Developing a Systems Thinking Capacity in Learners of all Ages

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Abstract - *Schools across the United States and throughout the world are actively pursuing the advantages of integrating systems thinking in classrooms and schools. The benefits of such approaches are both immediate to student achievement goals and long-lasting as systems citizenry are developed. While many educators view secondary schools as logical entry points for the introduction of systems thinking concepts and tools, it can be argued that children as young as five years old benefit from systems thinking classrooms. Building a systems thinking capacity in learners of all ages is a worthy investment as educators prepare the young people of today so they are ready to solve the problems of tomorrow.*

Introduction

In a student-centered systems thinking classroom, teachers are the facilitators of thinking and learning. The Waters Foundation's Systems Thinking in Schools project is focused on supporting teachers in their ability to create such desirable learning environments for children. The mission of this project is "to increase the capacity of educators to deliver academic and lifetime benefits through the effective application of systems thinking concepts, habits and tools in classroom instruction and school improvement." Student benefits come from teachers who themselves are willing to learn and develop a systems thinking capacity. Schools across the United States and around the world are currently applying and integrating systems thinking into instruction and school improvement efforts.

Benefits of a systems thinking learning environment

The benefits of a systems thinking approach are not limited to the achievement of prescribed, curricular learning standards. In a keynote address delivered to educators in July of 2002, Dr. Barry Richmond, long-time friend, mentor, and colleague of those involved with systems thinking in schools coined the term "Systems Citizen." He noted that, "Systems citizens are *being* the changes they wish to create in the world, but…they also know how to best pursue the systemic orchestrations required to bring those changes about." If the purpose of education is to develop the skills and knowledge necessary to manage the complexity of future problems and states of being, then educational institutions are compelled to develop learners who think and behave as *systems citizens*. Systems citizens view themselves as members of a global community. They understand the complexities of today's worldly systems and have the capability to face into problems with an informed capacity to make a positive difference.

Many might argue that pressure to achieve academic standards associated with prescribed curricula takes educators away from the vision of developing systems citizens. Statistical measures of student achievement are currently viewed as the most recognizable measures of success. Systems thinking schools demonstrate that both standards-based education and systems thinking approaches can not only exist side by side, but can also complement one another. For most educators, short-term goals encompass the mastery of grade-level skills within a standards-based curriculum. These goals can best be accomplished and transformed into long-term "systems citizenry" development through a systems thinking learning environment. In this environment children are immersed in a practice field rich in relevant problem-solving, interdisciplinary connections, and opportunities for in-depth analysis, and thought-provoking dialogue.

A systems thinking learning environment is motivating and engaging for even the most reluctant learner. Teachers report that the visual nature of the system thinking tools enables students to organize and express their thinking. The tools help motivate those children who tend to appear less involved, shy or reluctant to fully engage in learning activities. Teachers recognize that these children along with their peers are natural systems thinkers as they readily make connections, embrace the big picture, and eagerly to share new insights. Peter Senge writes in the forward to the Dutch book, *Natuurlinjk leren: Systeemdenken in een lerende school*, by Jan Jutten,

> Children do not have to be taught to interpret their reality. They are doing it continuously. But their ability to steadily expand this instinctive sense making into more and more complex subjects must be developed over time. Failure to do so contributes to the growing gap between the complexities of our world and the understanding of our citizens... No one can say just how far a true systemic education process can go toward developing new levels of collective intelligence. But it does not seem an exaggeration to say that our future depends upon it [6].

It is a growing priority to encourage educators to develop and apply their own systems thinking capacity to teaching and learning. Our future depends on the preparation efforts of today. Children will need to have the skills and knowledge necessary to manage the complex problems they will ultimately inherit. It is imperative that K-12 schools and classrooms strive to develop and nurture the 21st century learning associated with a systems citizenry in order to prepare the next generation for the needs of tomorrow. Educators should not underestimate the systems thinking capabilities of children and should re-examine instructional practices that fragment educational objectives into unrelated, non-systemic parts.

Starting early

Learning is an active enterprise for both children and adults at Borton Primary School, a Waters Foundation demonstration site focused on the education of five, six, and seven year old children. One hundred percent of Borton teachers use systems thinking teaching techniques in their classrooms. At this school, children solve complex problems, develop big ideas about topics of interest, and generate insights that connect classroom curriculum with relevant life issues important to young children. Teachers are the facilitators of such engaging systems thinking classrooms.

In the early days of systems thinking in schools, few thought children as young as five years old capable of using line graphs, feedback loops, and stock-flow maps, let alone the thinking that serves as a foundation for those tools. Many educators interested in systems thinking viewed the complexity of the concepts and the tools as too difficult for young children. Early childhood educators, schooled in Piagetian theories were influenced by the research that informed traditional age-appropriate instruction [11], [12]. For example, in the United States, line graphs are

typically not used with children younger than eight years of age. The rationale is the level of abstraction associated with trend graphs is not appropriate for primary-aged children.

In Waters Foundation demonstration schools, such as Borton Primary School, however, the limits of traditional age-appropriate instruction have been challenged and replaced with a new view of what is developmentally appropriate. Students actively depict and analyze trends, connect existing knowledge to novel settings and consider other points of view in addition to their own perspectives. All of these accomplishments refute traditional beliefs of what and how young children are capable of learning. As one teacher has shared, "As I integrate systems thinking into my classroom, I continue to be amazed at what my students can do, the complexity of their thinking and the ease with which they express their ideas."

In primary-aged systems thinking classrooms examples of what one would notice include children

- drawing and sharing behavior-over-time graphs of changing story elements or changing variables observed during a science experiment (e.g. Students may say, "Tell the story of your graph.")
- making connections using causal loop archetypes like the Fixes that Fail (e.g. A student said, "The story of the three little pigs is like a fix that fails because pigs with houses of straw or sticks never really solved their problem of needing shelter that protected them from the wolf.")
- generating *lessons learned* at the end of learning activities (e.g. A student said, "Sometimes you need to spend more time and resources if you really want to solve a problem for good, like the pig who build his house out of bricks.")
- constructing stock-flow maps of changing populations of endangered species (e.g. A student said, "After creating my stock-flow diagram I learned that unless people stop hunting gorillas and cutting down trees, the gorillas will eventually become extinct.")
- teaching one another to build system dynamics computer models of changing populations of endangered species (e.g. Students asked one another "What influences births?" and "Do you see any connection between chopping down trees and food supply?" and "Do you see any connection between the health of the moms and birth rate?")

Habits of a systems thinker

As teachers strive to develop systems thinking classrooms, they reinforce a number of habits of thinking that encompass the guiding principles of systems thinking. These habits draw upon the expertise of a wide variety of renown systems thinkers including Drs. Peter Senge,. Daniel Kim, Linda Booth-Sweeney, Dennis Meadows, Jay Forrester, George Richardson, John Sterman, and Barry Richmond [14, 7, 2, 4, 16, 13].

Teachers discover close connections between many of the habits of systems thinking and the learning goals embedded in curricula. A list of the habits of systems thinking that constitute a systems thinking capacity include:

- Considers how mental models affect current reality and the future
- Observes how elements within systems change over time, generating patterns and trends
- Changes perspectives to increase understanding
- Identifies the circular nature of complex cause and effect relationships
- Considers both short and long-term consequences of actions
- Finds where unintended consequences emerge
- Recognizes the impact of time delays when exploring cause and effect relationships
- Seeks to understand the big picture

- Recognizes that a system's structure generates its behavior
- Checks results and changes actions if needed: *successive approximation*
- Surfaces and tests assumptions
- Uses understanding of system structure to identify possible leverage actions
- Considers an issue fully and resists the urge to come to a quick conclusion

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Building a systems thinking capacity

Over the past thirteen years, Waters Foundation systems thinking trainers have learned how best to build adult and student systems thinking capacity. Borrowing from learning theories that reinforce the importance of learning styles [8], experiential learning [3], and multiple intelligences [5], systems thinking training is most effective when visual, linguistic, and kinesthetic modalities are utilized (see figure 1). The visual nature of systems thinking tools (e.g. behavior-over-time graphs, causal loop diagrams, the iceberg model of systems thinking, the ladder of inference, stock-flow mapping, and connection circles) align with research-based instructional practice. Robert Marzano (2001) in his seminal work, *Classroom Instruction that Works,* posits the value of using nonlinguistic representations that promote student learning. "The more we use both systems of representation-linguistic and nonlinguistic-the better we are able to think about and recall knowledge" [10].

The ability to express complex thinking, insights, and new ideas orally and in writing is integral to systems thinking learning. Speaking and listening skills include dialogue, discussion, inquiry and advocacy. A common vocabulary helps facilitate conversations about complex systems and relevant problem-based scenarios. David Bohm (1996) shares "…in dialogue, each person does not attempt to make common certain ideas or items of information that are already known to him. Rather, it may be said that the two people are making something in common, i.e. creating something new together" [1]. Linguistic strategies can be used to practice systems thinking habits as they help create new insights and give rise to new understanding about complex issues.

Studies conducted by the Fundamentals of Experiential Training and Development indicate that people remember 20% of what they hear, 50% of what they see, and 80% of what they do. Teachers who plan for hands-on, kinesthetic, and experiential learning understand the long-lasting benefits for students. Experiential learning theory defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" [8]. Experiential learning can be either concrete or abstract (e.g. games, physical challenges, role play, simulation or computer modeling). Whether systems thinking learning activities are designed for young children, teens or adults, both concrete and abstract conceptualizations are effective capacity-builders. "…some of us perceive new information through experiencing the concrete, tangible, felt qualities of the world, relying on our senses and immersing ourselves in concrete reality. Others tend to perceive, grasp, or take hold of new information through symbolic representation or abstract conceptualization—thinking about, analyzing, or systemically planning, rather than using sensation as a guide" [9]. The three modalities: visual tools, speaking and listening linguistic approaches to communication, and kinesthetic learning activities, together maximize the ability to build a systems thinking capacity in learners of all ages.

Conclusions

Schools across the United States and around the world, are currently applying and integrating systems thinking into instruction and school improvement efforts. The demands of the 21st century necessitate the development of skills

and knowledge necessary to manage the complexity of current and future problems. Thus, educational institutions are compelled to develop learners who think and behave as *systems citizens*. Systems citizens view themselves as members of a global community. They understand the complexities of today's worldly systems and have the capability to face into problems with knowledge and skill.

The goals of standards-based curricula and systems citizenry can best be accomplished through a systems thinking classroom learning environment. In this environment children are immersed in a practice field rich in relevant problem-solving, interdisciplinary connections, and opportunities for in-depth analysis, and thought-provoking dialogue. It is imperative that schools and classrooms strive to develop and nurture the 21st century learning associated with a systems citizenry in order to prepare the next generation for the needs of tomorrow.

Educators should not underestimate the systems thinking capabilities of children and should re-examine instructional practices that fragment educational objectives into unrelated parts. Until recently, few thought children as young as five years old capable of the thinking and the using of tools associated with systems thinking. Young children are quite capable of solving complex problems, developing big ideas about topics of interest, and generating insights that connect classroom curriculum with relevant life issues. They can manipulate and apply the thinking tools with surprising skill and insight. Teachers are viewed as the facilitators of such engaging systems thinking classrooms.

As teachers strive to develop systems thinking classrooms, they reinforce a number of habits of thinking that are considered the guiding principles of systems thinking. Habits of systems thinking are purposely embedded in lessons, and reinforced across disciplines and extra-curricular learning opportunities. In order to effectively build a systems thinking capacity in learners of all ages, three instructional modalities are recommended: visual tools, speaking and listening linguistic approaches to communication, and kinesthetic learning activities.

Current world issues demand immediate attention, and world leaders are seldom patient for the time it takes to invest in and build a capacity for action. Recognizing the inherent 12-16 year time delay it takes to educate a child through traditional schooling, the time is now to begin to build a citizenry of systems thinkers—citizens of all ages who are prepared to make a positive difference, both today and tomorrow.

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