Building the Big Picture: Developing Systems Thinking Tools with Young Children

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Over the last five or six years, our faculty has explored the use of systems thinking tools with our primary students in grades kindergarten to third grade. Our observations of the students’ work and our discussions with the students and among ourselves provide insight into how each year of experience with these tools leads to deeper understanding of concepts in different areas of the curriculum and increasing sophistication in the use of the tools for a variety of purposes, for students and teachers.

Barbara introduces systems tools to our students in kindergarten with the use of Behavior Over Time Graphs (BOTGs) to examine their own anxieties about joining a new classroom community. As the class listens to the story of Miss Bindergarten Gets Ready for Kindergarten, they consider their questions: What would school be like? Would they make new friends? What do they need to do to get ready? With Barbara leading the discussion and supporting the children in negotiating the placement of points on a BOTG, the children map Miss Bindergarten’s degree of preparation for the first day of school. As the year progresses, Barbara continues developing BOTGs with her students, gradually releasing responsibility for marking them to the children. She discovered that by acting out the changes kinesthetically when appropriate, for example, as the caterpillar in The Very Hungry Caterpillar, by Eric Carle, grows ever larger and becomes a butterfly, the children are more readily able to demonstrate their understanding of the line that’s created on their BOTG. A common use of BOTGs beginning in kindergarten is to “tell the story of the line,” prompting a retelling and beginning analysis of a character or plot or the development of a group activity.

In first and second grade, the students continue using BOTGs to analyze different aspects of stories such as character changes, theme development, and the author’s use of tension in developing a plot. Students also apply the idea of “telling the story of a line” by using post-it notes and blank BOTGs to organize events for their own narrative writing. Students move their post-its around to reorder events, add an event that was omitted, and even make their stories more exciting. By brainstorming a wide range of descriptors for the y-axis and encouraging the children to use those words in their stories, the children employ more precise word choices than they otherwise would.

The first and second graders in Molly’s class use BOTGs to describe their own learning process. They document their level of learning over the course of a week on a BOTG, question each other’s statements of learning, and explain their rationale for plotting points. They represent their learning as “a ton of learning,” “some learning,” and “a little bit of learning.” The students also plot a BOTG for the class as a whole on a daily basis by deciding on points that represent the learning outcome for a majority of the students that day.
Molly’s second grade students analyzed the steps in solving story problems using BOTGs. Using their story problem checklists, Molly’s students plotted their personal levels of difficulty for each step of addition and subtraction problems. Students then shared their reasoning for each plotted point and analyzed their graphs in comparison with those of other students.

By the time children are in second and third grade, they can easily “tell the story of the line” and begin to see that the slope of the line is related to the rate of change. In a unit on Water, to help children see that water expands when heated and contracts when cooled, Caryl’s second and third grade students constructed bottle thermometers. The children weren’t content to simply measure temperature change in hot and cold water in the classroom; they wanted to see if their bottle thermometers would really work outdoors. The students crudely calibrated the bottle thermometers by taping paper rulers to the straws, recording the start point for each thermometer, and then placed them in different areas outdoors—some in the sun, some in the shade, on different surfaces like grass, concrete, dirt, etc. The children made predictions about what they expected to see and then recorded the level of water in the straws every two minutes for 10 minutes on a t-chart. When they returned to the room, each group drew a BOTG to show what happened and also reproduced its graph on clear acetate with different colored overhead pens. They looked at each graph individually and discussed the results, and then layered all the graphs one on top of each other, lining up the starting points. It was easy to see that some graphs had lines that were steeper than others. When the children noted the locations of the bottle thermometers, they quickly realized that a steeper line meant a faster temperature change.

Caryl uses systems tools extensively in the science curriculum in her classroom. She sometimes creates simulation games in which the results can be visualized using two lines on a single BOTG. One such game is a variation of a very common simulation that looks at how animal populations are interdependent and go up and down in relation to the available resources for survival. At the end of each round of play, all the animals and resources are counted and recorded. The data is graphed, showing that when there are lots of animals, rabbits in this case, there are fewer resources available for the next round and the rabbit population declines. As the rabbit population declines, the number of resources increases, followed in the next round, by an increase in the surviving rabbit population. Using the BOTG, the children were able to identify a range of rabbit population that would be fairly stable. The children’s ability to see the relationship of two “stories” on the BOTG provided a meaningful segue to the application of Stock Flow Diagrams and Causal Loops.

We also introduce Stock Flow Diagrams in kindergarten. Barbara and Ginger brought a kindergarten science study of Liquids to a personal level for the students by tracking the use and/or waste of water during tooth brushing. Water conservation is a critical issue in Tucson’s desert community and as soon as children have any teeth to brush, they are taught to turn the water off until it’s time to rinse. The children’s personal connections to this practice helped them recognize inflow and outflow converters that affected the accumulation of the stock of water.
Molly’s students use the BOTGs of their levels of learning to create Stock Flow Diagrams that represent what makes them learn, what increases their levels of learning, and what decreases their level of learning. The Stock Flow Diagrams allow them to see the big picture in what contributes to their learning.

In their studies of ecosystems, Caryl’s students used the data collected on BOTGs of simulation games and actual population studies of endangered species to create Stock Flow Diagrams, Causal Loops, and Connection Circles. The tools helped the children visualize their own understandings of the interrelatedness and interdependency of living and non-living organisms and the impact that humans have on ecosystems.

What has perhaps surprised us the most is the children’s ability to use systems tools to understand and solve the social problems that are inherent in classroom communities and schools. Most teachers experience those days when the children come in from lunch and bring all the problems of the playground with them. In Caryl’s second grade classroom, the Stock Flow tool helped them begin a lengthy process of analyzing playground issues and trying to effect positive change. In adding converters to the inflow and outflow of a stock of “Playground Problems,” it was obvious the children knew what the problems were and what should be happening on the playground. But before they could make a change for the better, they needed to understand at a deeper level why the problems were happening.

The Iceberg as a model was introduced in a meeting of our Systems Thinking Collaborative. Caryl decided to dive in and give it a try because she felt it had the potential to help the children see the underlying issues that result in disruptive and harmful behavior at lunch recess. For six weeks, the class devoted the weekly class meetings to the playground problems. As each level of the Iceberg was developed, lengthy and sometimes contentious discussions took place. The children drew BOTG lines to represent the patterns they saw and easily explained their rationale for each line. Getting at the rules and structures took multiple meetings in which Caryl’s most commonly asked question to the students was “Why?” Eventually, the children uncovered mental models that merited even more discussion, particularly gender issues and recognition of the monitors’ increasing frustration levels. A leverage point was identified – not everyone had the same idea of what the playground rules were – and surveys were conducted. The children organized a presentation to the monitors and made concrete suggestions for improvement based on the leverage point they identified and on their now somewhat deeper understandings of human behavior.

As our work with systems tools moves forward, we are attempting to collect data that might reveal to us identifiable characteristics of student growth as systems thinkers. This year, the kindergarten teachers read the same story to all their students and then asked the children to individually create BOTGs that analyzed a single characteristic of the main character’s behavior. They video-taped the children describing their graphs and “telling the story of the line.” At the very end of the year, our faculty began a discussion about this attempt to assess the children’s understanding of BOTGs, raising our awareness of a need for further review of our rubric, story selection, and the procedures and questions
that were used to prompt the children’s responses. In the fall, we plan to take up this
discussion again in a collaborative effort to understand how children view and use
systems tools and acquire the habits of systems thinkers.

As a result of our work with students, these consistent observations have emerged:

*Students’ thinking is visible.* Students see their own thinking on paper and can step back
to examine it. They are able to expand their thinking, grasp abstract concepts and
question with greater independence. This allows teachers to understand a student’s
thinking in order to extend ideas or explain misconceptions.

*Students are better able to make connections.* The use of systems tools helps students
deepen their thinking by making connections between school learning and the wider
world, and between their own experiences and abstract concepts. They understand the
interrelated and interdependent nature of human and natural interactions.

*Students develop as readers and writers.* Their responses to literature, personal and
social problem solving, science inquiry, task analysis, and topical research have been
enhanced by the inclusion of systems thinking tools. The tools support analysis of
literary elements and push students to examine their mental models, seeing things from
different viewpoints. The tools also help students organize their ideas prior to their first
draft writing and encourage revision.

*Students solve more complex problems.* The use of tools and habits require students to
challenge the obvious, to examine problems from multiple points of view and to consider
a more complex view of possible solutions. They consider reasons for observed
outcomes and predict future events based on the patterns they see.

*Student engagement increases.* The hands-on nature of systems thinking tools is
inherently engaging to students, enabling students to access more complex content than
they might otherwise comprehend. We see students taking greater ownership for their
learning, demonstrating independence in their use of the tools and developing a
perspective of viewing the whole of a system rather than just its components.

*Students’ ability to see the big picture grows.* Through the use of systems thinking tools,
our students are developing the habits of mind of systems thinkers – surfacing and testing
assumptions, holding tension, looking for patterns and trends, and considering unintended
outcomes in order to understand the big picture.
As teachers, we expect more from our students, guiding them through more complex and diverse ways of thinking than those required from scripted instruction and standardized tests. Perhaps most importantly, we can affirm our trust in students as learners by following where they lead. They often suggest viewpoints that we have not considered. As a result, we continuously strive to provide them access to rich curricular experiences and new ways to apply systems thinking tools and habits. Their learning is driving our professional development and the role distinction between teacher and student is blurred. Additionally, our systems thinking work as a school opens our classroom doors, inviting us into each other’s individual learning communities for collaboration, dialogue and reflection on our students’ learning and our own professional development. We value the support and critical dialogue that our colleagues provide. Their thoughtful reflections and suggestions on the work we are doing in our own classrooms help us rethink plans, revalue our own efforts, and try new things with systems tools. In return, we celebrate each other’s efforts and discoveries as we move forward together.