilemmas. However, we know better. These issues are affecting our students and communities daily. When we call on school librarians to prepare 21st-century learners, we are calling on them to help learners gain the skills necessary to tackle these dilemmas, these wicked problems.

This is where systems thinking comes in. The National Research Council defines systems thinking as "the ability to understand how an entire system works; how an action, change, or malfunction in one part of the system affects the rest of the system" (2010, p. 3). Systems thinking skills are crucial in addressing wicked problems (large systems with many confounding parts) such as healthcare because they provide a "set of concepts for understanding and reasoning about a system's behavior…including the observation that systems tend to have properties that cannot be traced to individual components or groups of components, but rather arise from the interaction of those components with the entire system" (Eastbrook 2014, p. 28). In other words, systems thinking helps us to identify not only the system but also the system's parts, as well as how the ways these parts interact with each other create more complexity in the system.

When a student understands a complex system, he or she is able to create a sophisticated mental model of it. In contrast, research tells us that people new to systems thinking may be able to identify parts of a system, but they struggle to understand how these parts relate and react to each other. They are often unable to identify the levels in a system and cannot explain how these levels are connected. At the other end, expert systems thinkers "represent complex systems in terms of interconnected structures, behaviors, and functions" (Tripto, Ben-Zvi-Assaraf, and Amit 2018, p. 669).

Orit Ben-Zvi-Assaraf and Nir Orion (2010) developed a hierarchy to demonstrate how systems thinking skills develop over time. Students with **basic skills** can identify and analyze objects and processes in a system. However, they still "tend to focus on simple linear relationships in systems, and on easily visible components" (Tripto, Ben-Zvi-Assaraf, and Amit 2018, p. 669). At the **next skill level,** students are able to evaluate and synthesize relationships between the objects and processes in a system. They can also create a mental model of the system, sketching out these objects, processes, and relationships. Students with **fully developed skills** are capable of treating "a set of phenomena as a system" (Roychoudhury et al. 2017, p. 73). They understand a system's dimensions, visualize how that system fits into a larger system, and are able to pull out a system's own individual subsystems. Students at this level are also capable of rich mental modelling that helps them make predictions about how the system might behave when modified.

Systems thinking can be taught with instructions, suitable cognitive tools, and a gradual progression from modeling simple to more complex systems (Hung 2008; Akcaoglu and Green 2018). In a study that examined how high school students develop systems thinking skills over time, researchers used the topic of climate change as the curriculum focus. The ability to develop a rich and detailed mental model of climate change "involves understanding complicated evidence from various sources such as ocean, ice, atmosphere, land, human activities, and the interactions among them" (Roychoudhury et al. 2017, p. 79). Consequently, Anita Roychoudhury and team found that students developed a deeper understanding of climate change when they explored it as a complex system, rather than focusing on memorizing facts about climate change and its causes.

While research on the development of systems thinking skills in K–12 is relatively new and somewhat hampered by the overwhelming time constraints educators and students face, there are a few items I would like to draw to your attention. First, because the higher a student's system thinking ability is, the richer his or her mental models are, external representations of systems (for example, concept maps) are a great way to assess student understanding (Akcaoglu and Green 2018; Jacobson et al. 2017; Hung, 2008). Second, there is promising evidence that students can develop systems thinking through design tasks. Akcaoglu and I (2018) detail how systems thinking skills were indirectly addressed and nurtured in a project with sixth grade middle school students who used Kodu to design original video games. This finding is especially relevant to school libraries that host makerspace programs to encourage student creativity and innovation. Third, complex systems are becoming more heavily emphasized in science education. Science education researchers argue that students who understand complex systems are able to make connections between different science subjects—a hallmark of scientific literacy (Jacobson et al. 2017).

If you are wondering what this has to do with school librarianship, then let me assure you that the answer is: plenty! The development of systems thinking skills has been marked by the National Research Council as a 21st-century critical skill (2010). Even so, systems thinking cannot be developed overnight. Helping students develop such mental complexity takes time and should be an effort undertaken over the years, beginning as early as possible. As a school library researcher and educator, I am passionate about our involvement in fostering systems thinking skills because I believe we are part of the foundational learning (reading, inquiry, and ethical behavior) students need in order to grow systems thinking skills (Johnston and Green 2018). Without the abilities to read and engage with information in critical and ethical ways, our students are not capable of developing the background knowledge and rich mental models that accompany growth in systems thinking. Research in our field provides plenty of evidence for what I am claiming.

School library researchers consistently find students are better at verbalizing the process for finding information than they are at evaluating and curating the information they collect (Krueger and Donham 2013). In fact, without a structured inquiry process, modeled and supported by the school librarian, students settle for the first information source they find (Kuhlthau, Heinström and Todd 2008; Kovalik, Yutzey, and Piazza 2013). Left to their own devices, students skip "a point of focus formulation…without building background knowledge and formulating essential questions" (Kuhlthau, Heinström and Todd 2008, para. 9). Additionally, students rarely select and analyze information from multiple resources on their own, a step crucial to the process of identifying components of complex systems (Kovalik, Yutzey, and Piazza 2013; Jacobson et al. 2017).

In contrast, students who participate in a structured and guided inquiry process understand that "information seeking is a demanding process which requires reflection and analytical decisions" (Kuhlthau, Heinström and Todd 2008, para. 9). They consistently develop more meaningful investigations that go beyond fact-finding (Krueger and Donham 2013). We also know that when school librarians co-design, co-teach, and co-assess student research projects, students improve in performance on higher-order thinking tasks (Ercegovac 2012). This is because despite information literacy standards outlining information seeking, access, evaluation, use, and communication, classroom teachers tend to focus exclusively on location skills (Newell 2004).

These studies are just a few examples of the ways school librarians contribute to development of the foundational learning required for growth in systems thinking. Again, these are not skills students will develop after one project, or even one school year. Growth in systems thinking is a marathon, not a sprint. It requires a commitment to vertically plan with other school librarians and classroom teachers. It means the school library program lays a strong and robust foundation in information literacy and inquiry beginning in the early grades, consistently threading these concepts throughout the curriculum in progressive years.

Fully realizing our role in student development of systems thinking means we carefully consider each and every technology tool, collaborative project, or makerspace activity for the opportunity to wrestle with the complex systems and wicked problems these vehicles may or may not provide. Finally, it means a professional commitment to familiarizing oneself with the terminology of systems thinking and the research in this area so that you are able to advocate for the critical role in foundational learning your program plays, in ways accessible to other stakeholders. It is a big calling, but one we answered long ago when we claimed the library as the heart of the school.

Works Cited

Akcaoglu, Mete, and Lucy Santos Green. "Teaching Systems Thinking through Game Design." *Educational Technology Research & Development* (May 9, 2018). doi.org/10-1007/s11423-018-0506-8.

Ben-Zvi-Assaraf, Orit, and Nir Orion. "Four Case Studies, Six Years Later: Developing Systems Thinking Skills in Junior High School and Sustaining Them over Time." *Journal of Research in Science Teaching* 47, no. 10 (2010): 1253-1280.

Eastbrook, Steve. "From Computational Thinking to Systems Thinking: A Conceptual Toolkit for Sustainability Computing." *Proceedings of the 2nd International Conference on Information and Communication Technologies for Sustainability* (2014): 24-27.

Hung, Woei. "Enhancing Systems-Thinking Skills with Modelling." *British Journal of Educational Technology* 39, no. 6 (November 2008): 1099-1120.

Jacobson, Michael J., et al. "Designs for Learning about Climate Change as a Complex System." *Learning and Instruction* 52 (December 2017): 1-14.

Johnston, Melissa P., and Lucy Santos Green. "Still Polishing the Diamond: School Library Research over the Last Decade." School Library Research 21 (2018).

Kovalik, Cindy, Susan Yutzey, and Laura Piazza. "Information Literacy and High School Seniors: Perceptions of the Research Process." *School Library Research* 16 (2013).

Krueger, Karla Steege, and Jean Donham. "Professional Staffing Levels and Fourth Grade Student Research in Rural Schools with High Poverty Levels." *School Library Research* 16 (2013).

Kuhthlau, Carol C., Jannica Heinström, and Ross J. Todd. "The 'Information Search Process' Revisited: Is the Model Still Useful?" *Information Research* 13, no. 4 (2008).

National Research Council. *Exploring the Intersection of Science Education and 21st Century Skills: A Workshop Summary.* National Academy Press, 2010.

Newell, Terrance. S. "Thinking beyond the Disjunctive Opposition of Information Literacy Assessment in Theory and Practice." *School Library Media Research* 7 (2004).

Rittel, Horst W. J., and Melvin M. Webber. "Dilemmas in a General Theory of Planning." *Policy Sciences* 4, no. 2 (June 1973): 155-169.

Roychoudhury, Anita, et al. "The Need to Introduce System Thinking in Teaching Climate Change." *Science Educator* 25, no. 2 (Winter 2017): 73-81.

Tripto, Jaklin, Orit Ben-Zvi-Assaraf, and Miriam Amit. "Recurring Patterns in the Development of High School Biology Students' System Thinking over Time." *Instructional Science* 46, no. 5 (October 2018): 639-680.

For helpful insight, with examples, on the differences between computational thinking and systems thinking, check out Lucy Santos Green's infographic "Computational Thinking v. Systems Thinking: What's the Difference?"

About the Author

Lucy Santos Green, EdD, is associate professor of Library and Information Science at the University of South Carolina's Knowledge School. She earned her MLIS at Texas Woman's University and her doctorate in instructional technology at Texas Tech University. Her article with Dr. Melissa P. Johnston, "Still Polishing the Diamond: School Library Research over the Last Decade," was recently published in *School Library Research*, the scholarly refereed research journal for the American Association of School Librarians. Lucy is the chair-elect for the Educators of School Librarians Section of AASL, and a member of the AASL Accreditation of Educator Preparation (CAEP) Coordinating Committee.

MLA Citation

Green, Lucy Santos. "Wicked Problems and the Systems Thinking Skills We Need to Solve Them." *School Library Connection*, January 2019, schoollibraryconnection.com/Home/Display/2145385.