System Dynamics and Student Leadership
by Dan Barcan

“Mr. Barcan, shhh.” Ryan, a fifth grader at Murdoch Middle School, where I served as the Waters Foundation Mentor for System Dynamics, silenced me as I began to address the students leaving our activity. I explained to him that I was going to tell them not to share their solution with the incoming group, but Ryan was a step ahead of me. “We don’t need to,” he said. “You can’t cheat at this.” Then, turning towards the new group entering the room and raising his voice to a level that conveyed calm control without anger or force, he quieted the crowd of teenagers and began explaining the rules to the new group.

Ryan was leading the game as a part of DynamiQueST, an annual meeting for students and teachers from grades five through twelve with an interest in system dynamics. In its first two years it has drawn students from Massachusetts, Vermont, and Ottawa, Canada, who come to display and explain posters showing their insights from work with models, causal loops, and behavior-over-time graphs. Professionals who use system dynamics in their daily work—writers and publishers, consultants, professors—provide expert coaching on each project and then support the students as they apply SD tools to a new problem which is presented to the students that day.

Developed by Russ Reid, Ryan’s Challenge teacher (Challenge is Murdoch Middle School’s take on what is traditionally called “gym class.”), the game helps students understand the concepts of feedback and unanticipated consequences by trying to get a team from one end of a room to the other on a “boat” made of a few wooden planks. Most groups find out in a variety of hard ways what happens when part of a team moves before the whole group is ready, or when we try to break systems into small parts and optimize those parts without considering the whole system. All spend about two-thirds of their time trying to “cross the ocean,” and the rest debriefing. Though Ryan had his name on the agenda next to the game’s title, Russ and I still thought we were the ones in charge. Luckily, we have learned that when we get a hunch that the kids know more about what’s going on in one of these activities than we do, we ought to keep our mouths closed.

It was a good thing we did, too. After we shut up, we got to watch Ryan line up the group on the “boat,” spin a story about why they needed to cross the “water,” and redirect them whenever they edged towards a violation of the rules in letter or spirit. In one instance, a six-foot tall high school junior asked if his group could take the boat apart, making it into more of a walkway. It was the sort of judgment call that teachers make a thousand times each day. Sometimes we make good decisions and sometimes they return to haunt us, but it takes time to learn how to choose well without agonizing so long that we disrupt a classroom’s flow. As I thought of how to answer this student—his idea was a new one—Ryan launched into a poised restating of the rules, explaining that, “even though we say it’s a boat, you’re really supposed to be learning about your actions and their
consequences, so you can decide if that idea would be legal.” Keep quiet, I reminded myself.

While I had been spending my year planning with and mentoring Russ and visiting classes each week to observe systems lessons, Ryan had seen his own class internalize some of the lessons we were teaching at DynamiQueST and knew, he just knew, that he could help other students to learn those lessons as well. From observations at school I had seen him as a polite participant in group activities, but not someone who took over and led other kids. Another student at DynamiQueST, Carisa, acted similarly to Ryan at school. Carisa at DynamiQueST, though, would end the day by challenging the conclusions of one of the coaches—one of the most respected thinkers in the field of system dynamics—in a polite, well-argued group discussion. How many of the adults present would have had the confidence to do that? And, more interestingly, how did these normally reserved students become leaders for a day?

One obvious answer is that most of Ryan’s and Carisa’s days are not spent using system dynamics. By preparing for DynamiQueST, all these kids had already demonstrated some interest in and acumen for this discipline. Certainly their comfort and expertise with the material encouraged them to take a more active role. But they are “experts” in other subjects at school—writing, math, Capture the Flag—and yet do not demonstrate such tendencies. Perhaps, then, it is work with system dynamics, rather than mastery of it, that encourages new leaders to emerge. System dynamics has a variety of qualities that seem to allow different leaders to emerge than those we normally see in the school day:

**System dynamics activities de-emphasize competition.** When Ryan told me not to worry about students cheating, he had ample evidence for his claim. According to Ryan and Russ, each of the groups they saw that day came up with a different answer. When a group heard about how an earlier group had crossed the ocean, they would consider parts of the solution and integrate or reject them. None saw the challenge as one with a single answer to be found as quickly as possible. Instead, teams strove to solve the problem in divergent, elegant ways. Unfortunately, there are too few opportunities for this sort of challenge in most regular school days, for a variety of reasons. Kids who fear doing something wrong won’t step up to lead under those circumstances. But when problems truly do not have a “best answer,” these students may feel more confident to lead the way to one of many solutions. Teaching system dynamics encourages divergent thinking and forces us to plan curricular challenges that are open-ended. Less cheating and decreased concern about “getting it right” improve student behavior, which in turn invites new leaders who might shy away from policing their peers.

**System dynamics tools appeal to students who tend to find debriefing too abstract.** Plenty of activities, from character education to literature groups to science labs, involve some sort of debriefing, in which the class talks to reflect upon the activity just completed. Anyone who has incorporated this valuable tool into a class knows that, while some students benefit from this oral reflection, others tune out or become disruptive during this time. Having students lead activities, including debriefing, can put kids in the tough position of attempting to discipline or make accommodations for their peers. But
the tools of system dynamics—loops, models, graphs—provide a visual language within which more students can access what tends to be an entirely spoken activity, with no graphical record. Students who might consider any participation in a debriefing session mystifying—let alone leading that debrief!—may find these tools a point of entry that makes the debrief something they can help others through.

When teachers work as guides, not experts or police officers, different students can see themselves playing our role. When we teach about dividing fractions, or analyzing symbolism in literature, or Manifest Destiny, we usually know more about those subjects than anyone in the room. Even in a student-centered classroom, where kids are led to create their own meaning, teachers still play the role of expert, answering questions and assessing work as needed. Perhaps this role is too intimidating for some kids to take on. But when leading a system dynamics game, we are no longer experts in anything except the rules of the game. Participants ask us questions not because they don’t know answers and we do, but as part of a collaborative problem-solving strategy or to help them interpret rules. And no one asks about our assessment, since it is clear to all when a team’s process worked and when it did not. For many teachers and students, the latter role is a more natural and fun role to play than the former.

Finally, system dynamics is a low-pressure part of the school day. No one teaches system dynamics because it is on a high-stakes test. It’s not a curriculum teachers are forced to “get through.” Though some schools or districts may mandate that all teachers learn to use its tools and understand its tenets, it does not lend itself to suddenly appearing in faculty mailboxes in the form of a new book or unit. In addition, most of us would consider ourselves novices at this discipline, and so perhaps it seems more appropriate for a student to lead. As opposed to “core” classes, where we may be more likely to have convinced ourselves—and conveyed to the students—that we know the best way to teach our material, we can be open about the fact that we are all still experimenting with system dynamics. In this environment, we can provide nurturing and un-anxious expectation more readily than we can when we work with the sense that there is little margin for error; and through these expectations we can make it clear that leadership and good, rigorous questioning must be the norm for everyone, not just the teacher or the boldest students. In other words, perhaps these kids lead because we finally let them.
Activity: The S.S. Murdoch

Systems principles: After sailing with the S.S. Murdoch, students should understand:
1. Optimizing the parts of a system does not necessarily optimize the whole, and can even prevent the whole system from working effectively.
2. Groups of people working together are systems. As such, they need to have specific rules or policies in order to build the system the way they want and get the desired result.
3. Systems behave as they are designed to behave, though sometimes we believe we have designed them one way when, in fact, we have created something that will surprise us.
4. Solutions sometimes create new problems.

Materials:
- A room at least 60’ x 25’ or outdoor space.
- If you are outdoors, you will need rope or chalk to mark the sections. Inside, masking tape will do nicely.
- 8 pieces of wood, roughly 1" x 6" x 2'. Using two-by-fours proved dangerous, since they are more prone to rolling over. If you can find any sort of sturdy foam material to use in place of wood, you will protect your floors. We used cardboard for a while but it did not hold up very well. Also, eight boards worked for us. You may need to experiment with more or fewer boards to achieve the proper level of challenge.

Time: Allow at least 40 minutes for directions and playing the game with a class of 20-25, and make sure you have at least 20 minutes to debrief. If you have to cut somewhere, cut the game short rather than the debrief. Set up the room like so:

<table>
<thead>
<tr>
<th>Section 1 (water to be crossed with stones)</th>
<th>Section 2 (island)</th>
<th>Section 3 (water to be crossed by ship)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begin here.</td>
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<td>End here.</td>
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Description:
This game requires students to use small pieces of wood as stepping stones, get an entire class standing on a small wooden “boat” that they construct, and cross a section of the room without allowing any parts of their boat to separate from the others.

Students begin as survivors of a shipwreck. They are able to snag a few of boards from the ship and first must use those as stepping stones to get to the island (Section 2), where they can work safely. In this section, students enter the “water area” one at a time and can only stand on stepping stones. If they fall off, they exit the game. The most important
rule for moving through Section 1 is that any board that is not being touched by a
shipwreck survivor gets washed away by the current.¹ In the debrief, help students
connect this part of the game to the parts vs. whole principle. In other words, one student
leaping from the last stone to the island (Section 2) may make himself safe, but he loses a
stone and endangers all the others. This is also a good way to access the idea that
solutions create new problems—moving quickly may help us get more people to the next
area within the allotted time, but it also increases the chance someone will leave a stone
unattended and lose it for the group.

Once the group makes it to Section 2, where they can touch the floor again, they need to
put together whatever pieces of wood are left from the stepping-stones crossing to make a
boat on which all students can fit. Once everyone is standing on the “boat,” they move
the boards carefully to cross to the end of the room. In this activity, all students are
moving together, as opposed to the stepping-stones, in which some waited at the
beginning for others to get partway across. While boards can be left untouched here, they
all must be touching at least one other board at all times—they can be stacked or laid
end-to-end or side-by-side—but they need to remain in contact as the kids move the boat
across Section 3. It is important to note here that the greater the number of students who
“perished” in Section 1, the easier the boat crossing becomes. While you may decide to
re-include them to make management of the game smoother, it is also a worthy topic for
debrief to ask the students if losing people early on is a good or bad thing. This can help
them get at the idea that a system does what it is designed to do, and if theirs was
designed to allow for only 10 survivors out of 20, then so be it—the question is whether
they designed the system they actually set out to design. If their answer is “no,” perhaps
new policies are in order.

Miscellaneous tips:
• If you play outside on blacktop, the wood can splinter around the edges.
• Fingers can be crushed while kids are moving boards. This is one large plus of using
  cardboard or foam.
• Generally, students will do one of two things. Some groups talk about a plan for 35
  minutes, which can be debriefed once, but tends to just make kids frustrated after
  that. Be attentive to when they need a push to get going. Other groups leap onto the
  boards and aim for speed rather than caution. Both of these scenarios are fertile
ground to talk about how solutions can create problems.
• Debrief, especially for younger students, can be focused on planning strategy to be
  more successful in another attempt at the game. Sometimes this line of discussion
can be more engaging than talking about abstract principles.

¹ We learned a version of this “stepping stones” activity at the Browne Center in Durham, NH.