The Challenges of Infusing System Dynamics into a K-8 Curriculum

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ABSTRACT: If system dynamics is to fulfill its promise of fundamentally improving education in kindergarten through twelfth grade, then it must be fully integrated into the curriculum. This means not only developing effective lessons using the tools and perspective of system dynamics, but also finding the best ways to help teachers adopt them. Both are very challenging. Teachers and administrators at the Carlisle (Massachusetts) Public Schools have been working to infuse system dynamics into their K-8 curriculum since 1994. This paper will describe the process of developing and implementing system dynamics lessons. Using one lesson as an example, it will illustrate what the children do and what they learn. It will also present the problems of imbedding the lesson and the systems approach into the curriculum.

INTRODUCTION

System dynamics can fundamentally improve education for students in kindergarten through twelfth grade (K-12). Experience in the classroom has shown that system dynamics can help students develop critical thinking and problem-solving skills. It can also enhance their understanding of the current curriculum by helping them to ask better questions and to recognize connections and patterns across subjects.

The potential of system dynamics in education reaches beyond the subject learning of individual students, however. It promises to transform the structure of education itself. When students use the tools and perspective of system dynamics, education becomes more learner-centered. Teachers become guides helping students construct their own knowledge. Instead of being passive receptacles of information dispensed by the teacher, students become engaged in working together to figure things out for themselves. As teachers also begin to work together to build their own system dynamics skills and develop interdisciplinary lessons, the change permeates the school culture, fostering even further change.

The curriculum is the driver in initiating and sustaining improvement in education through system dynamics. The challenge is to find the best ways to improve current teaching using the tools and perspectives of system dynamics and then to embed them so deeply into the curriculum that they take hold and grow on their own. Teachers at the Carlisle Public Schools in Carlisle, Massachusetts have been working to integrate system dynamics into their K-8 curriculum since 1994. This paper will describe the process of developing and implementing a curriculum using system dynamics. Using one lesson, the In and Out Game, as an example, it will explain what the students learn. It will also illustrate the difficulties of getting a lesson to stand on its own.

SYSTEM DYNAMICS FOR EVERY STUDENT IN CARLISLE

Carlisle is a small affluent town west of Boston, known for its excellent school system. Carlisle has one school campus for students in kindergarten through eighth grade (K-8, ages 5 through 13) with a total enrollment of 815 students. It is a caring friendly place where everyone knows everyone else, in a community that holds very high expectations for its schools. System dynamics was first introduced here when a few teachers and administrators attended the Creative Learning Exchange conference on system dynamics in education in 1994. From a small beginning in two middle school science and math classes, system dynamics has very slowly spread to all other grade levels and subject areas in the school as more and more teachers have witnessed its benefits for their students. Now, seven years later, every student in the school has some exposure to system dynamics every year. With strong active support from the school board and the administration, system dynamics is gradually becoming part of the school culture.

The growth of system dynamics in Carlisle has been led, nudged, and occasionally salvaged by a team of five people. Rob Quaden, the original math teacher involved, and Alan Ticotsky, a former elementary classroom teacher and science coordinator, are Systems Mentors. Generously supported by the Waters Foundation since 1997, their role has been to develop lessons and help other teachers learn how to use the tools of system dynamics with their students. Eileen Riley, the district business manager, has been interested in organizational learning as well as the smooth operation of the program. Davida Fox-Melanson, Carlisle School Superintendent, has led the school with a clear vision of improved education while also fostering progress in system dynamics through building community support, faculty collaboration and risk-taking, and professional development. Debra Lyneis, former teacher, Carlisle parent and former Carlisle school board member, now works with Alan and Rob to develop and publish curriculum materials available free on-line through the Creative Learning Exchange (http://clexchange.org). In addition, Jim Lyneis, a professional system dynamicist at PA Consulting Group and Senior Lecturer at MIT in system dynamics, has been a valuable and steadfast resource for system dynamics expertise over the years. This team has worked hard despite setbacks to infuse the principles and practice of system dynamics into our school. We are pleased with our progress so far, but we realize that that progress still depends on our being here to nurture it along. Our ultimate goal is to have system dynamics so tightly knit into the fabric of our school that it will thrive without us.

SYSTEM DYNAMICS IN THE CURRICULUM

In Carlisle, system dynamics is not taught as an end in itself; it is not a separate school "subject." Instead, system dynamics offers a set of tools which teachers use to improve what they are already teaching about change over time. These tools are: behavior over time graphs, stock/flow diagrams, causal loop diagrams, simulation games, and computer models. They are used across disciplines and grade levels to help students gain a deeper understanding of whatever patterns of change they are studying. For example, students use behavior over time graphs to examine changes in science experiments and literary plots. They use causal loop diagrams to explore the unintended consequences of environmental policies. They use games and models to learn about epidemics, over-fishing, and their own bank balances. They use the tools to study common

patterns across different disciplines, such as exponential growth. Throughout, they build their math reasoning, problem solving, collaboration and communication skills.

When students are using these tools, their instruction becomes more learner-centered because system dynamics involves an engaging process of asking better questions, figuring things out and learning from mistakes. While improved pedagogy is one benefit, we also have a higher goal. We teach our students to use the tools of system dynamics because we want them to learn to think and act systemically. We want to equip them with the skills and perspectives to deal effectively with the dynamically complex social, economic, and environmental problems that they will face. We would like them to recognize the effects of positive and negative feedback on accumulations over time. We would like them to understand that cause and effect can be distant in time and space, that policies involve tradeoffs and unintended consequences, that unlimited growth cannot last forever, and that what they do makes a difference. We would like to give them the tools and the courage to address complex problems objectively with logical consistency. These are very high expectations.

Obviously, we are not there yet! Our students have only rudimentary system dynamics skills. Our curriculum is new and evolving, and we still have not seen students move up through our entire K-8 sequence. Meanwhile, our teachers are still learning too, all at different stages. Ultimately, we would like our graduating eighth graders to leave with the ability to build and interpret basic system dynamics models. Again, model building would not be for its own sake but in service of the curriculum. Furthermore, there are many preliminary skills that students must learn to prepare for and complement model building. In Carlisle, developing a system dynamics curriculum is definitely a work in progress, with a long way to go.

WHAT MAKES A GOOD SYSTEM DYNAMICS LESSON?

As systems mentors Rob Quaden and Alan Ticotsky have worked with teachers to infuse system dynamics into the Carlisle curriculum, several criteria for successful lessons have emerged:

- **The lesson must enhance the current curriculum**. It must provide teachers with a way to teach what they are already teaching, only more effectively. Teachers are already busy with a full curriculum. A good system dynamics lesson must demonstrate to teachers that it benefits their students without adding to the load. Usually when teachers see how absorbed and insightful their students can be using the system dynamics approach, they are convinced of its merits.
- **The idea for a good lesson often comes from a classroom teacher who recognizes a possible systems application in a current lesson.** Often in Carlisle a classroom teacher will invite one of the mentors in to help develop a systems lesson around what begins as a vague idea. These lessons fill a perceived need in the curriculum and the teachers take ownership of them.
- **A good system dynamics lesson has a hands-on component that helps students reach from the concrete to the abstract**. Students learn by doing. In an effective lesson for K-8 students, the use of system dynamics tools should flow directly from the concrete activity. For example, students count and graph beans to learn about exponential growth, or they spread a “disease” by secret handshakes before they use a model of epidemics.

- **A good lesson is learner-centered**. Students are engaged in figuring things out for themselves.
- **A lesson must be suited to the developmental level of the students**. Because K-12 system dynamics is still in its infancy, developing a sequence of system dynamics skills and determining their age appropriateness is still a matter of trial and error. In Carlisle, often a lesson is presented at one level and later moved to a younger or older grade to find where it fits best.
- **Lessons deliver two kinds of learning: curriculum content learning and system dynamics skill building.** The primary aim is to help students think more deeply about science, social studies, literature, math, etc.; the tools of system dynamics aid that process. However, students also need to sharpen their system dynamics skills if they are to use the tools most effectively. The best system dynamics lessons do both.
- **A good system dynamics lesson stands on its own**. If the lesson meets the above criteria, classroom teachers are willing to adopt it and make the approach an integral part of their curriculum. As teachers build their own systems skill and confidence, they are willing to conduct the lesson independently and develop more applications of their own.

HOW DOES A LESSON GET INTO THE CURRICULUM?

System dynamics was first introduced in Carlisle in eighth grade science and math classes. As these two teachers conveyed their enthusiasm for the approach to colleagues, the use of the tools began to spread very slowly into other classes. After Rob Quaden and Alan Ticotsky became systems mentors supported by the Waters Foundation, the spread accelerated down into elementary grades and across middle school subjects. The mentors sought places in the curriculum where systems tools could improve instruction and worked with classroom teachers to develop and co-teach lessons. Initially, they worked with the teachers who were most inclined to be interested and on applications that were most obvious, usually in math or science – in pioneering, new ideas get their best start in "fertile ground." Gradually, as the word has spread, the mentors have reached out to other teachers and disciplines. The fifth grade team of teachers has been a wellspring of ideas and enthusiasm, now generating many of their own lessons with the support of the mentors. Eighth grade has been another very active grade. There are now lessons at every grade level, K-8, taught in all sections of each grade.

System dynamics is now becoming an expectation in our curriculum. Improving our curriculum through system dynamics is an explicit system-wide goal presented by the superintendent to the school board and evaluated annually. Furthermore, through collective bargaining several years ago, we established a financial incentive for teachers to build competencies related to the school system goals. Teachers are compensated for participating in local system dynamics training and demonstrating their competency in the classroom. Although there are still widely disparate levels of skill and interest among the staff, system dynamics is becoming more and more a part of "what we do here."

The mentors and the administrators are not the only forces behind the growing use of systems tools. The students also play an important role – maybe the most important role. Recently, eighth graders were using behavior over time graphs and causal loop diagrams in science class to structure the research and writing of their interdisciplinary ecology term papers. Each student

also worked with another teacher as an advisor. For a long time, the system mentors had been trying unsuccessfully to find an entrée into the social studies curriculum. The eighth grade teacher was willing, but system dynamics seemed too difficult and foreign. However, after she saw her student advisees' facility and depth of understanding with causal loops on his science project, she decided to let her social studies class loose with them too. With a little support from Rob, the students drew perceptive causal loop diagrams of the causes of the rise of Nazism. The teacher was impressed with the richness of the class discussion. Now she is ready for more.

ONE LESSON: THE IN AND OUT GAME

The In and Out Game is an example of a lesson using system dynamics tools in math. In the first and second grades, very young students use the game to learn about graphing and the concept of stocks and flows. Later, students revisit the lesson in the fifth and eighth grades to reinforce and extend their learning. This lesson is a good example because it shows that although the lesson benefits students, integrating it into the regular curriculum is not assured. It is a dilemma that currently puzzles us.

Alan Ticotsky created the game for young students; Rob Quaden adapted it for older students. The complete lesson, "The In and Out Game: A Preliminary System Dynamics Modeling Lesson" by A. Ticotsky, R. Quaden, and D. Lyneis, 1999, is available free on-line from the Creative Learning Exchange at http://clexchange.org under the List of Materials, #SE1999-09.

The First Grade Lesson

Six year olds physically act out and graph an accumulation. Mentor Alan Ticotsky delineates a place in the classroom that will hold the "players in the game." There is also a path "in" and a path "out." First, the class discusses the "rules of the game," starting with "two in and one out." Each round, two students walk into the designated area and one student walks out. Meanwhile, the teacher "keeps score" on a large table recording the flows in and out as well as the total number of players at the end of each round. The teacher also plots the number of players on a large line graph. The class discusses the emerging pattern on the graph. They also notice that while the flows in and out remain constant, the number of players in the game increases.

Round	Players Going In	Players Going Out	Total Players
(Start)			0
1	2	1	1
2	2	1	2
3	2	1	3
4	2	1	4
5			

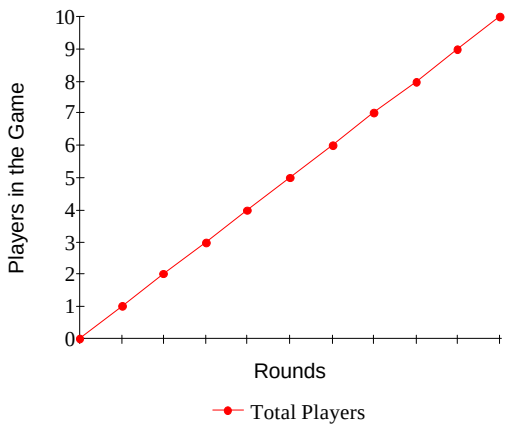

Figure 1. Table and graph of "Two in and one out."

From the In and Out Game, first grade students learn that the line graph is a representation of the information they have gathered. They learn that the vertical axis stands for the number of players in the game, and that the horizontal axis records time, or rounds in the game. As they play the game, they see that the line on the graph shows how the number of players is changing over time – if the number of players is increasing the corresponding line on the graph goes *up*. They are learning the concept of stocks and flows in a concrete way without using these terms yet. Reinforcing their regular math instruction, students practice addition, subtraction, and estimation each round.

It takes about 45 minutes to explain and physically play four or five rounds of the game with these young children. The students love everything about it: following the rules, counting, and thinking about graphs. They soak it all up.

The Second Grade Lesson

We know that students have absorbed the lesson because when Alan returns to play the game with them a year later in second grade they remember the details and are eager to play again. Needing only a brief review, second grade students are able to play and graph more rounds of the game. They can also change the "rules." After playing "two in and one out" for a few rounds, they can try "one in and two out," "one in and one out," or "three in and one out" and observe and graph the difference as a class.

At the second grade level, students are introduced in a concrete way to the concept of slope. A "steeper" line means faster growth in the number of players; a "flatter" line means slower growth, or no change if the inflow and the outflow are the same. This year they are also introduced to a basic stock/flow diagram as another way to represent the game. They observe that the change in the stock depends on the flows in and out in the game as well as in the diagram, the graph and the table.

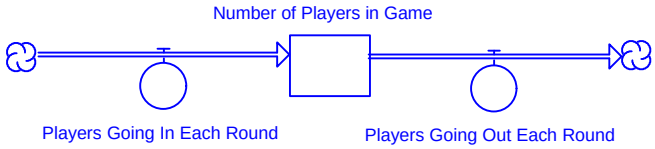

Figure 2. Stock/Flow diagram of the In and Out Game

Playing the game continues to reinforce the students' regular math instruction; students practice their more advanced skills of adding, subtracting, predicting, and graphing. In 45 minutes these second graders are able to do much more than the first graders could. The first grade lesson laid the groundwork.

The Fourth/Fifth Grade Lesson

In the upper elementary grades, the In and Out Game serves as a review of the concept of stocks and flows and as an introduction to computer modeling with STELLA. The lesson was first used in fifth grade because the teachers were very receptive and because the game tied in with other system dynamics lessons there. The mentors are now considering moving part of it to fourth

grade because the younger students appear ready for it and because this preparation would allow students to “hit the ground running” in the fifth grade.

By age 10, fifth grade students no longer need to walk into and out of the game to understand the concept of stocks and flows. They still need some reminder of the concrete activity to solidify their grasp of the abstract concept, however. For those students who played the game in second grade, a brief recall of the game is enough. Another option is to describe the game to students as “little kids” would play it and play an abbreviated version. Instead of moving around the room, students going “in” or “out” just stand and sit at their places while the teacher records the progress of the game on a large graph. It only takes a few rounds before the students are ready to manipulate the ideas without the actions. Students can try different rules, discuss the slopes, and predict accumulations 20 or 30 rounds out. They briefly review a stock/flow diagram of the game, noting that the graph and the diagram describe how the accumulation changes over time as a result of the flows in and out.

This year, fifth grade students went on to build STELLA models of the game. Originally, modeling was an eighth grade lesson, but younger students have taken to it easily and it has prepared them well for other fifth grade system dynamics lessons. (An introduction to model building through the In and Out Game may also appropriate at the fourth grade level, but probably not younger than that.) The mentors and, increasingly, the fifth grade classroom teachers lead the students through the mechanics of STELLA using a computer with a projection device. The teachers very briefly explain how to drag down and label stocks and flows of the players in the game. They show students how to set up a graph and run the model. (Students are always impressed when the model generates the same table and graph that their classroom game did!) The explanation takes about 10 minutes. Then, students go to their own computers in teams and build the same model. As a challenge, they try other rules for the game, predicting the graphs before running them. They love doing this.

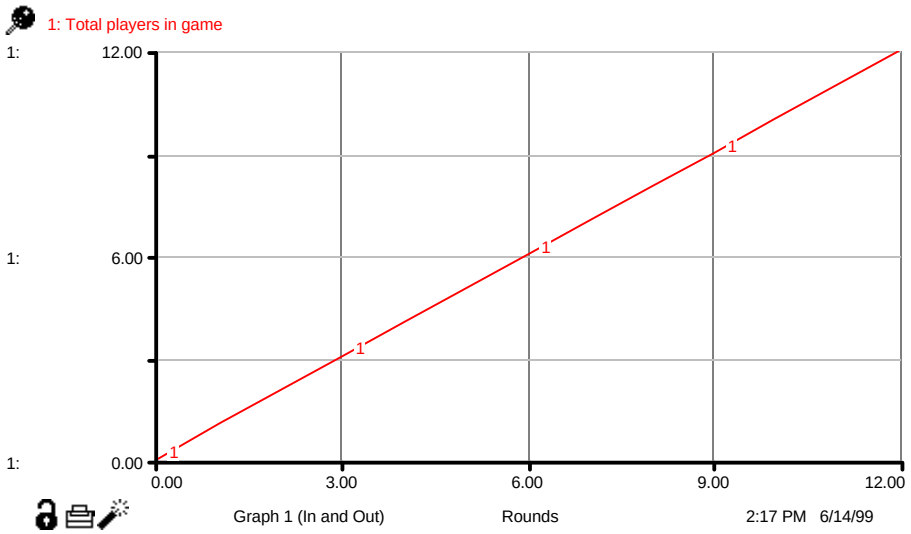

Figure 3. STELLA graph of “Two in and one out”

At the upper elementary level, the In and Out Game helps students gain a deeper understanding of stocks and flows. They learn more about slope and rates of flow. Finally, they are introduced to the concept of a computer model as another way to represent and examine change over time.

The Eighth Grade Lesson

Thirteen year olds no longer need to play the concrete game. However, a quick review of it does refresh their memories of the concept of stocks and flows. When Rob Quaden conducts this lesson in his eighth grade Algebra I class, he spends 10 minutes at the board going over the rules of the game, the graph of a few rounds, and the stock flow diagram. Students spend the remainder of the period in teams at the computers building their own models of the game. They use their models to answer questions like these:

- Can you get the line on the graph to be less steep? (Less slope, smaller net in-flow.)
- Can you make it steeper? (Greater slope, larger net in-flow.)
- Can you start the line at a different level. (More initial players.)
- Can you make the line slant the opposite way? (Out-flow >in-flow.)
- Can you make it horizontal? (Out-flow = in-flow.)
- Can you make it horizontal starting at a different level?
- What does it mean when the line crosses zero?
- For any graph, can you predict the value after 20 or 30 rounds? (Change the length of simulation.)
- What happens to the line if the flow changes during the game? (Step functions.)

At the eighth grade level, the In and Out Game further develops students' system dynamics reasoning and modeling skills. It also ties in to the math curriculum as another way to express $y = mx + b$, where m is the slope and b is the y-intercept. Modeling gives students another way to visualize and understand the equation.

The In and Out Game is still a preliminary system dynamics lesson because the game and model do not include feedback. Also, especially at the youngest ages, the game focuses on discrete rather than continuous change. These more advanced steps come later in other lessons. The In and Out Game is an attempt to present sophisticated system dynamics concepts in manageable concrete pieces for young children.

SO, WHAT'S WRONG WITH THE IN AND OUT GAME?

In Carlisle, we have been very pleased with this elegant little lesson, and we hear that mentors in other school districts have found it useful too. The students gain an understanding of the concept of stocks and flows based on their own concrete experience. They learn to construct and analyze behavior over time graphs. They sharpen their math reasoning and computation skills. They build nice little models on the computer. And, best of all, the students love doing all of this. They are engaged in learning by doing.

The problem we are encountering now is getting the lesson to stand on its own in the lower grades, however. In the upper elementary grades and in middle school, the classroom teachers are beginning to adopt the lesson and conduct it themselves, without the assistance of the

mentors. They see its benefits to their students and a need for it in their curriculum. The In and Out Game helps them more effectively use the tools of system dynamics in teaching other social studies, science, literature, and math lessons. It is taking root.

The first and second grade teachers do not see a similar need, however. Alan Ticotsky has conducted the lesson in their classes and they have always participated, but instead of adopting the lesson, this year they have suggested that their students do not need the graphing lesson at all. They are feeling pressured for time and concerned about diverting any from their primary goals. In first and second grade, the teachers have a strong, almost single-minded, focus on early literacy, with good reason. Students who are not proficient readers by the end of second grade fall behind in school from the very beginning and never catch up. Primary teachers devote most of their attention to helping students develop essential reading skill. Furthermore, because primary teachers' interests and training have focused on literacy and early childhood development, they have not studied as much advanced math or science. They are not inclined to see how a system dynamics graphing lesson fits into their curriculum or into the larger picture. The choice is up to them.

While it is easy to point to the teachers as the reason for our stall in system dynamics progress in the primary grades, perhaps we should look at the lesson itself. In Carlisle, the primary grade teachers are conscientious and skilled; they work hard to educate their students well. If they thought the In and Out Game could benefit them and their students, they would adopt it. It may help to take another look at the criteria for a good lesson presented earlier:

- **The lesson enhances the current curriculum**. While the In and Out Game at the primary level does reinforce arithmetic skills, it does not grow directly out of the current math curriculum. It also does not address reading skills. In the older grades, the lesson does blend with the curriculum offering math problem solving skills, computer literacy, and groundwork for other system dynamics lessons.
- **The lesson comes from the classroom teacher**. The primary teachers did not come up with the idea for this lesson. Instead, Alan Ticotsky presented it to them and they allowed him to teach it because they respect him and because they were curious about the systems initiative in Carlisle. The primary teachers do not own the lesson. In the upper grades, teachers have adapted the lesson to their needs.
- **There is a hands-on component.** Yes, the In and Out Game meets this criteria well, especially in the primary grades. The students learn by doing.
- **The lesson is learner-centered.** Again, the In and Out Game succeeds. The students love to play this game in the primary grades as well as in older grades. They are absorbed in the activity, and the sophistication of their understanding is impressive. The knowledge they construct stays with them and prepares them for subsequent learning.
- **It is developmentally appropriate.** Because this lesson has been moved around and adapted for different ages, we think that it has found its developmentally appropriate spot…for now. It will take time for a complete and consistent system dynamics curriculum sequence to evolve fully.

- **The lesson embodies both curriculum content learning and system dynamics skill building.** Maybe this is our biggest problem. The In and Out Game is fundamentally a system dynamics lesson. It is designed to teach students about behavior over time graphs, stocks and flows, and computer modeling. It does build other skills and touch on other curriculum topics, but the balance tips toward system dynamics. In the later grades, there are many Carlisle lessons that use systems tools to teach a broader curriculum subject; the content learning is the objective of those lessons. However, students also need to learn system dynamics skills if they are to make the best use of them. The In and Out Game fills this need. In the older grades, the teachers recognize this need, but in the primary grades the need is not so apparent.
- **The lesson stands on its own.** In the older grades, the In and Out Game is beginning to happen without the support of the mentors. In the primary grades it is losing ground because the teachers do not see its need. If we cannot engage the teachers, we have no hope of engaging the students. If lessons cannot stand without our support, they will not last or spread.

WHAT CAN WE DO?

System dynamics debuted in Carlisle in the middle school curriculum. As we have worked at that level, we have always felt that students could benefit if we could help them become systems thinkers at a much earlier age. The In and Out Game has shown us that young students can indeed begin to build and use system dynamics skills. Integrating the lesson into the curriculum is proving to be a challenge, however. What can we do?

- If the K-2 curriculum focuses on early literacy, and if the systems approach enables students to become engaged in constructing their own knowledge, then we need to find a way to infuse the systems approach into the teaching of reading. As with older students, young children can also benefit from asking better questions and learning by doing (in fact, this is their natural inclination—they do it all the time.) The goal is not just to find a way to fit system dynamics into the curriculum; instead the aim is to use the tools to teach children more effectively in a departure from the way we do things now. At the primary teachers' suggestion, Alan Ticotsky will be working with them to use behavior over time graphs in literature. Students will draw graphs to trace and discuss changes in stories and think more deeply about what they read. Alan is gracious and tireless in his efforts to find a way to improve instruction using systems tools; now teaching reading has become his target.
- Alan has developed another primary grade graphing lesson based on the Friendship Game (also available on-line from the Creative Learning Exchange.) This lesson complements the current social competency curriculum. Students play and graph a classroom game that shows how friendly behavior can spread in a class; they discuss the implications for their own class. Since primary teachers are very interested in early childhood development and socialization, we should observe how well this lesson is accepted. (Alan also has a similar kindergarten lesson and game about planting and harvesting trees that ties into the current rainforest unit. We need to observe and learn from this lesson too.) Perhaps the graphing can be useful in a different context than the In and Out Game.

- We need to pay attention to our own criteria for good lessons. Through the In and Out Game, we have learned at least that the criteria are valid because when we violated them the process did not work!
- We may need to rethink or delay the introduction of system dynamics graphing in the primary grades. Of course, we are reluctant to do so because the students seem to understand, but we also know that we cannot push these ideas onto teachers. They may be right. It might be better to save the graphing for an older grade when students can learn it more quickly just when they need it. For now, maybe it is enough to use the tools in a more general way. We need an open mind to achieve the best long-term results.
- Meanwhile, we need to explain the goals and benefits of system dynamics to all teachers, including primary grade teachers. Because they are busy with their own curricula, many teachers do not often get a chance to see what is going on in the rest of the school. It might help primary grade teachers to see older students engaged in an exciting system dynamics lesson in science, math, social studies, literature, or health. System dynamics is new in K-12 education. If it were already integrated into the curriculum, all teachers would see it as one of the life-long skills that we help students acquire as they progress through the grades. For now, the challenge is getting that reinforcing cycle started.

CONCLUSION

The In and Out Game has been a good lesson for us in Carlisle. We are pleased that it is such a successful system dynamics lesson for our students, and the systems team has learned a great deal from the process. It is a concern that the lesson does not stand on its own, but it serves to give us insight into what we don't know – which is the first step in finding a solution.

We suspect that finding ways to integrate system dynamics lessons and perspectives into K-12 education is a challenge that extends beyond Carlisle's experience with the In and Out Game. Most teachers are pressed for time and already very busy "covering" their current curriculum in the ways that they have been taught. For a few of these teachers, the systems approach suits their curriculum and their own way of thinking – they are natural systems thinkers already looking for a change. These are the pioneers and initiating change with them is easy. Carlisle's fifth grade team is a good example.

The bigger challenge is to move beyond these early adopters into the larger group of teachers for whom the curriculum applications or teaching approach are not so obvious. It can happen at any level in a school. In Carlisle, the issue has arisen in the primary grades, but we suspect that it would also be the case in high schools where the philosophy and structure of the school make teachers even more inclined and pressured to cover their own separate subjects in the traditional way. In Carlisle, we have found that some teachers who were not early adopters have given system dynamics lessons a try and found them very effective and useful; they now develop applications of their own. Each has approached the idea in a different way and at a different pace. We need patience and creativity to find a good path "In" for the K-2 teachers too.

Developing good systems lessons is a challenge, but finding ways to integrate them into the current curriculum requires equal attention if K-12 system dynamics is to flourish.

Resources

Ticotsky, A., Quaden, R. and Lyneis, D., 1999, "The In and Out Game: A Preliminary System Dynamics Modeling Lesson." Prepared with the support of the Gordon Stanley Brown Fund. The Creative Learning Exchange, Acton, MA, http://clexchange.org (This paper is available free on-line, #SE1999-09.)

Ticotsky, A. and Lyneis, D., 2000, "Graphing the Friendship Game: a Preliminary System Dynamics Lesson," Prepared with the support of the Gordon Stanley Brown Fund. The Creative Learning Exchange, Acton, MA, http://clexchange.org (This paper is available free on-line, #CC2000-10.)