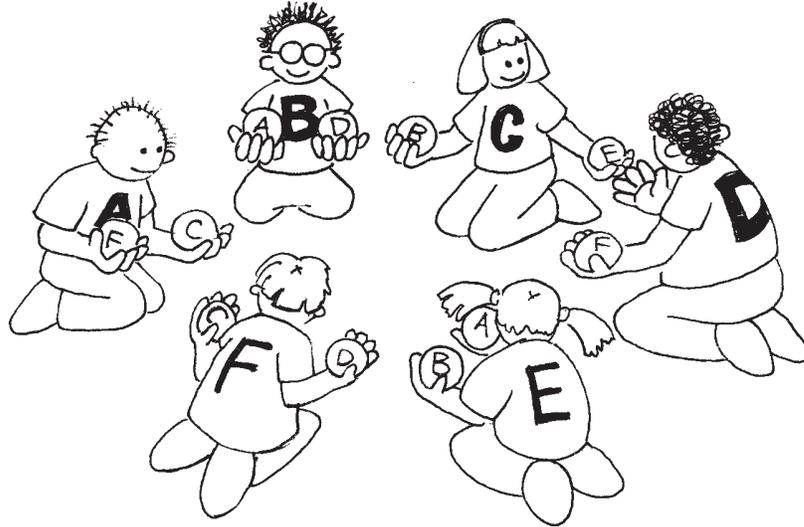# Activity 10

The Orange Game—*Routing and Deadlock in Networks*

Summary

When you have a lot of people using one resource (such as cars using roads, or messages getting through the Internet), there is the possibility of "deadlock". A way of working co-operatively is needed to avoid this happening.

Curriculum Links

✓ Mathematics: Developing logic and reasoning

Skills

✓ Co-operative problem solving
✓ Logical reasoning

Ages

✓ 9 years and up

Materials

Each student will need:

✓ Two oranges or tennis balls labeled with the same letter, or two pieces of fruit each (artificial fruit is best)
✓ Name tag or sticker showing their letter, or a coloured hat, badge or top to match their fruit

The Orange Game

Introduction

This is a co-operative problem solving game. The aim is for each person to end up holding the oranges labelled with their own letter.

1. Groups of five or more students sit in a circle.

2. The students are labelled with a letter of the alphabet (using name tags or stickers), or each is allocated a colour (perhaps with a hat, or the colour of their cloths). If letters of the alphabet are used, there are two oranges with each student's letter on them, except for one student, who only has one corresponding orange to ensure that there is always an empty hand. If fruit is used, there are two pieces of fruit for each child e.g. a child with a yellow hat might have two bananas, and a child with a green hat may have two green apples, except one child has only one piece of fruit.

3. Distribute the oranges or fruit randomly to the students in the circle. Each student has two pieces, except for one student who has only one. (No student should have their corresponding orange or colour of fruit.)

4. The students pass the oranges/fruit around until each student gets the one labelled with their letter of the alphabet (or their colour). You must follow two rules:

    a) Only one piece of fruit may be held in a hand.

    b) A piece of fruit can only be passed to an empty hand of an immediate neighbour in the circle. (A student can pass either of their two oranges to their neighbour.)

    Students will quickly find that if they are "greedy" (hold onto their own fruit as soon as they get them) then the group might not be able to attain its goal. It may be necessary to emphasize that individuals don't "win" the game, but that the puzzle is solved when everyone has the correct fruit.

Follow up Discussion

What strategies did the students use to solve the problem?

Where in real life have you experienced deadlock? (Some examples might be a traffic jam, getting players around bases in baseball, or trying to get a lot of people through a doorway at once.)

Extension Activities

Try the activity with a smaller or larger circle.

- Have the students come up with new rules.

- Carry out the activity without any talking.

- Try different configurations such as sitting in a line, or having more than two neighbours for some students. Some suggestions are shown here.
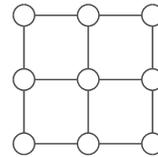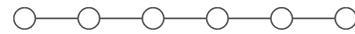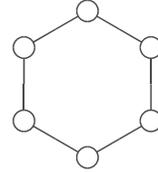
What's it all about?

Routing and deadlock are problems in many networks, such as road systems, telephone and computer systems. Engineers spend a lot of time figuring out how to solve these problems—and how to design networks that make the problems easier to solve.

Routing, congestion and deadlock can present frustrating problems in many different networks. Just think of your favourite rush-hour traffic! It has happened several times in New York City that the traffic in the streets has become so congested that it deadlocks: no-one can move their car! Sometimes when the computers are "down" in businesses (such as banks) the problem is caused by a communication network deadlock. Designing networks so that routing is easy and efficient and congestion is minimized is a difficult problem faced by many kinds of engineers.

Sometimes more than one person wants the same data at the same time. If a piece of data (such as a customer's bank balance) is being updated, it is important to "lock" it during the update. If it is not locked, someone else could update it at the same time and the balance might be recorded incorrectly. However, if this locking is interfered with by the locking of another item, deadlock may occur.

One of the most exciting developments in computer design is the advent of parallel computing, where hundreds or thousands of PC-like processors are combined (in a network) to form a single powerful computer. Many problems like the Orange Game must be played on these networks continuously (but much faster!) in order for these parallel computers to work.