<table>
<thead>
<tr>
<th>Name of Lesson</th>
<th>Characteristics of Systems</th>
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<td>Acknowledgements</td>
<td>This lesson plan is based on an activity described in <em>The Systems Thinking Playbook – Exercises to stretch and build learning and systems thinking capabilities</em> by Linda Booth Sweeney and Dennis Meadows (ISBN 0-9666127-7-9)</td>
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<td>Overview</td>
<td>The purpose of this lesson is to introduce students to general characteristics shared by all dynamic systems. Lesson activities include a physical simulation, a debriefing discussion, direct teaching of vocabulary, and student application of what has been experienced to other systems within their experience. This lesson is intended for students in grades 3 and above. The same lesson, using a different physical simulation, is recommended for students in grades Kindergarten through two (details described in Modifications section near the end of this lesson plan).</td>
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<td>Length</td>
<td>About one hour, including the debrief. When to do: Anytime, but the earlier in the school year the better. This is very much an introductory lesson with wonderful capacity to be used as both a lens through which to view each new piece of curriculum as it unfolds throughout the year, and as a base upon which other systems thinking and system dynamics concepts can be layered. While there is no truly bad time to use this lesson, the earlier in the year it is used, the greater the benefits that can be derived from it.</td>
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| Curriculum Context | This lesson is best used to introduce the concept of a system and increase students’ awareness of the systems all around them. It can then be used as a reference point in any area of the curriculum by asking students to reflect on the topic at hand using the characteristics of systems discussed in this lesson to identify any systems involved in their current study. Students can be encouraged to use the system descriptors as criteria to determine whether something is a system or not by asking questions such as:  
  · Which parts are needed to produce the behavior of this system?  
  · In what ways are the parts interdependent?  
  · What changes do I see when I watch this system over time? |
| **Lesson Objectives** | 1) students will identify the following characteristics that are shared by all systems:  
· the parts of the system are interdependent (a change in the status of one causes change in others- sometimes after a time delay)  
· all the parts are needed to produce the behavior of the system  
· the behavior of the system changes over time  
· the structure of the system generates its behavior  
· causes often generate effects which then become causes  
2) students will use these characteristics to identify at least two systems that have influence in their lives  
3) Given a system, like a toy car, students will make decisions about what is and is not part of that system based upon the general system characteristic, “all parts of the system are needed to produce the behavior of the system.”  
4) students will be able to explain the terms interdependence and leverage and give examples to illustrate their meaning.  
5) students will be able to explain how delays influence what happens in the simulation and will explain how delays influence another system with which they have experience. |
|---|---|
| **Assessment** | We have had students create journal entries explaining what a system is, giving examples of systems, and describing main characteristics in their own words  
Transferability:  We have asked students to discuss what systems are involved (if any) in stories they read, new topics they encounter by referencing the characteristics the class identified in this activity |
| **Systems Thinking Concept(s)** |  
· dynamic system  
· change over time  
· interdependence  
· feedback  
· leverage  
· structure generates behavior  
· delays  
· boundaries |
| **Instructional Considerations** | Prerequisite instructional skills of teacher:  
· ability to frame experience in way that will cause students to be curious and want to engage  
· ability to pose questions that will allow students to reflect on their experience and share their observations, feelings, etc.  
· ability to ask questions which probe students’ thinking when the logic of a student’s initial response is not clear, the response does not seem relevant, or it does not seem to be grounded in what actually happened  
Prerequisite Systems Thinking knowledge/skills of teacher: |
· understanding of general system characteristics
· examples of other systems to use with students that are appropriate to the developmental level and interests of the specific group for which the lesson is intended

Prerequisite skills/knowledge in content or process for students:
· skill in participating in group discussions - active listening, taking turns, sharing thoughts with the whole group

Suggested background reading for teacher:

Application of the following best practices is important to the success of this lesson:
1) Active processing of experience - According to Caine and Caine (1997) “Although people find meaning in experience, they do not automatically extract all the potential meaning that is implicit or move beyond their current meanings without being challenged.” Hence, it is important that teachers probe student thinking with questions that help children “consolidate and internalize information in ways that are personally meaningful and conceptually coherent...The pervasive objective is to focus on the process of our learning and extract and articulate what has been explored and what it means.” Children should be asked in as many ways as possible, “What did I do?”,”Why did I do it?”, and “What did I learn?” (To read more about this see Caine, Renate and G. Caine (1997). Education on the Edge of Possibility. ASCD: Alexandria, VA.  
2) A classroom climate that is characterized by “relaxed alertness” of students - Caine and Caine use the term “relaxed alertness” to describe the optimal state of mind for learning. It is characterized by a moderately high level of challenge and combined with a low threat. “Ongoing relaxed alertness if the key to people’s ability to access what they already know, think creatively, tolerate ambiguity, and delay gratification, all of which are essential for genuine expansion of

3) Activating prior knowledge and experience - Many years ago Madeline Hunter articulated the importance of activating student’s prior knowledge when introducing new learning. This serves as a platform from which students can make sense of new experience. Belinda Williams and Michele Woods extended our understanding of the importance of this practice in their work with Research for Better Schools. They describe in vivid detail the power of bringing students’ experiences outside of school into classroom lessons to motivate and engage urban learners. (To read more about this see Williams, B. and M. Woods (1997). “Building on Urban Learners’ Experiences”. Educational Leadership 54: 7 (29-32) and Sousa, David A. (1995) How the Brain Learns. NASSP: Reston, VA.

4) Constructivism - In this lesson it is important to student’s learning that they be encouraged to discover/build concepts as opposed to being having concepts explained to them. This is encouraged in this lesson by having children physically experience the concepts and then facilitating their reflection and articulation of that which they experienced. (To read more about this see Brooks, J.G. and M. Brooks (1993). The Case for Constructivist Classrooms. ASCD: Alexandria, VA. and Daniels, H. and M. Bizar (1998). Methods that Matter. Stenhouse: York, ME.

5) Reflection - Zemelman, Daniels and Hyde remind us that “balancing the immersion in experience and expression must be opportunities for learners to reflect, debrief, abstract from their experiences what they have felt, thought and learned.” Using student learning logs is one simple way to provide this opportunity for students. (To read more about this see Zemelman, S., H. Daniels, and A. Hyde (1998). Best Practice : New Standards for Teaching and Learning in America's Schools. Heinemann: Portsmouth, N.H.)

6) Experiential learning - This is frequently referred to as “learning by doing”. The bulk of student time should be spent in active engagement in using knowledge to solve problems rather than reading about topics or listening to teachers talk about topics. To get the most out of this lesson, children should be accustomed to participating in physical activities for learning. (To read more about this see Resnik, L.B. and L. Klopfer ,Eds. (1989). Toward the Thinking Curriculum: Current Cognitive Research. ASCD: Alexandria, VA. and Sousa, David A. (1995). How the Brain Learns. NASSP: Reston, VA.)
7) Making connections throughout the lesson and following the lesson – Williams and Woods describe the importance of making connections between student experiences and curriculum content, especially for urban learners. They say, “Student experiences include such things as household knowledge associated with learning a living: values, beliefs, interests, and motivations representing things that are important to urban learners, and routine behaviors. These daily experiences are rich with examples that can be used to create themes, analogies, and other learning strategies that serve as powerful emotional, cognitive, and cultural connections between learner and content.” (To read more about this see Williams, B. and M. Woods (1997). “Building on Urban Learners’ Experiences”. Educational Leadership 54: 7 (29-32).

<table>
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<th>Materials</th>
<th>Chart paper with influence diagram sketched on it, adhesive name tags, blank chart paper for student reflections in the debrief, masking tape, markers</th>
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| Activity Overview | This lesson involves a physical simulation, followed by a whole group discussion. It requires a large open space so that students can move around freely without being constrained by furniture. Minimum number of students: 12 Maximum number of students: 30 (including 6 as observers) Ideal number of students: 24 Set-Up: Prepare one self-sticking tag for each student. Tags should be numbered 1-24 (or however many students you have). Distribute tags to students, making sure they understand that there is no special significance to the numbers. They are merely to identify the participants. Prepare a large circle (influence diagram) with numbers around the perimeter on chart paper or black/whiteboard. |
Have this ready on an easel in close proximity to the activity.
Activating students’ thinking: “Take a minute to remember a time when you wanted something to happen. You made a plan and followed it, but in the end, the result you were counting on did not happen. Something else did.” Let kids share a few of these incidents. Typical incidents kids have shared include: outcome of a team sport, parents separating, making a new friend... The activity we’re about to do will help us understand why things sometimes turn out differently than how we think they will. By understanding this, we will have a start at making better decisions which will make it more likely that we can see the results we want - in school, with friends, with family, in our world.
Procedures:
1) Put a numbered name tag on each student.
2) Have students stand in a large circle, facing each other.
3) Give the following directions: “Look around the circle and, in your head, pick two people. Do not say their names aloud, look at them, or give any clues about who you picked.” (At this point we usually suggest that students do not pick their best friends or anyone who
might guess that they have been selected.)

“When I give the signal, I want you to try and position yourself equidistant between the two people that you picked...and maintain that position until I tell you to stop.” It is a good idea to physically model what you want students to do. It is important to explicitly tell people that equidistant, in this case, means, “an equal distance away from the two selected people.” Have three people stand in a few different arrangements and asking students each time, “Are the people equidistant from each other?” It is important to do this to ensure that all participants understand the task before beginning. **(For very young children we sometimes use somewhat different language, such as replacing the term “equidistant” with “half way between”.)** “When I say stop we are going to sit down and discuss this activity. I am going to ask you what happened when you moved, why that happened, and how it felt.”

4) Give the signal to begin. You should see constant movement as people continually change their positions in order to attempt maintaining equidistance. If you do not see this, stop the group and have them tell you’re their assignment. Clarify any misunderstandings. Once things are going as they should, be sure to allow enough time for people to show some signs of frustration before telling the group to stop. (This will usually exhibit itself as laughter, comments about wanting people to stop moving, etc. If the movement seems to come to a stop, be sure and wait a few seconds more. It will usually begin to move again.)

5) When you feel people have had adequate opportunity to experience the behavior of this system, and its interdependencies, tell them to stop.

6) Have everyone take a seat where they can see the influence chart and begin the debrief.

The Debrief:

1) Begin by gathering data to complete the influence chart (circle with numbers around it. To do this, the teacher has the student wearing tag #1 name the two people he/she selected. The teacher then draws an arrow from #1 on the circle number to each of the numbers of the two selected students. Repeat this procedure for each student in the circle. **(We do this chart right after the**
activity so that students will not forget who they selected, but we begin the debrief with consideration of other issues and return to this later on.)

It would look like this:

2) Ask student the following questions:
What happened? What made that happen? How did it feel? Have students look at the influence diagram. What does this tell you? As students are responding to these questions jot main ideas on chart paper for all to see. Probe their responses, by asking additional questions when appropriate, to try and bring forth as many of the following main system characteristics as possible (examples of such questions are in bold): systems are made up of different parts that work together to produce a certain behavior. The different parts are interdependent with one another. When a change happens in one part, it impacts other parts. (What created the behavior that we saw? What happened when one of your numbers moved...and then what...and then what?)

To understand the behavior of a system you have to watch it in action over time (If I took a picture of you doing this activity and showed it to someone, would they be able to understand what was going on? Why or why not?) The system cannot produce the behavior without all the parts (What was needed to produce the behavior we saw? Would we have seen the same behavior without the people? without the rules?) There can be delays in the system which make it confusing to understand how the system really works.
(What, if anything, did you notice about the timing of when people moved? Did everyone move at the same time? Why or why not?) Different parts of the system have different amounts of influence over the system (leverage) (Looking at the influence chart, what can we say about the amount of impact different people had on the movement in the system? Did everyone have the same influence? Why or why not?) Systems have boundaries (Were there some things in the room that were not part of this system? If so, why not?)

If students have difficulty with this ask them to consider things such as plants on the desk, bookshelves, lighting, etc.)

3) At this point we usually tell students that they have just studied something called a system. “Systems are all around us and are often difficult to understand, just like the team, the family situation, and the friendship (fill in the examples your students generated) you told us about at the start of the lesson. All systems have certain characteristics, which you have just told us a lot about.” We introduce the systems thinking vocabulary by using the students’ language to define the technical terms. Terms to introduce include the following: change over time, interdependencies, feedback, structure generates behavior, delays, leverage, and boundaries.

It is important to both say and write the terms as you summarize the students’ comments. Examples of this are as follows:

“Remember when Jason told us that whenever Tom moved, he had to move. In systems language we call that “interdependence” . Interdependence is when one part of the system affects other parts.”

“When Tasha said that the rules made everyone keep moving, she was describing another important aspect of all systems. We call this “structure generates behavior.” Structure can be rules, like in this activity, or any other aspect of how things are set up.

4) Use the group to summarize the main points in their language. Put these on chart paper that can be displayed in the classroom for future reference. It is not anticipated that students will have a complete understanding of these concepts after this introductory
lesson. This written reference can be used in future lessons and activities to further explore the concepts and reinforce the use of the technical vocabulary.

5) Remind students that you told them they were going to play this game to learn why things don’t always turn out the way we expect. Now that they have played it, what might this tell them about some of the examples they cited earlier (the team, the friendship, the separation)?

6) Explore other applications. Now that students understand some of the main characteristics of systems, what other systems can they think of? in the curriculum? In school? outside of school? in nature?

**Modifications and Extensions**

Risk factors - We have found that students under third or fourth grade have had some difficulty with this activity. Very young children appear to be so consumed with achieving the equidistance that they frequently switch people they are trying to remain equidistant from in mid-activity to “achieve success”. For this reason, recommend substituting another physical activity for younger children, while conducting the same debrief (except for the influence diagram). The activity we have had most success with is tug-o’-war. We set it up in a controlled way, telling students that we do not want them to pull as hard as they can, just medium hard, making sure students can experience the back and forth pull of the rope.

Extension(s) and/or possible next steps:

1) Create a bulletin board - post the influence diagram and any analogies kids have surfaced during the debrief surrounding it...if no analogies surfaced, kids could be asked to think of some...this is like________

2) Have kids work in groups to identify systems in their lives, in the curriculum - use the characteristics they have identified to justify their identifications - verbally or in writing ask kids to respond to the question, “How long would someone have to observe this system to understand its behavior?” and to explain their answer. “What misunderstandings might someone have who observed it for a shorter period of time?”

3) Have kids bring systems to school to share with the class. Have them explain why each item is a system,
referencing the criteria identified by the class.

4) At the outset of a new unit of study, do a systems K-W-L (Know-Want to Know-Learn Chart) of the topic(s) to be studied. To do this, make three columns on large chart paper. Label them Know, Want to Know, and Learn. Create a chart at the beginning of the unit ask what students know about the characteristics of the system under study. “What do you know about the interdependencies, feedback, delays, structure, behavior, leverage within this system?” Record these responses in the Know column. Place those things that they say they don’t know but want to in the Want to Learn column.

During the course of study, return to the chart and guide students in reflecting on that which they said they “know”. Sometimes their learning will cause them to want to modify the content of that column. At the same time, record that which students report they have learned in the “learn” column. To reinforce a growing understanding of systems concepts, a categories section can be created at the bottom of the page listing the general characteristics of systems (change over time, interdependence, feedback, etc.) Students can be asked to identify which term describes each statement they offer for the “know” and “learn” categories, and these designations can be recorded on the chart.

5) Investigate, through use of causal loop diagrams or stock-flow diagrams, the interdependencies involved in some unit of study in which class is engaged.

6) For students in grades 4 and above, try this: ask, “Could this system ever be still for a time period with participants following the rules? Why or why not?”