Lesson 1: Keep in Touch – Communications and Satellites

Grade Level: 4 (3-5)	**Lesson #:** 1 of 6
Time Required: 15 minutes	**Lesson Dependency:** None
Keywords: communication, orbit, satellite, motion	
Summary: How do we communicate with each other? How do we communicate with people who are close by? How do we communicate with people who are far away? In this lesson, students will explore the role of communications and how satellites help people communicate with others far away and in remote areas with nothing around (i.e., no obvious telecommunications equipment). Students will learn about how engineers design satellites to benefit life on Earth. This lesson also introduces the theme of the rockets curricular unit.	
Engineering Connection: Satellites have been used for years for various purposes including scientific research, weather, communications, navigation and even for observing Earth. Engineers have played a key role in designing these satellites, getting them into orbit, and using the information they relay back to Earth. Communicating with people has always been an important part of human's existence. As people live further away from each other, and as they explore more and more remote regions, communication with each other becomes even more important.	

Figure 1. Communications Satellite

Learning Objectives

After this lesson, students should be able to:

- List several different types of satellites that have been designed by engineers.
- Describe how a satellite phone receives and transmits signals for communication.
- Explain the concept of an orbit and give examples of several things that orbit.

Introduction/Motivation

Spacewoman Tess and Spaceman Rohan's daughter Maya is heading off on a six-month solo canoe trip through northern Canada to previously unexplored waters. Spacewoman Tess and Spaceman Robert are very excited, though very worried about their daughter. If you were Maya's parents, what would you be worried about? If you were Maya herself, what would you be worried about?

They are all worried about being able to communicate with their daughter — to know where Maya is and that she is safe. Communicating is how we are able to get ideas or messages across to another person. Let's brainstorm a list of different ways of communicating. (Possible answers include: speaking, sign language, telephone, letters, body gestures, television, radio, email, websites, etc.) Which ways work well for people who are standing close together? (Possible answers: speaking, body gestures, sign language, newspaper, etc.) Which ways work well for people that are far apart, as in a different country? (Possible answers: telephone, email, television, radio, newspaper, etc. If types of mass communication don't come up, ask students how news is communicated, or what kind of television service they have at home?) Leave this list on the board.

What about knowing where you are located or where other people are located? Let's brainstorm ways that people can know where they are or where other people are located. (Possible answers: Maps, calling people to ask them, identification markers, satellite navigation. To get the answers going, ask how pilots know where they are in the huge open sky?) How do vehicles such as aircraft or ships, or even some cars know where they are at any time? (Possible answers: maps, global positioning satellite systems, identification markers, etc.) Leave this list on the board as well.

Demonstration: Before class begins, attach a string to a ping pong or tennis ball. Hold the string/ball out in front of you, letting the ball drop towards the ground. Holding the string between your fingers, begin twirling the ball in a circle using your wrist to obtain a smooth, consistent motion. When you have the ball turning in a constant motion, cut the string.

Let's think about what has happened with the ball. Have you ever looked up into the sky at night and seen something moving really slowly across the night sky? Chances are you were seeing a man-made object that was put into the Earth's atmosphere by engineers and is now orbiting the Earth. What is an orbit? Well, an orbit is when an object moves around another object in a complete path, like a circle or an oval. What about the moon, what is it doing as it moves across the sky at night? (Answer: It is orbiting the Earth.) What about all of the nine planets in the solar system? Do they orbit? (Answer: Yes, they are all orbiting the sun.) In the demonstration, what was the ball orbiting before the string was cut? (Answer: It was orbiting the teacher's write; also okay to accept finger(s) as an answer.)

The common theme we have discussed so far is *satellites*. Engineers design and build satellites for different types of communication. Some satellites are used for communication between people, while other satellites send data to be processed to a computer back on Earth. There are hundreds of satellites orbiting the Earth right now for various purposes, including scientific research, weather research and prediction, navigation and observation of the Earth. Actually, the Earth even has a natural satellite. Do you know what it is? (Answer: The moon!) People can communicate via satellites and even know exactly where satellites are being utilized. So, how can Spaceman Rohan, Spacewoman Tess and Maya use a satellite for their benefit? (Give time for students to answer. Possible answers may include: to find/confirm their location and to talk to each other.)

Man-made — or artificial — satellites orbit the Earth, receiving and transmitting signals. Basically, a signal is sent from a computer or a person in one location on Earth up to a satellite that is orbiting the Earth, and then back down to another person or computer somewhere else. By using orbiting satellites in space, Spaceman Rohan and Spacewoman Tess will be able to communicate with Maya by using something called a *satellite phone*. Can you guess how this special phone works? A satellite phone is a mobile phone that *transmits* (sends) signals to an orbiting satellite that receives the signal, and then transmits them to another phone. Maya's parents can definitely use a satellite phone to communicate with her. Maya can even use satellites to help her figure out exactly where she is during her trip using something called *GPS* (Global Positioning System). GPS is a special type of satellite that records locations of signals and sends the coordinates of that location back to another transmitter or computer. Today, we are going to learn some more about satellites and how engineers have designed them for different forms of communication.

Lesson Background & Concepts for Teachers

Orbits

Figure 2 illustrates how an artificial satellite can *orbit* the Earth. In theory, if a cannon is fired fairly weakly, the path of the cannonball will be that of a parabolic arc and will land perhaps a few hundred yards away. The numbered frame 1 shows a cannon using a little more gunpowder, which causes the cannonball to shoot a little bit farther. In this situation, the ball lands perhaps a few hundred miles away. We can see just a little of the Earth's curvature, but it does not really affect anything. In the second numbered frame, using a super-shooter, the cannonball is shot hard enough that it travels several thousand miles. This frame illustrates that the curvature of the Earth has had an effect. The ball travels much farther than it would have had the Earth been flat. Finally, in the third numbered frame, a mega-super-big cannon fires the cannonball at the unbelievable velocity of 5 miles/second (nearly 17,000 miles/hour; the fastest jet planes can fly 2 or 3 thousand miles/hour). The result of this shot is that the ball *misses* the Earth as it falls.

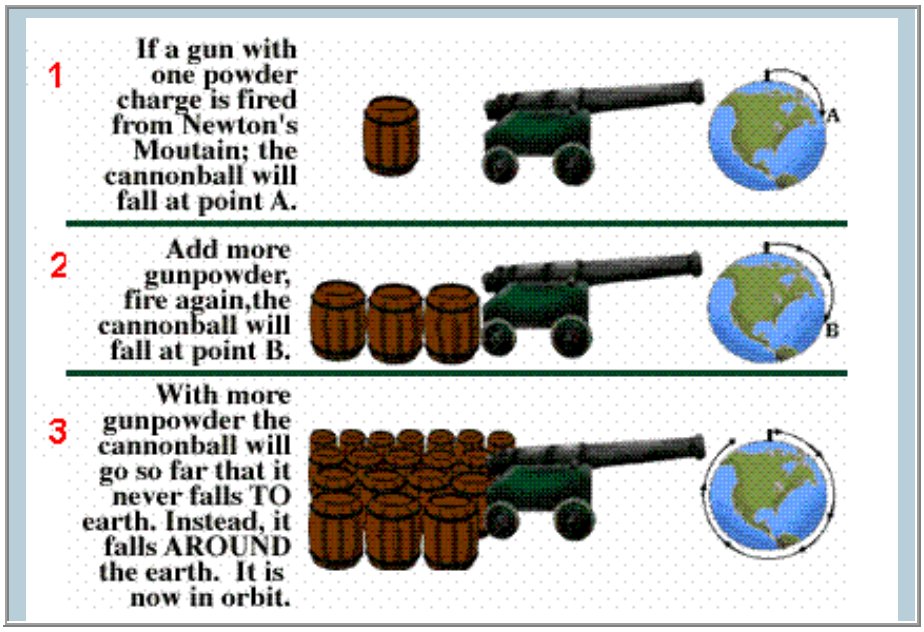

Figure 2. An illustration of an artificial satellite launch.
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However, the Earth's gravitational pull causes it to both continuously change direction and continuously fall. The result is a "cannonball" which is orbiting the earth. In the absence of gravity, however, the original throw (even the shortest, slow one) would have continued in a straight line, leaving the Earth far behind.

Satellites

An *artificial satellite* is a manufactured object that orbits Earth or something else in space on a continual basis. Satellites are used to study the universe, to help forecast the weather, to transfer telephone calls and to assist in ship and aircraft navigation. Specifically, communications satellites serve as relay stations, receiving radio signals from one location and transmitting them to another. A communications satellite can relay several television programs or many thousands of telephone calls at once. They are used to bounce messages from one part of the world to another.

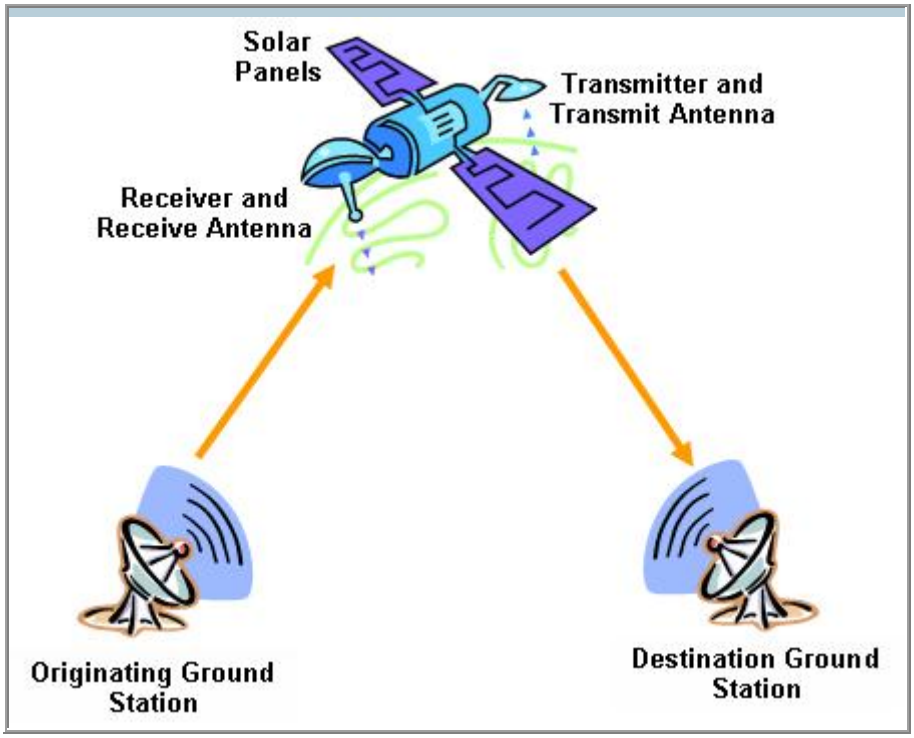

Figure 3. The basic components of a communications satellite link

Every communications satellite involves the transmission of information from an originating ground station to the satellite, followed by a retransmission of the information from the satellite back to the ground (see Figure 3). The retransmission may either be to a select number of ground stations or it may be broadcast to everyone in a large area.

Space shuttles carry some satellites into space, but most satellites are launched by rockets that fall into the ocean after the fuel is used up.

Cellular Phones and Satellite Phones

A *cellular phone* can be described as a very sophisticated radio. They are a type of wireless communication device that uses many small cells with a base station and a cell phone tower at the center of each cell. These cells have extensive *frequencies* that allow many thousands of people to use cell phones at the same time. In this process, cellular calls are transferred from base station to base station as a user travels from cell to cell. A cellular network is composed of cellular towers. In essence, when a call is placed from your cell phone, it travels by radio waves to a cellular tower that picks up the specific signal from your phone. These cellular towers are thought of as *cells*, with each cell able to typically pick up a signal within 10 square miles. The signal is then sent to a *Mobile Telephone Switching Office* (MTSO) which handles calls from several towers — called a *cluster*. The MTSO transfers the signal to a local phone line that sends the signal to the final destination via landline, microwave signals or satellite. The MTSO senses when the signal is becoming weak and hands your call off to the next tower — or the MTSO in the next cluster. It controls the quality of your link by keeping you connected to the best possible signal as you move from cell to cell. When you have traveled beyond the range of the towers, the signal is lost and you cannot make or receive calls.

Satellite phones do not use cells or cell towers for sending/receiving calls. Most satellite phones use *Low Earth Orbiting* (LEO) communication satellites. When a satellite phone is turned on, the signal goes up to any number of satellites in a compatible *constellation* (group of satellites) where it is then registered with the constellation. When a call is made through the satellite phone, the signal goes to the satellites and then is directed down to a ground station and then further directed to the call destination. The call can be directed to a land-line as well as a cellular network and the reverse is also true. This process allows the satellite phone to be used in the middle of no where — great distances from any cellular phone tower — and thus providing an essential form of communication for those who travel to the beyond!

Vocabulary/Definitions

Constellation:	An easily recognized group of stars or satellites that appear to be located close together in the sky.
Gravity:	The force by which a planet or other celestial body tends to draw objects toward its center.
Low Earth Orbiting (LEO):	When a satellite circles close to Earth (200-500 miles high), it is in Low Earth Orbit (LEO). Because they orbit so close to Earth, they must travel very fast (17,000 miles per hour) so that gravity will not pull them back into the atmosphere.
Navigation:	The science and technology of finding the position and directing the course of vessels and aircraft.
Orbit:	The path of a celestial body or an artificial satellite as it revolves around another body.
Parabolic:	Plane curve consisting of all points equidistant from a given fixed point and a given fixed line.
Satellite:	An object that travels (orbits) around another object, while under the influence of a gravitational force.

Associated Activities

- **I'm Not in Range** - In this activity, students learn about cellular phone and satellite phone communication. They will create a model to demonstration their knowledge.

Lesson Closure

In this lesson, we learned that engineers design satellites for a variety of purposes, including communication. Many of these satellites are in orbit around the Earth. The satellite stays in orbit using the Earth's natural gravitational force. Rockets and other spacecraft are used to get the satellites into orbit. Satellites receive signals from one person or computer and transmit them to somewhere else. These satellites help people receive information from around the world in regards to news, weather, location, research and just the latest word from a friend. Can you remember some examples of specific satellite technologies designed by engineers? (Answers: satellite phones, global positioning satellites)

Now that we better understand some methods of communication, Spacewoman Tess, Spaceman Rohan and Maya have options available to them so they can stay in touch with Maya, even in the middle of nowhere.

Assessment

Pre-Lesson Assessment

Discussion Question: Solicit, integrate and summarize student responses.

- Ask students to individually think about their mornings and write down all of the different forms of communication they may have used or have seen used. (Answers may include: talking, reading - a book, the newspaper or the chalk/white board, using the telephone, etc.)
- Ask students if they know anyone who lives very far away from them and how they communicate with that person? Or, do other people far away communicate with them? Discuss how these methods of communication differ from communicating with someone close to them.

Post-Introduction Assessment

Diagramming: Break students into groups of 2 or 3, and ask them to draw a picture of a communications satellite orbiting the Earth. Tell them to include as much detail as possible in their diagram; they should label components.

Post-Lesson/Lesson Summary Assessment

Diagramming/Reiteration: In their groups, have students look again at their pictures of a communications satellite orbiting the Earth. Have them discuss if there anything they need to add to the picture or take away to improve it.

Communication and Satellite Jeopardy: Break students into groups of 3 or 4. Using the chart below, ask students to pick a category and dollar amount. (Note: a copy of the chart without the questions is included in the attachments section to use an overhead or to be copied.) The answer corresponding to the dollar amount and category is read out loud. The student groups have to come up with the question (i.e., Student says: "I'll take Communication for four hundred please." The answer is read by the teacher: "This form of communication uses the computer to type and send messages that are read by their recipient on another computer via the internet." The students would have to come up with the question: "What is E-mail?")

Types of Satellites	Communication	Engineering and Satellites	General Space
$100: Answer: This type of satellite is used to help forecast if it might rain or snow or how the winds will go. Question: What is a weather satellite?	$100: Answer: This type of communication is often used between two people who are right next to each other. Question: What is talking?	$100: Answer: In order for Spacewoman Tess to help get her satellites into space, whose assistance might she need? Question: What is an engineer?	$100: Answer: This is the Earth's natural satellite. Question: What is the moon?
$200: Answer: This type of satellite is used to help pilots and captains of ships find their way to where they are going. Question: What is a navigation satellite?	$200: Answer: This type of communication is often used between two people who are far enough apart that they cannot hear each other, even if they speak loudly. Question: What is the telephone?	$200: Answer: Fill in the blank: Satellites that are circling the Earth are said to be -------- the Earth. Question: What is orbiting?	$200: Answer: These are satellites or stars that are always found together, sometimes in a certain pattern. Question: What is a constellation?
$300: Answer: This type of satellite is used to transmit information from one place or person to another place or person. Question: What is a communications satellite?	$300: Answer: This type of communication is read by many people in the mornings. Answer: What is the newspaper?	$300: Answer: Since there is no power cord available in space, satellites usually have these built in to harness solar energy. Question: What are solar panels?	$300: Answer: This star has nine major natural satellites, one is the Earth. Question: What is the sun?
$400: Answer: This type of satellite is used for such things as observation and taking measurements. Question: What is a scientific research satellite?	$400: Answer: This form of communication uses the computer to type and send messages that are read by their recipient on another computer. Question: What is e-mail?	$400: Answer: Since there is no power cord available in space, satellites have to use what to give them power. Answer: What is the sun?	$400: Answer: This is the time that it for the Earth to orbit around the sun one time (also equal to 365 days). Question: What is 1 year?
$500: Answer: This is the type of satellite that Spacewoman Tess will have to put into orbit to communicate with Maya. Question: What is a communications satellite?	$500: Answer: This form of communication uses a phone but can be used in very remote areas of the Earth where cellular phones do not work. Question: What is a satellite phone?	$500: Answer: Communications satellites have these two types of antenna and equipment. Answer: What are a receiver and a transmitter?	$500: Answer: This term refers to satellites that occupy a lower orbit in the Earth's atmosphere, so they have to travel very fast in order to stay in orbit. Answer: What is Low Earth Orbiting (LEO)?

Lesson Extension Activities

Have students investigate other methods of communication that use and do not use technology. Ask them to answer questions, such as: what types of communication did people in Asia use in the 19th century? What types of communication do specific animals use? What types of communication might people without communication technology — who are in distress — use?

Have students research what other types of satellites do and why they also might be useful. Challenge students to find pictures or other information that was generated via an Earth orbiting satellite.

Have students make models of satellites including the power-generating devices, the receiver and transmitting antenna and devices, etc.

Lesson 1: Keep in Touch – Communication and Satellite Jeopardy Overhead

Types of Satellites	Communication	Engineering and Satellites	General Space
Question: What is a weather satellite?	Question: What is talking?	Question: What is an engineer?	Question: What is the moon?
Question: What is a navigation satellite?	Question: What is the telephone?	Question: What is orbiting?	Question: What is a constellation?
Question: What is a communications satellite?	Answer: What is the newspaper?	Question: What are solar panels?	Question: What is the sun?
Question: What is a scientific research satellite?	Question: What is e-mail?	Answer: What is the sun?	Question: What is 1 year?
Question: What is a communications satellite?	Question: What is a satellite phone?	Answer: What are a receiver and a transmitter?	Answer: What is Low Earth Orbiting (LEO)?

Activity 1: I'm Not in Range

Grade Level: 4 (3-5) **Group Size:** 30

Time Required: 50 minutes **Activity Dependency:** None

Expendable Cost Per Group: US$ 30

Keywords: communication, phones, range, satellite, cell phone

Summary: In this role-playing activity, students learn how cellular phone service works, its advantages and its limitations. Students also learn about the advantages and limitations of satellite phone service. Phone communication involves many aspects of science, math and engineering, and this activity conveys to students how these technologies help people to stay better connected. Students use what they learn to understand what communication options might be available for Maya and her parents, Spacewoman Tess and Spaceman Rohan.

Engineering Connection: Just because people are far away from each other or in constant movement does not mean that they have to stop communicating. As people move further away, travel more often and to more remote locations, and, in fact, chose to live in these more remote areas, engineers are developing ways for them to keep in touch. The invention of the telephone already changed they way people communicate, and engineers - many different types working together - are continually working towards newer and better ways for people to stay in touch with the people they care about. These engineers need to understand how communication can occur over great distances which means they need to know about satellites and transmissions, receiving and measurements.

Learning Objectives

After this activity, students should be able to:

- Understand and explain the basic concepts of how cellular phone service works.
- Understand and explain the basic concepts of how satellite phone service works.
- Describe how spatial arrangements affect different types of communication.

Materials List

- 30 (1 per student) poster boards, cardboard or large pieces of paper, either pre-cut into hexagons, pre-stenciled or in original (rectangular) form.
- 15+ pair of scissors to cut the poster board or paper

Introduction/Motivation

Let's brainstorm different ways that people who are not physically close together can communicate with each other. (A list might include: phones, cell phones, yelling, or sending parrots with messages). We will keep this list on the board. How many of you have ever used a cell (short for cellular) phone? Do your older siblings have them, or do you perhaps have one? Do your parents have them?

Have you ever wondered how making cellular phone call works since they are not hooked up to anything? Have you ever wondered why you can call in certain places and not others? This is what we are going to learn about today!

So, what is really happening when a cellular phone disconnect you while you are talking with somebody? Do you know why? Why doesn't this happen with a regular phone (a land-line)? Land-line phones use actual telephone lines or wires that connect from place to place. When using a land-line phone, you are literally connected to the vast network of telephone wires that exist, so it is fairly rare that your phone would stop working, unless… Can you think of ways that a land-line telephone might stop working? (Answers might include: telephone line falling down and getting disconnected, the actual phone becoming broken or the connection from your phone to the telephone line getting disconnected or cut).

But what about cellular phones? There are not any wires that can get disconnected or broken. So why then do cellular phones stop working? Well, cellular phones work like your radio works. They rely on wireless technology, and they use an antennae to receive the sound signals like a radio. The antennae might not be visible, as it can be on the inside or the outside of the cell phone. This means that when a call is placed from your cell phone, it connects to a cellular phone tower by radio waves that then gets transferred to a central station which sends the signal (the phone call) to the person you are calling. Therefore, no wires are needed. Instead, there needs to be a cellular tower close enough to pick up the signal and a station to receive the signal and send it to the person who is being contacted.

Have any of you heard of a satellite phone? Well, a satellite phone works like a cellular phone, except it uses a satellite that is orbiting the Earth to pick up phone signals (rather than using a cellular phone tower to receive/transmit signals). A satellite phone sends the signal of your voice back down to Earth in just the right spot using very advanced technologies. Engineers must learn everything they can about how sound travels in order to develop cell phones, cell phone technologies, communication towers and satellites. Engineers also need to understand where to place the cell phone towers so calls can be connected to central stations.

Today we will learn how cellular telephones make/receive calls and why you cannot call everybody everywhere — but what type of phone technology might be useful instead in these cases.

Cellular Phones

A *cellular phone* can be described as a very sophisticated radio. They are a type of wireless communication device that uses many small cells with a base station and a cell phone tower at the center of each cell. These cells have extensive *frequencies* that allow many thousands of people to use cell phones at the same time. In this process, cellular calls are transferred from base station to base station as a user travels from cell to cell — in the case of this activity, from hexagon to hexagon. A cellular network is composed of cellular towers. In essence, when a call is placed from your cell phone, it travels by radio waves to a cellular tower (in this activity, a student) that picks up the specific signal from your phone. These cellular towers are thought of as *cells*, with each cell able to typically pick up a signal within 10 square miles. The signal is then sent to a *Mobile Telephone Switching Office* (MTSO) which handles calls from several towers — called a *cluster*. The MTSO transfers the signal to a local phone line that sends the signal to the final destination via landline, microwave signals or satellite. The MTSO senses when the signal is becoming weak and hands your call off to the next tower — or the MTSO in the next cluster. It controls the quality of your link by keeping you connected to the best possible signal as you move

from cell to cell. When you have traveled beyond the range of the towers, the signal is lost and you cannot make or receive calls.

Satellite Phones

Satellite phones do not use cells or cell towers for sending/receiving calls. Most satellite phones use *Low Earth Orbiting* (LEO) communication satellites. When a satellite phone is turned on, the signal goes up to any number of satellites in a compatible *constellation* (group of satellites) where it is then registered with the constellation. When a call is made through the satellite phone, the signal goes to the satellites and then is directed down to a ground station and then further directed to the call destination. The call can be directed to a land-line as well as a cellular network and the reverse is also true. This process allows the satellite phone to be used in the middle of no where — great distances from any cellular phone tower — and thus providing an essential form of communication for those who travel to the beyond!

Procedure

The general summary of this activity is as follows: the majority of students are role playing as cellular phone towers. The student's (tower's) range of activity is the size of their hexagons that they make or are pre-made for them. This means that if any student is either touching or entirely in one of the hexagons, that person is "in range" of a cellular phone tower because they are in one of the "cells." Each tower represents one cell in cellular phone network and is typically sized at 10 square miles. The towers can be arranged in pretty much any fashion as long as there is at least one cluster of towers and some space in between other towers. An example of a setup is shown in Figure 1 (with this layout, a 30 student class is assumed allowing for 24 tower students, 3 moving students, 1 house, 2 recorders).

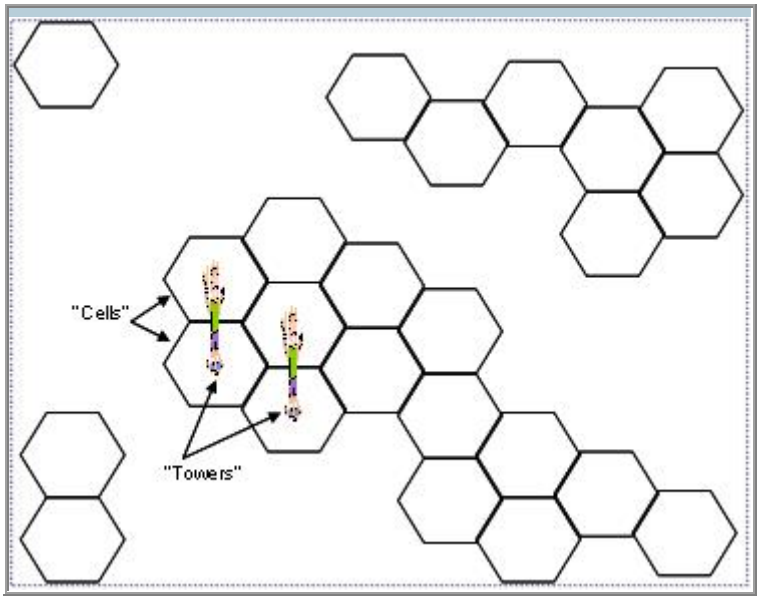

Figure 1. Example layout of communication towers

Before the Activity

Clear out a space either in the classroom (move all the desks to the walls so there is an open space in the middle of the room) or if possible use the school gymnasium or an outside area such as a basketball court.

Prepare the poster board/cardboard/paper for the students (material can either be pre-cut or pre-stenciled into hexagons, or just in rectangular poster board form).

With the Students

1. Explain the activity to the students: go through the general procedure with the students so they have an idea what to expect.
2. If necessary, have students either cut out their hexagons (or give them the pre-cut hexagons).
3. Have students place their hexagons (towers) around the room, with some in clusters and some father apart.
4. Ask for six volunteers. (All remaining students can stand on a hexagon in the tower configuration. These students are known as "towers" and do not move during the activity.)
5. Assign four of the six student volunteers as "people" with cell phones who will role play as follows:
6. A person on a bike (bicyclist),
7. A driver of a car (driver),
8. A person in a house (house), and
9. A paddler in a canoe (canoeist).
10. Ask the four "people" volunteers to stand anywhere on the tower arrangement - either on a hexagon or not. The driver, bicyclist and canoeist can move anywhere, but the person in the house cannot move at all. The movements can be made as follows: the bicyclist can only move one step (one hexagon) at a time, the canoeist can move two steps (two hexagons) at a time, and the car driver can move three steps (three hexagons) at a time. Make sure that the students in these roles know how far they can move at any given turn.
11. The two remaining student volunteers are recorders. They will record who can communicate with whom at any given time. Recorders should use the attached Communications Recording Data Sheet .
12. Next, start the role playing. The teacher says Step 0 to start and everyone stays where they are. The teacher then asks any of the students: who is able to call whom? All the students should look around and see who is in range of a cellular tower. (Remember: students can only make or receive a call if they are touching a hexagon. This means that if any student is either touching or entirely in one of the hexagons, that person is "in range" of a cellular phone tower as they are in one of the "cells." Students can tell who can call whom as only those people within range of a cellular phone tower — with a cell phone — can place a call.) The recording students write down who can call whom.
13. Then, the teacher says Step 1, and the students with phones can move their designated steps in any direction in the room (i.e., the driver moves 3 steps, the canoeist moves 2 steps, the bicyclist moves 1 step and the person in the house moves no steps). Emphasize that the students who are role playing as towers cannot move at all, as they are stationary objects. Again, the teacher asks all students: who is able to call whom? All of the students should look around and see who is in range of a cellular tower. The recording students write down who can call whom.
14. Repeat these steps: Step 2, Step 3, Step 4, for about 8 more steps for a total of 10 rounds. In the middle of these steps, ask the first part of the Activity Embedded Assessment questions.
15. Now, replace the canoeist's phone with a satellite phone. (Say, "The canoeist, <student's name here>, now has a satellite phone.") For variety, some of the student's roles could be switched at this time, particularly the recording students' roles. (What benefit does a satellite phone have? Answer: The satellite phone can call anywhere. How does a satellite phone work? Answer: When a call is made through the satellite phone, the signal goes to a satellite and then is directed down to a ground station and then further directed to the call destination. The call can be directed to a landline as well as a cellular network; the reverse is also true. This process allows the satellite phone to be used in the middle of nowhere far away from any cellular phone tower.)
16. Start over with Step 0. The teacher asks the students: who is able to call whom? All the students should look around and see who is in range of a cellular tower. The recording students write down who can call whom.
17. Then, the teacher says Step 1, and the students who can move, move their designated steps (i.e., the driver moves 3 steps, the canoeist moves 2 steps and the bicyclist moves 1 step). Again, the teacher asks any of the students: who is able to call whom? All of the students

should look around and see who is in range of a cellular tower. The recording students write down who can call whom.

18. Repeat these steps: Step 2, Step 3, Step 4, for about 8 more steps for a total of 10 rounds. In the middle of these steps, ask the second part of the Activity Embedded Assessment questions.

Attachments

- Communications Recording Data Sheet

Assessment

Pre-Activity Assessment

Discussion Question: Solicit, integrate and summarize student responses.

- Ask the students what sort of telephones they or their families use to communicate? Whom do they call? Do they have cell phones? How is the reception with their cell phones? Is the reception good sometimes and bad other times? What does going "out of range" on a cell phone mean?

Activity Embedded Assessment

Discussion Question: Solicit, integrate and summarize student responses.

- Part 1: During the cellular phone role play, ask students the following questions:
- Whose phone communications changed the most? Why? (Answer: Since the car driver can move more steps than the rest, it would be expected that his/her communications change the most. The driver should be moving in and out of range the most, followed by the canoeist, bicyclist, and person in the house).
- Where is a location where people cannot receive very many phone calls and why not? (Answer: Places where no cellular phone towers exist would be difficult places for people to receive any cellular phone calls. Presumably on the board there are spaces without any "cells" or hexagons - these would be places where not very many cellular phone calls could be transmitted or received.)
- Where is a location where people can receive phone calls and why is it better? (Answer: Places where there are numerous clusters of hexagons or "cells" would be able to receive more phone calls. If you leave one cell, then there is one right next to it). Think about what you would change so that everybody could call everyone else all the time? (Answer: You could put in more "cells" (hexagons) so that there were no empty spaces without cellular towers. Then, everyone with a cell phone could call everyone else with a cell phone; OR, you could develop phones that did not rely on the existence of cellular phone towers.)
- Part 2: During the satellite phone role play, ask students the following questions:
- Whose phone communications have changed the most since we started over? Why? (Answer: The person with the satellite phone should now be able to call anyone from anywhere as s/he is bouncing signals off of a satellite.)
- Who can't the canoeist call? Why? (Answer: The canoeist still cannot call somebody who is not in range of a cellular phone tower. While the canoeist can send a call even when not in range of a cellular phone tower, the receiving end must be in range of a tower to receive it.)
- Is there a location where the canoeist cannot call anybody at all? Why? (Answer: It depends, as long as someone else is within range of a tower. The canoeist can call from anywhere, but if nobody is in range of a tower, no matter where the canoeist is, it might not be received.)
- Is there a location from which the canoeist cannot be called? Why? (Answer: Yes, if someone is calling from a regular landline phone. Even though the canoeist has a satellite phone, the canoeist needs to be in range of a cellular phone tower or landline to receive the caller's call, which is not going through a satellite.)
- What would you change so that everybody could call everyone else all the time? (Possible answer: If everyone had satellite phones, their chance of calling each other would increase.)

Post-Activity Assessment

Question/Answer: Ask students questions and have them raise their hands to respond. Write answers on the board and discuss as a class.

- What do both the caller and receiver need in order to make a cellular phone call? (Answer: to be in range of a cellular phone tower)
- What would have happened if all of the towers were separate from all of the other ones — i.e., no sides of the hexagons were touching other hexagons? (Answer: When movement happened, the phones would go completely out of service.)
- What could the person in the house do about his/her phone service? (Answer: If the person was not in range of a tower, they should move in range of one, or have one built, or get/borrow a satellite phone.)
- What major difference did you see between the cellular phones and the satellite phone scenarios? (Answer: The person with the satellite phone could call anybody with a phone from anywhere in the world.)
- What change could you make to the cellular phone scenario so that everyone could call each other all the time? (Answer: more cellular towers in more places, mobile cellular towers) What about the satellite phone scenario? (Answer: Even though the person with the satellite phone could call everyone wherever that person was, no one else could; so you could have everyone have satellite phones.)

Activity Extensions

Students can think about the engineering and costs associated with putting in cellular phone towers and implementing satellite phone systems and create an advantage/disadvantage list. What about places where there is currently no phone service at all, what are the advantages of land-line phones over cell phones or vice versa?

Create a coordinate system on the space where the towers and movement is and record and analyze everyone's coordinates and how they change.

Activity Scaling

For upper grades, put one or two students in charge of the Steps. They should call out Step 1, Step 2, etc. and can even be in charge of ask the questions. Also, students can measure, draw, and cut the hexagons.

For lower grades, either pre-cut or pre-stencil the hexagons.

Safety Issues

To keep the activity running smoothly, remind students not to run from hexagon to hexagon; they should move slowly and quietly so as not to run into each other.

Troubleshooting Tips

The bigger the poster board, the better; but remember that larger poster boards require more space.

Watch the moving student's steps: no jumps or hops allowed!

If the class is quite large, you could have a second group of students recording.

Depending on the size of the space, students might be tightly packed.

Since this is a whole class exercise, students who are towers might get antsy, be sure to ask questions directly to them to keep them on their toes.

If there is not enough space for all the students to participate as towers, you can have the students who are not assigned a role watch from their seats.

Name: _____ **Date:** _____

I'm Not in Range Activity – Communications Recording Data Sheet (Cellular Phone)

Step Number	Who Can Call Who? (Circle the people who can get a call from the first person)			
0	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
1	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
2	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
3	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
4	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
5	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
6	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
7	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
8	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
9	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
10	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver

Name: _____ **Date:** _____

I'm Not in Range Activity – Communications Recording Data Sheet (Satellite Phone)

Who has the satellite phone (circle)? Canoeist Bicyclist Driver House

Step Number	Who Can Call Who? (Circle the people who can get a call from the first person)			
0	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
1	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
2	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
3	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
4	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
5	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
6	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
7	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
8	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
9	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver
10	Canoeist →	Bicyclist	Driver	House
	Driver →	Bicyclist	Canoeist	House
	Bicyclist →	Driver	Canoeist	House
	House →	Bicyclist	Canoeist	Driver