Getting Started with Systems Thinking in the Primary Grades

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How I Got Started--

About four years ago, the headmaster of Maumee Valley brought the idea of Systems Thinking to our school. I was one of the faculty members asked to be in a reading group. We read numerous articles and discussed them. We spent a lot of time trying to figure out Stella models and diagrams of systems. I was, at best, hesitant on how this could apply to my students, who are first and second graders. It seemed to me that the Upper School students were the ones to tackle Systems Thinking.

I was given the chance to go to workshops and the National Conference in Norton, Massachusetts. Things started to make more sense to me personally. I began to understand what the diagrams meant, as well as the tools used by Systems. Most of us need to see an application in the real world before an idea crystallizes. I had that, "ah-ha," experience in a workshop in Ann Arbor, Michigan. One of the tools of Systems Thinking was introduced in a game called, *Oh Deer.* This environmental game hit a nerve, since I am a science teacher. Now I get it, I thought. I can see how my students could use the systems tool of stock-flow and Systems Thinking. However, this was just the beginning of an exciting learning experience for me and the children I teach.

And So it Begins----

At the Wheaton College conference, I saw a simple computer program called, *Kid PIX,* that introduced causal loops. I was sure that I could use it with my students. However, I found the format, with all the scrolling, a little difficult. I wasn't sure it would hold the attention of the computer savvy children I teach. So using HyperCard, I made my own program and used topics from our curriculum to model causal loops.

Jump Right In And Get Your Feet Wet.--

The Wonderful World of Causal Loops was the title of the program I made. I first explained to the children that people think in many ways, and we were going to learn about Systems Thinking. We would look at how one thing can affect another. I continued with a discussion of cause and effect. One example the children understood easily was when you put your foot out as someone passes by (the cause), the person will most likely trip (the effect). We continued doing scenarios of cause and effect. Then I showed the children, *The Wonderful World of Causal Loops.* I asked the children to work in teams to make their own causal loops, after demonstrating some on paper for them. The children did a terrific job and came up with many causal loops. Not all of the loops were correct, but the idea had been planted. For some reason the language seemed to fascinate them. "The more seeds, the more flowers, the more flowers, the more seeds." Soon they were seeing causal loops everywhere.

Systems Thinking Is A Tool To Aid In Teaching, Not an Add On.

Systems Thinking
Primary Ocean Unit Activity-Predator and Prey
Sharks and Fish

Important information before beginning: This game must be played with an odd number of total players. The sharks should be an odd number and the fish should be an even number. To make an odd number, let one of the children be the recorder.

Directions: The sharks and fish are divided into two lines. When "feeding frenzy" is called, the sharks go over to the fish and take one back to their line. The fish that have been brought over become sharks. Call "feeding frenzy" again and the sharks go over to pick another fish. If there are no fish, the sharks who did not find a fish, become fish. Each time a shark brings over a fish, that fish becomes a shark too. Whenever a shark can't find a fish, it becomes a fish. Continue the game and call each round by weeks. Have the recorder keep track of the number of fish and sharks for each week. Continue the game for at least nine rounds.

Now graph the results on a large piece of graph paper so that all the children can see. Use a different color marker for fish and sharks. Then connect the dots and you should see an oscillating relationship between the two. If you use an overhead projector, you can graph the fish on one transparency and the sharks on another. Then lay one transparency over the other. You should see the oscillation.

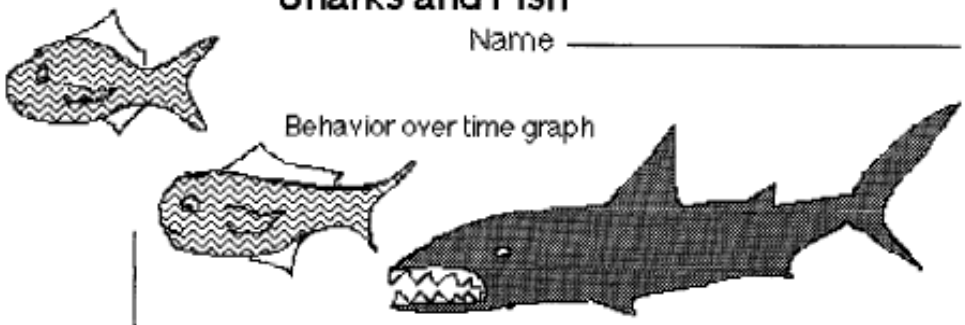
Now introduce a causal loop to the children. Diagram what happened in the game. Ask if they see a relationship between the sharks and the fish. This is a cause and effect pattern that makes a balanced causal loop.

You can play the game again and not fix the numbers. Doing this will cause an extinction of one of the species. Ask the children what they think happened. You can also graph this activity.

Sharks and Fish

Name _____

Behavior over time graph



sharks

fish

time

I made a work sheet for the children to graph the results. I did not use numbers on their work sheet. My intent was for them to understand the general concept of oscillation and a balanced causal loop.

Finding The First OOPs--

You can not play a predator, prey game without at least three variables, as in, *Oh Deer.* If you do, you will find that the game doesn't work and one species will become extinct. That is why I had to manipulate the numbers in *Shark and Fish*. If your students are observant, they will see a pattern in the *Shark and Fish* game. The manipulated numbers make this happen.

Worksheet is on the previous page. The worksheet is a **Behavior Over Time Graph.** I initially explained that the graph showed what had happened over time. I called it a **Change Over Time Graph** to make it simple for the children to understand.

The Second OOPs----

When using the term, **Behavior Over Time**, make sure the children understand that it does not mean behavior like crying or being afraid. The graph shows how something responds over a period of time.

Now Where To Go-----

The next Systems Thinking tool I tried was a stock-flow diagram. I introduced the concept to the children by using the bathtub idea. They understood the idea of holding water in the tub, but also filling and draining it. With the use of an overhead projector, I made a simple stock-flow diagram. I explained that one side was the positive flow-in and the other side was like the drain and flowed out. The stock, the center, was where things collected.

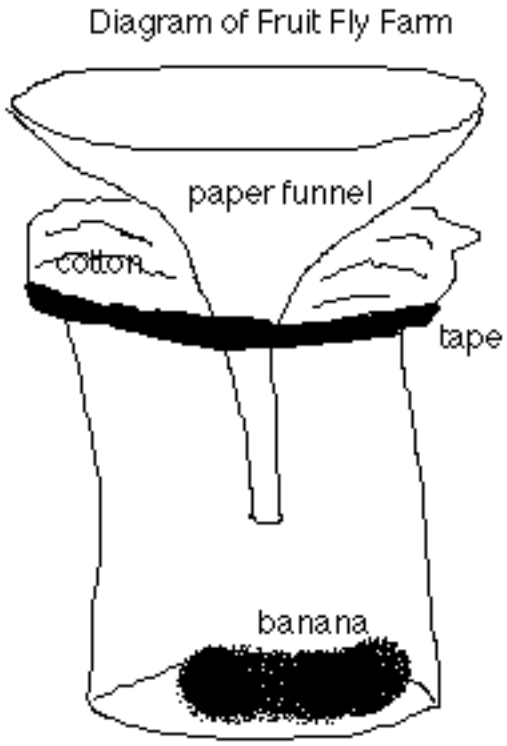
In my curriculum we study insects, and I had made fruit fly farms to let the children see metamorphosis in action. As I thought about this, it seemed to me that the fruit fly farm was a perfect example of a stock-flow. It would also be a real world application that the children could watch daily.

How to make a Fruit Fly Farm

Material: large plastic jar, cotton or part of an old pair of panty hose, banana, paper funnel and masking tape.

Peel the banana and put it in the large plastic jar. Cover the top with the cotton or the hose. Make a large funnel with a piece of paper and insert it in the middle of the cotton. Tape all around the cotton. Leave the funnel in the cotton until you have caught at least five fruit flies. Then, remove the funnel and cover the hole made from the funnel and watch and see what happens. It will take about a week for the fruit flies to start to multiply.

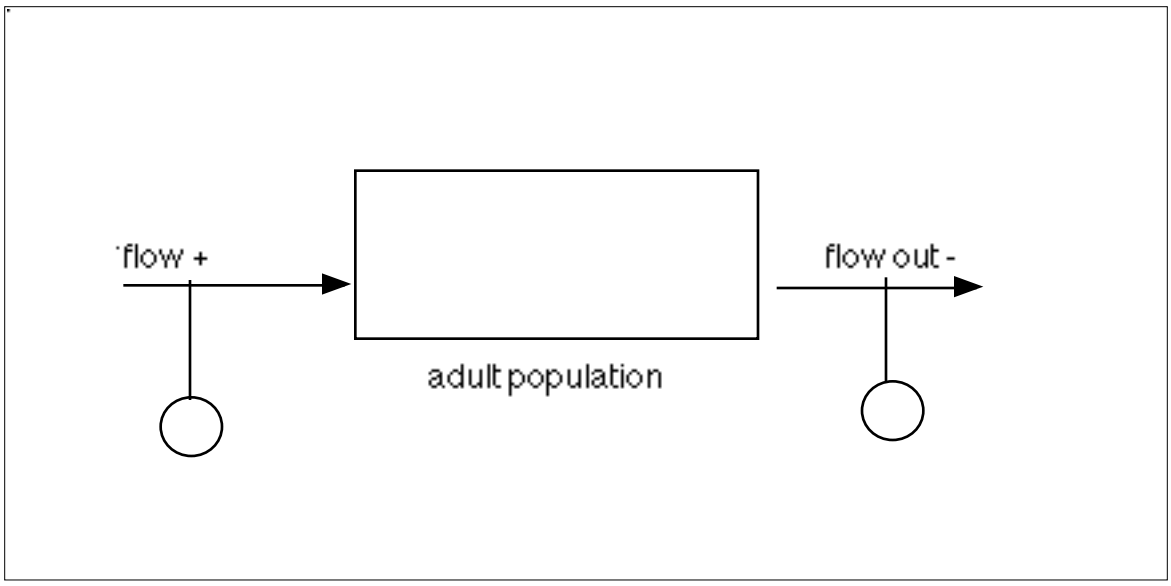
Picture of how the fruit fly farm should look.



Stock-Flow Activity

After talking about what is happening in the Fruit Fly Farm (metamorphosis is taking place) show the children a simple stock-flow diagram. I did this using an overhead projector and a transparency I made. Tell the children the stock is the number of adult fruit flies. Have them brainstorm all the ideas they can think of that will affect the adult population of fruit flies in the farm. Divide the children into cooperative groups of about three or four. Each group works on the activity sheet showing the fruit fly farm and the factors that flow-in and flow-out that affect the adult population. A copy of the activity sheet is included.

Simple Population Stock, Flow



Instead of calling those things that changed the population convertors, I first called them factors. Eventually the children learned the terminology of convertor.

To reinforce the concept of metamorphosis, population growth and a reinforcing causal loop, I read Terry and the Caterpillars, by Millicent Selsam. Ant City, by Arthur Sorros, also explains the life cycle of an insect.

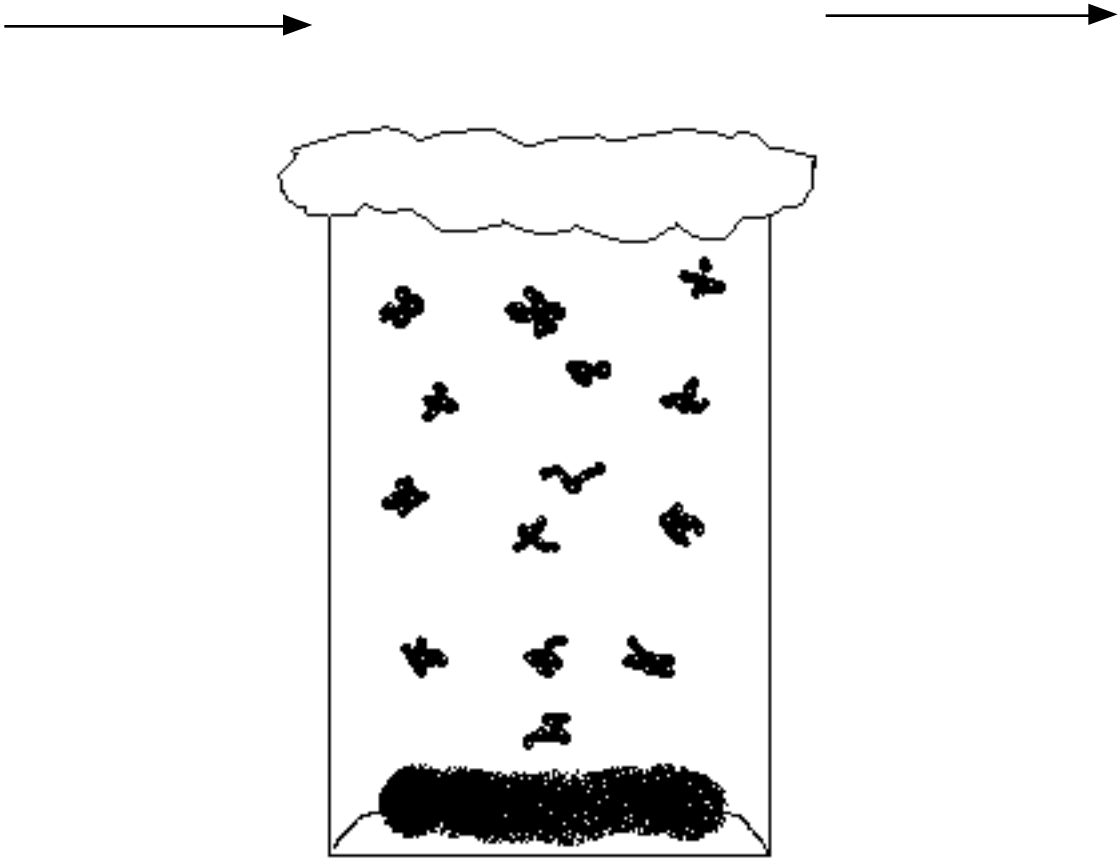
Another OOPS

Metamorphosis is a cycle, not a reinforcing causal loop. It shows the stages of development of an insect. The reinforcing causal loop is the egg-to-adult effect. The more eggs, the more adults, the more adults, the more eggs. It is a population model.

Fruit Fly Farm Stock-Flow

Flow-in Factors

Flow-out Factors



Name _____

If you let the fruit fly farm continue on its own for about four weeks, the population will eventually die out. This gave me an opportunity to ask the children to make a BOTG of the fruit fly farm. We discussed the limitations of the fruit fly farm and how that might effect populations in our world. The children, using the fruit fly farm as a model, predicted that eventually a reinforcing causal loop would be limited in its growth potential by the factors in the system. These limiting factors would eventually cause the system to die, or become extinct.

Factors generated by the children were: food, air, adult population, number of males and females, space, habitat, and water.

Introducing the idea of Behavior Over Time Graphs---

While learning about our country's history, the children in the Primary grades are exposed to time lines. To introduce change over time, to the children, the book McCrephy's Field, by Christopher and Lynne A. Myers, is read. The story explains what happens to a barn and fields when left for fifty years unattended. The children are then asked to make their own time lines. Each child is given a paper eighteen inches long and asked to fold it into four sections.

When I was little	I learned	My first day at school	Now I can

They are given the title **How I changed over time.....** to place on the paper.

As a follow-up activity, the children are given an assignment for Show and Tell to complete. Then all the pages are collected and put on a bulletin board with only the baby pictures showing. The rest of the children are asked to guess who they think is the classmate in the baby picture.

This activity is not really System Thinking in the pure sense, but it allowed the children to related to the idea of change over time in a real sense of their own development.

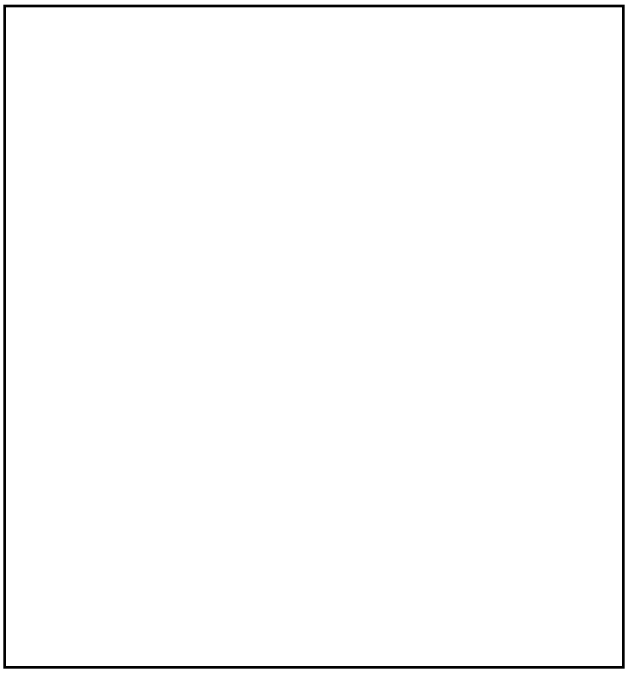
I Have Changed, Too

When I was a baby,

I weighed_____pounds

_____ounces.

I was _____inches long.

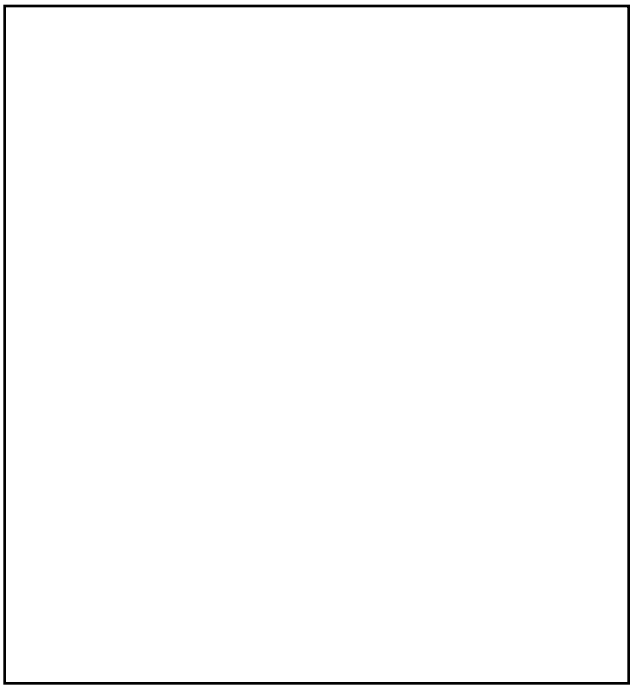


Now,

I weigh_____pounds.

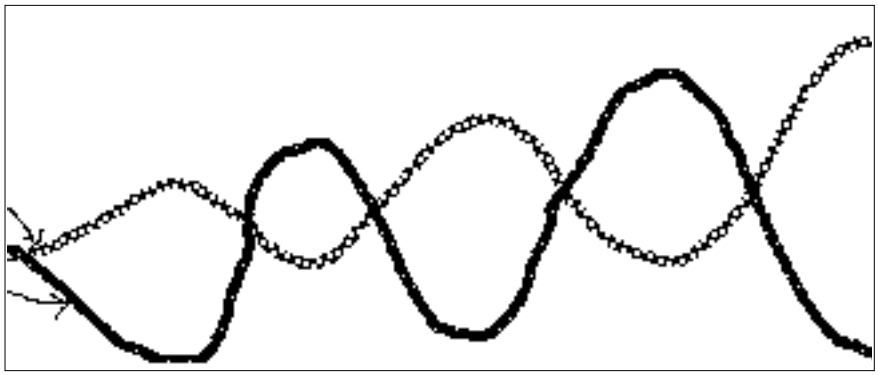
I am_____feet

_____inches tall.



On To Literature and More Behavior Over Time Graphs---

We spend a half hour every day reading to the children in the Primary grades. We have a two year rotating curriculum. The read-a-louds are chosen to integrate with our program. One year science starts with a study of the oceans. The read-aloud for that study is Mr. Poppers Penguins, by Atwater. We chose to look at Mr. Popper's happiness through the novel. After each chapter, the children, in a group, were asked to give a number to Mr. Popper's happiness level. The numbers ranged from one to ten. We kept a graph of the happiness level throughout the story. I also developed a writing book with questions about the story. Many of the questions dealt with Mr. Popper's happiness and events that affected it. The conversations that developed when the children were attempting to give a number value to the happiness level were very thoughtful and exciting. Each child had to justify his/her choice with information from the story. The group finally had to come to a consensus and vote. Majority ruled, and that number was affixed to that chapter. The graph was always visible and the children could see how it was changing over time. They began to see that the greater the worries, the less happy Mr. Popper was. They also noticed that his greatest level of unhappiness came just before the resolution of the story. At the end of the writing booklet, the children were asked to graph something that changed over time in the story. Then they were asked to graph Mr. Popper's happiness. Many children noticed the cause and effect relationship between worries and happiness. They saw a causal loop that showed, "the more worries, the more unhappiness; the more unhappiness, the more worries." This is a reinforcing causal loop. However, when they graphed the happiness level with the worries, they saw an oscillating pattern.



Now the graph reads: " the less worries, the greater the happiness, but the greater the worries, the less happiness." This is a balanced causal loop.

The success with BOTGs with Mr. Popper encouraged booklets using Island of the Blue Dolphins, by Scoot O'Dell and The Lion, The Witch and The Wardrobe, by C.S. Lewis.

Using BOTGs when looking at literature seems to make the children's conversation and understanding of the material greater. It asks for higher thinking skills to interpret the story, and not the standard comprehension questions about what happened in the story and what did the characters do.

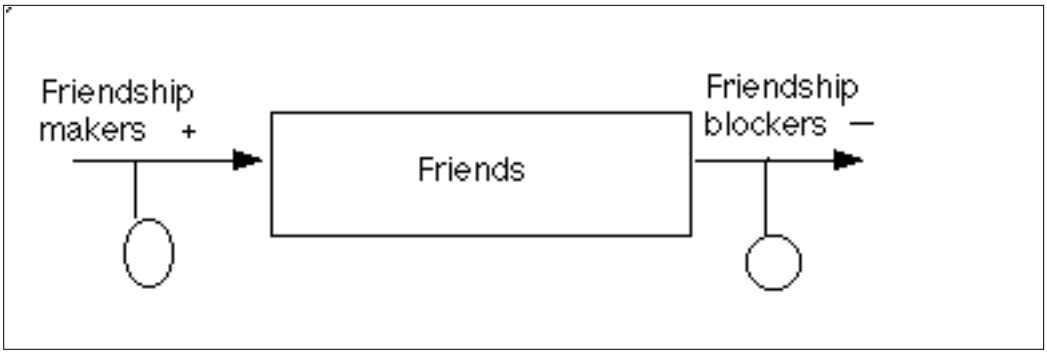
Working with Human Growth and Development using Stock-Flow, BOTG and Casual Loops.

Friendships and how to manage them seem constantly on young children's minds. Teachers often hear from unhappy children and parents about friendship issues. We hear about name calling, physical hurting and exclusion in recess games. This led me to try to develop an activity that would help the children understand how behavior affects relationships.

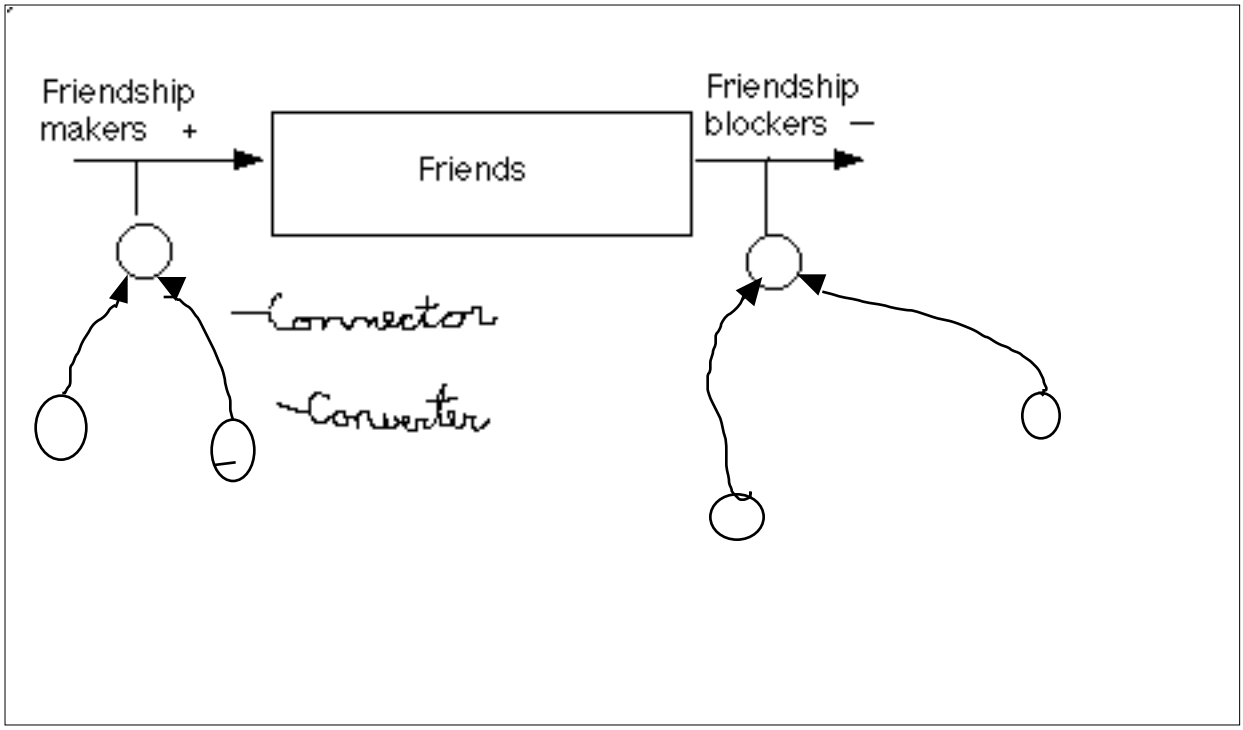
Friendship Stock-Flow Activity.

Initial activity: Read The Best Friends' Club, by Elizabeth Winthrop. Help the children identity the **friendship-making behaviors** and the **friendship-blocking behaviors**.

Now make a stock-flow diagram with friends as the stock. The input is friendship-making behavior and the output in friendship-blocking behavior.



Break the children into small cooperative groups. Ask each group to come up with five makers and five blockers. Give each group ten index cards on which to write. After about twenty minutes, have the children come back together, and let each group share the behaviors they have written down. Many will be similar. Collect those and place them on the sides of the diagram, to show makers and blockers. (I use a large piece of butcher paper on a magnetic blackboard. I collected the similar behaviors and put them together with a magnet clip and placed them on the diagram in the appropriate place, either makers or blockers.) At this time you can talk about converters and connectors. Convertors affect the rate of the flows or the content of another converter. Connectors indicate that changes in one thing affect the changes in another thing. **Connectors never point to a stock; only flows change stocks.**



A Circle of Friends

You will need: The cards generated by the children during the stock-flow activity. A large enough space to make a large circle and a basket or container.

The game is played like *Duck,Duck Goose.*

Have each child pick a card out of the basket. They should keep the card secret. Now have the group form a circle, sitting down with the card hidden beneath them. Pick one child to be the starter. Either the teacher or one of the children can be the recorder. The first child moves around the circle, touching each child's head, saying," I'm hoping, hoping,-----". When they choose another child, they say, "Friend." The child chosen reads his/her card. If it is a maker, that child joins hands with the first child and they continue around the circle. The new friend is the leader and says the hoping, hoping and chooses the next child. If it is a blocker, one child must sit down. If that leaves no one, pick another child to go around the circle. Continue playing and record the results. The recorder should be writing down the number of friends after each card is read.

Use the recorded information to make a BOTG and discuss why the numbers occurred.

I also made a board game called *Friends.* This game was available so that the children could play during their choice time. It includes BOTG and Stock-Flows.

Stop and Relax

Earl Oremus from the Marburn Academy, in Columbus, Ohio, was a speaker for one of our in service days. Marburn is a school for children with attention deficit disorder with and without hyperactivity. The school follows a simple system of rules to help improve student's behavior and focus.

Rules of the Road
Stop and Relax
What's Your Plan?
Focus
How Did I Do?

We taught these rules to all the Primary children. Our goal was to modify group behavior. After practicing the **Stop and Relax** technique for a week, we set a goal of going five days without a Stop and Relax. To help everyone keep track we used a BOTG. After accomplishing the five days, we tried for seven, and then ten. The BOTG helped the children visually see the group's record. It also helped them monitor their behavior. The final result was that the children could look over time and discuss the graph. They realized on days when they had many Stop and Relaxes that certain issues made those days troublesome. (Things like a cooking activity, the approach of a holiday.) They also saw that it was at first difficult to reach the set goal, but in the end, the final ten days came quickly.

My thought is that a BOTG can also be used with individual students. A particularly troublesome behavior could be noted and worked on with the teacher and student keeping a BOTG. Conferences between the student and teacher could be held weekly to look at the graph and plan strategies for improving the behavior. The graph would also be a good record for parents to see.

Anno's Magic Seed and Math Activities

Mitsumasa Anno's book puts all the Systems Thinking tools together. After reading the story, you can use a BOTG for the change in plants, people, seeds, and climate. The math is the equation to find the pattern for the amount of seeds. The pattern is -1, then double the number left. I let the students use calculators to predict the next number. We kept track on paper and then made a BOTG. The seeds could also be the stock. They are affected by population, planting and climate. You can also use a reinforcing causal loop to tell about the story. The more seeds planted, the more fruit. The more fruit, the more seeds.

Stella Modeling

This is something that I could not have imagined doing with young children. However, the more I tried Systems Thinking activities with the children, and saw how quickly they could use the tools, I began to wonder, " Why not?"

I went to Trinity College during the summer of 1997 with a number of teachers from MV. One of my teammates in the Primary started to do a computer model of Cinderella, using happiness as the stock. We decided to work on a computer model for Mr. Popper's Penguins. Two heads were better than one and we made a quick success of the model. We were excited to use the computer model along with the story. The children received it easily and understood the different topics graphed and how they related to one another.

One more OOPs

When trying to model a story, **always have the book on hand.** In our model we forgot that Mr. Popper and the penguins end up in jail before the resolution, and he goes off with Admiral Drake. Our model was not the same as the BOTGs we had made in class. However, it was similar enough that the children understood the point of the model.

I also made a model of Sharks and Fish. The children loved watching the model because it made them think of the sharks chasing the fish. The children could manipulate the numbers in this model and see the effect on the population of fish and sharks.

Why use Systems Thinking ----

It has been my experience through this learning process that the children have become better thinkers. They are more observant and see patterns that they can relate to numerous scenarios. They appear to be better fact finders because they need information to justify their opinions. The discussions on topics are of greater depth. Often, once the conversation has started, I could leave and they would carry on. The children are really talking to one another. They are not seeking my approval for the correct answer. I am amazed by the maturity of their insights.

I also found, over time, that the children's creative writing became better. They saw the need for the story to show change over time, which helped to direct their writing.

Behavior issues often improved because the children had a greater understanding of the cause and effect relationship. They also all had the same vocabulary in which to discuss issues.

Systems Thinking and Dynamic Modeling gives children another venue in which to learn. Multiple Intelligence is a current buzz word in education. Systems allows for more than the visual, auditory learner to be involved. Dynamic modeling on the computer or in a game helps kinesthetic learners even the field. The child with strong artistic intelligence may find the drawing of models stimulating. Those children with strong interpersonal intelligence usually see connections easily, and Systems Thinking is about cause and effect. I think those students with strong naturalist intelligence will probably be interested in the connection to the environment, on which many of the Systems activities are based. I have found that many times it is not the traditional student who excels in Systems Thinking, but often the child who seems to be struggling with more traditional methods.

Systems Thinking can be used in all parts of the curriculum. I have tried to include examples of activities that show how Systems Thinking integrates areas with a common language and course of study. Integration is important because our lives do not fit into curriculum areas, never to be related to one another. Systems is another tool to help students see the large picture and its integral parts, and how they affect one another.

We recently had a University of Toledo professor talk to the children about recycling. He had helped invent the numbers and system for recycling plastic. He was explaining to the children how important it was to recycle plastic and all the new products that could be made from old plastic containers. One of the children turned to me and in a whisper said, " Hey, that's a causal loop." I wondered if the professor knew that.