SYSTEMS ENRICHMENT EXERCISE

Dynamic Systems Dance

In this exercise, students learn how changes in just one or two variables can ripple throughout an entire system[1].

Objectives

After completing this exercise, students will be able to

- describe the concept of interrelatedness in complex systems;
- explain how systems organize around changes in conditions;
- explain how forests are interrelated systems; and
- explain how ecosystems are characterized by change, but have multiple stable states.

Materials

- None

Doing the Exercise

1. Ask students to stand in a circle in an open area so that they can see everyone else in the circle.

2. Tell the students to choose two other people in the circle. This should be done discretely and privately—students should not let anyone else know which two people they have chosen. These are their "connections."

3. Once the students have chosen two other people, explain that this circle is a system with one rule. Each variable in the system (each student) must always be equidistant from each of their two connections. When you say, "begin," the students should move so that they are the same distance from both of their connections. We recommend not providing these instructions before the students have chosen two people so that they won't be tempted to pick two people who are already equidistant from them.

4. During the first round, let the students begin with only the directions from steps 1, 2, and 3. They will likely continue to make adjustments as one or both of their connections move. (During this time, pay attention to the way that the students are moving. Try to identify a student who seems to be chosen by several others as a connection.)

5. When the group stops moving, the system has reached stability. In some cases the system may not find a stable position. The students


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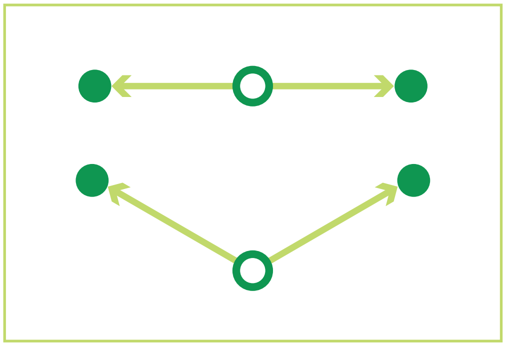
While focusing on their two connections, students move to be equidistant from both of them. When the group eventually stops moving, the system has reached a stable point.

[1] This exercise is based on a similar process described in the "Triangles" activity in The Systems Thinking Playbook by Linda Booth Sweeney and Dennis Meadows, 2010.

may even get all bunched up into a dense, ever-moving cluster. If this happens, remind students that being equidistant does not mean that they always must be between their two connections. See the example below.

Remind students that being equidistant does not mean that they always must be between their two connections.



6. After a few minutes, the students should be able to get to a point where no one needs to move; everyone is equidistant from his or her two chosen connections. When this happens, tell the students to look around. Their positions represent how this system responds to a certain set of conditions or rules. A forest is also a system made up of many variables (trees, plants, animals, and physical factors such as temperature, water, and sunlight). Although each variable in a forest does not actually move, the values of each variable constantly change in relation to each other (e.g., the number of plants, the amount of moisture).

7. Choose one person (preferably one who seems to be connected to many others, but moving any student will likely produce similar results). Move that student without the rest of the students adjusting. Then, ask the students to watch how the system changes when only those who are connected to that person make the necessary adjustments to once again be equidistant from their two chosen connections. Next, ask the rest of the students to move accordingly. Most likely, a large portion of the students will have to readjust their position as your single change ripples throughout the system in waves.

8. Eventually, the students should once again find a configuration where no one has to move and everyone is equidistant from his or her two connections. Once they reach this point, ask the students to look around again. How does this compare to the previous stable point that they found? It is likely to be significantly different.

9. You can repeat these steps if you wish. Afterward, ask the students to return to their seats and use the following discussion questions to help students understand systems.

- How does this exercise relate to the definition of a complex system?
  A system is a set of variables acting in relation to each other and to the environment. In a complex system, the variables are linked by a web of interconnections that make the behavior of the system impossible to predict precisely. This is exactly what the students have become in this exercise.
- How do you think this exercise demonstrates the concept of interrelatedness in complex systems?
  Everything is connected . . . but not directly. In complex systems, even seemingly small changes can ripple out and have a significant effect on the whole system. Note that each student was directly connected to only two other students. Yet the indirect connections made the entire group move.
- Who or what was dictating everyone's movement during the exercise?
  Self-organization. The behavior of complex systems can be affected by external changes. However, much of the behavior of complex systems is the result of internal connections within the system. In this case, no one was controlling everything in the system. The fairly simple set of connections resulted in the complex movement that we observed.

- What do scientists mean when they say that complex systems are dynamic?
  Using this exercise as an example, tell students that each one of them was a variable in the system. A student's change in position represented a change in that variable. Variables like trees or squirrels change in number. Variables like water and temperature change in amounts. When students think about complex systems in the future, the image of the entire class constantly making small adjustments in position in response to other parts of the system should help them to think of systems as dynamic. Dynamic systems demonstrate interactions, feedback, and delays, making it challenging to model or predict how one change might affect other variables. Although this demonstration had a simple rule, it played out in a very complex and dynamic way!
- Were there any points of stability in the system?
  Systems actually have several points of stability. Ecologists call these "multiple stable states." In the exercise, the points where the students all stopped moving represented points of stability in their system. Similar to the students finding multiple combinations of positions where everyone was equidistant from their connections, systems can stabilize in different configurations and conditions. In forest management, the goal is to maintain the forest system in a desirable stable state (e.g., a healthy, sustainable system). However, various stresses on the forest, such as extreme drought or disease, could cause the system to eventually transition to a different stable state, such as a field.
- In what ways is the system of students similar to a forest system?
  Like other complex systems, a forest system has many different interrelated parts. Students might visualize their movements during this activity by imagining that they represent different species or the health of different species in the forest. Changing the position of one student (i.e., the number or health of one species) can have effects that ripple through the entire system.

  They could also envision the activity more abstractly, with each student representing a changing variable in the system (e.g., precipitation, ground cover, temperature, atmospheric carbon dioxide levels). The same concept of interrelatedness applies. While each variable may not be directly connected to every other variable, the indirect connections can span the entire system.

  We do not recommend you actually assign species to students. The focus of this exercise is the dynamic movement and interrelatedness of the system in general. Later in the module (Activity 5), we will look more closely at the specific relationships among variables in a system.