FACT 5: COMPUTERS AND SATELLITES CAN HELP FARMERS MAKE BETTER DECISIONS

LESSON 1:	A Map is Worth a Thousand Words	(Language Arts, Music, Dance, Art, History)*
LESSON 2:	Yield Map Math	(Math)*
LESSON 3:	Satellite Science	(Science)*
LESSON 4:	Finding Your Way	(Geography)*

*All Lesson Plans are adaptable for ALL ages

DAVID EXPLORES NEW WORLDS

It was a dark July evening and David was lying on his back studying the stars, waiting for the one that would change his life. The grass was soft, and it was very quiet. He'd already found the stars outlining the Big Dipper and Leo the Lion.

He wanted to see a falling star. He had a wish, and his sister had told him that wishing on a falling star offered the best chance of success. So he waited.

The wish started with a bike, one with lots of speeds. But he didn't want just a bike. He wanted a bike that would take him places he'd never been. Places where he could see new sights, meet new people, try new things. Places he could explore, then name. Places where people would always remember him as the one who mapped the way.

He loved the story of the Lewis and Clark expedition. They'd studied the land and the native people, then drawn maps so others could follow.

He wondered if the stars had looked the same then. He had a book telling how important stars were to explorers. Once in a museum he'd seen a sextant, the tool explorers had used to find their positions on the earth.

He lay there quietly, slapping mosquitoes, dreaming about bikes and explorations. Wishing.

There, that was one. High over his head. A falling star! This was his chance! He leaped up.

He watched and waited, holding his breath. He wouldn't let it leave his sight. He waited. The seconds dragged by. One. Two. Three. Four. But the star didn't fall. It kept moving, slowly, across the sky. His hopes sank.

Later, his mom said, "I bet it was a satellite." David had seen a picture of one in his Weekly Reader in school, so he listened a little. "Some of them are useful in navigation. That means they can help make maps," she explained. "I'll have Kevin show you tomorrow."

The next day, at his mom's office, Kevin strapped a backpack on David. Kevin was an expert in Global Positioning Systems, or GPS. The backpack held a battery and a short pole topped with an eight-inch spaceship. At least that's what it looked like, but Kevin said it was called a satellite receiver. He handed David a little computer, then hooked the receiver to it.

David looked at the computer screen. There was a blinking dot on it. When he moved, the dot moved! Satellites in space were sending a signal to earth, straight to the receiver on his back. They were monitoring his location! It said he was at 44.20544922 latitude and –94.25583759 longitude. He moved. Now he was at 44.20531834 latitude and –94.25568914 longitude.

Kevin said there were 24 satellites that circled the earth. The receiver needed to get a signal from at least three of them to pinpoint any location on earth. He said every single place on earth had its own latitude and longitude. No two were the same, and no one would ever be lost if they knew those numbers.

David wasn't listening. He was watching the computer screen follow every step he took.

His mom said farmers liked GPS. They could make maps showing where they planted different corn hybrids or installed drainage tile lines, or where their crops had an insect problem or needed more fertilizer. If they put a GPS receiver in their combine they could make maps showing how much corn was produced in different parts of the field.

When they studied all those maps together, they could decide what was the most important, and then make better decisions. "Satellites give farmers a way to measure things they've never been able to measure before, to see things they've never been able to see before," said his mom.

That wasn't too hard for David to understand. He knew how important maps could be. In fact, he had an idea!

He asked Kevin to set the computer for making a map. Then he jumped on his bike, backpack and all. It was his old bike, the one with only one speed, but he wasn't worried. He pedaled around the blueberries and the windbreak. He rode around his house, through the front yard, then up the driveway to the barn. He circled the swing set, took a sharp right, and braked by his favorite tree.

Then he asked Kevin to print the map he'd made. It was wonderful!

He wrote names of all the places on his map, then asked Kevin to print a map of the world, showing how his little map fit into the big world. He hung it on his wall to remind him of his dream.

Someday he'd be an explorer. He would lead people to new places, mapping the way for them.

It would be easier if he got that new bike. But even without it, David was going places.

LESSON 1: A MAP IS WORTH A THOUSAND WORDS

SUBJECT: Language Arts, Music, Dance, Art, History

OBJECTIVE: Students will realize the importance of "place" in their lives and the lives of others. They will study maps, then document the places they spend an hour/day/lifetime. They will learn that GPS is a new way of documenting locations on earth, then use their creativity to imagine new uses for GPS, as well as imagine how it may have changed history.

MEASUREMENT: Students will appreciate that maps document where something is, or where something occurs. They will understand that GPS can be used to pinpoint those locations, and they will have imagined ways the technology might make a difference in their future. (Or how it might have made a difference in the past.)

BACKGROUND FOR TEACHERS*:*

GPS, which stands for Global Positioning System, is the only system able to show you your exact location on the Earth anytime, in any weather, anywhere. Twenty-four GPS satellites, the first launched in 1978, orbit at 11,000 nautical miles above the earth. They continuously transmit signals that are monitored by ground stations located worldwide. These signals can be detected by anyone with a GPS receiver!

Each satellite takes 12 hours to complete one orbit around the earth. They are equipped with very precise clocks that keep accurate time to within three nanoseconds—that's 0.000000003, or three billionths, of a second. This precision timing is important because the receiver on the ground must determine exactly how long it takes for signals to travel from each GPS satellite. The receiver uses this information to calculate its exact position.

The GPS receiver (in your hand, on your car, on the farmer's combine, etc.) calculates the difference between the time the signal is sent and the time it is received, and multiplies that by the speed of light. This allows it to calculate the distance to the satellite. It takes these readings simultaneously from three to four separate satellites, each one identifying a region on the earth. The intersection of these regions pinpoints the exact latitude, longitude and altitude of the receiver.

Global Positioning Systems have revolutionized the ability of people to find or document their location on the face of the earth. As GPS receivers are made smaller and at lower cost, they will begin to appear everywhere in our daily lives!

They will be used for activities and purposes we cannot even imagine today…or can we?

STUDENT ACTIVITIES:

1. Ask students to read the story David Explores New Worlds. Ask them to study the map that David made of his farmsite. Talk about maps; how they're made, and how and why they're used. Discuss different kinds of maps.(Example 1, 2 , 3)

- "Mapmaker, Mapmaker, Make Me a Map" discusses the importance of maps, from Peter Pan in Never Never Land to Dorothy in Oz to the political, road, and weather maps we use everyday.

- The U.S. Geological Survey site has a site entitled "Exploring Maps" with many kinds of maps illustrated.

2. Tell students you want them to record, individually or as a group, every place they go for an hour (or day). The purpose of this is to help them begin to appreciate that everything they do occurs in a certain location, and that they can create a map showing those locations.

   - They can sketch the classroom, and document the routes they take to the blackboard, the lunchroom, the library.

   - They can use a map of their city or county to document the route they take to school.

   - They can draw a floor plan of their house to document the routes they take between rooms, and the places they eat, watch TV, dress, and so on.

3. Show them the picture of David wearing the satellite receiver as a backpack. Tell them that GPS technology uses signals from satellites to pinpoint locations on earth (See the Background for Teachers section).

   - Ask them to imagine HOW they would like to wear a GPS receiver. Are they wearing it in their tennis shoes? On a wristband? On their glasses? On a hat?

   - Ask them to imagine WHY they might be wearing a GPS receiver. Do they get lost easily? Did their parents ground them and want to monitor them at all times? Are they a world famous map-maker on an adventure?

   - Ask them to imagine the place(s) WHERE they will wear this receiver. Will they stay in a familiar place like they just described in section 2? Will they be in a new place? A strange place? A foreign country?

   - Ask them to think of WHAT they will be doing while wearing the receiver. Are they looking for a treasure/person/answer? Making a map for a farmer/explorer/hunter/rescue team?

4. Let students, individually or in groups, choose one of the following methods to describe what they have imagined in Exercise 3. Explain again that the GPS receiver is a tool for **documenting location**. These stories, songs, or pictures must be about using GPS for some purpose…A map is worth a thousand words!

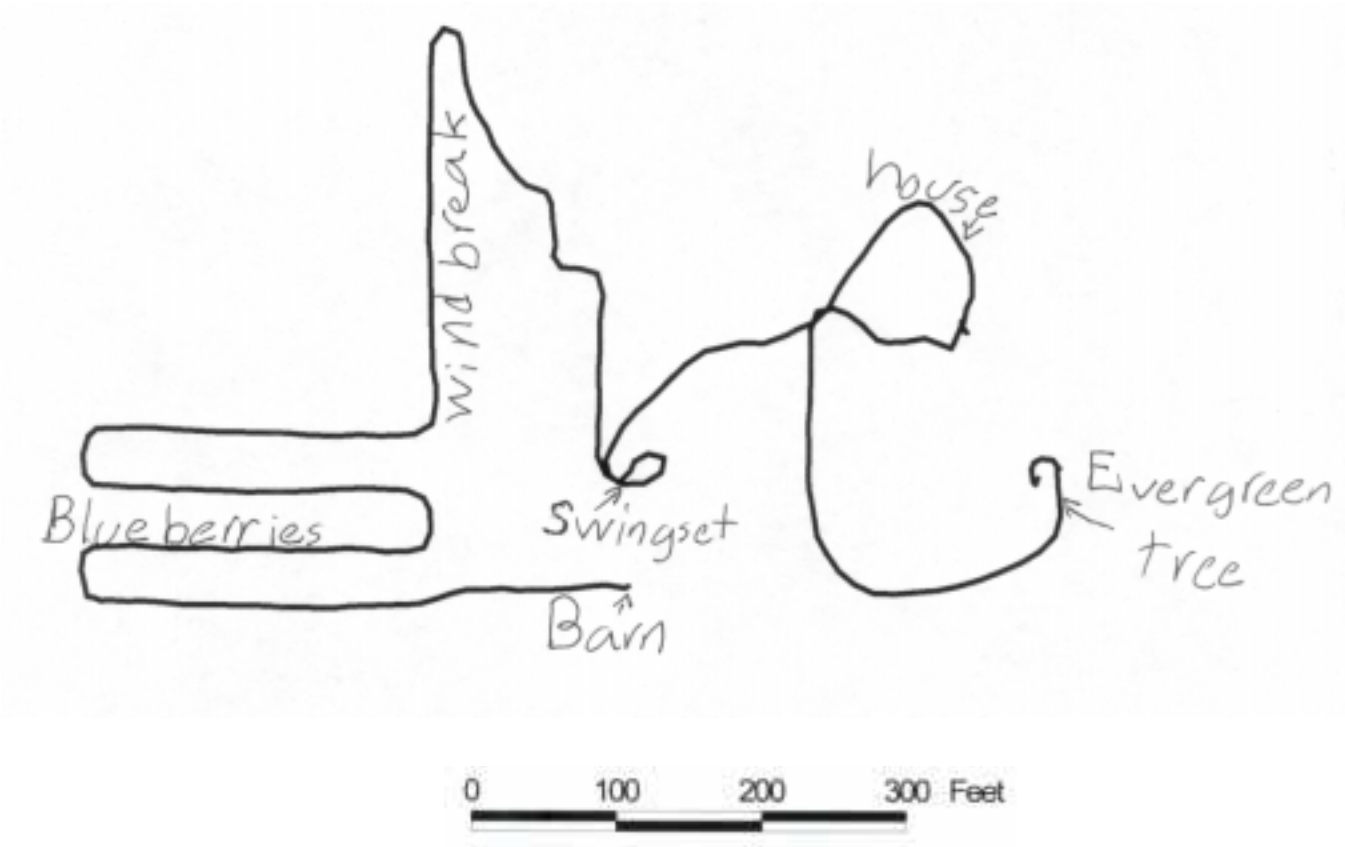
   The sky's the limit (pun intended) on this exercise. Students can think about GPS as a tool for anything from keeping track of babies to criminals, from hiking in the rainforest to mining for gold, from farming to piloting airplanes! It might be helpful for students to brainstorm ideas before recording them in one of these ways.

Give a "corny" prize to the student with the best AGRICULTURAL "adventure!"

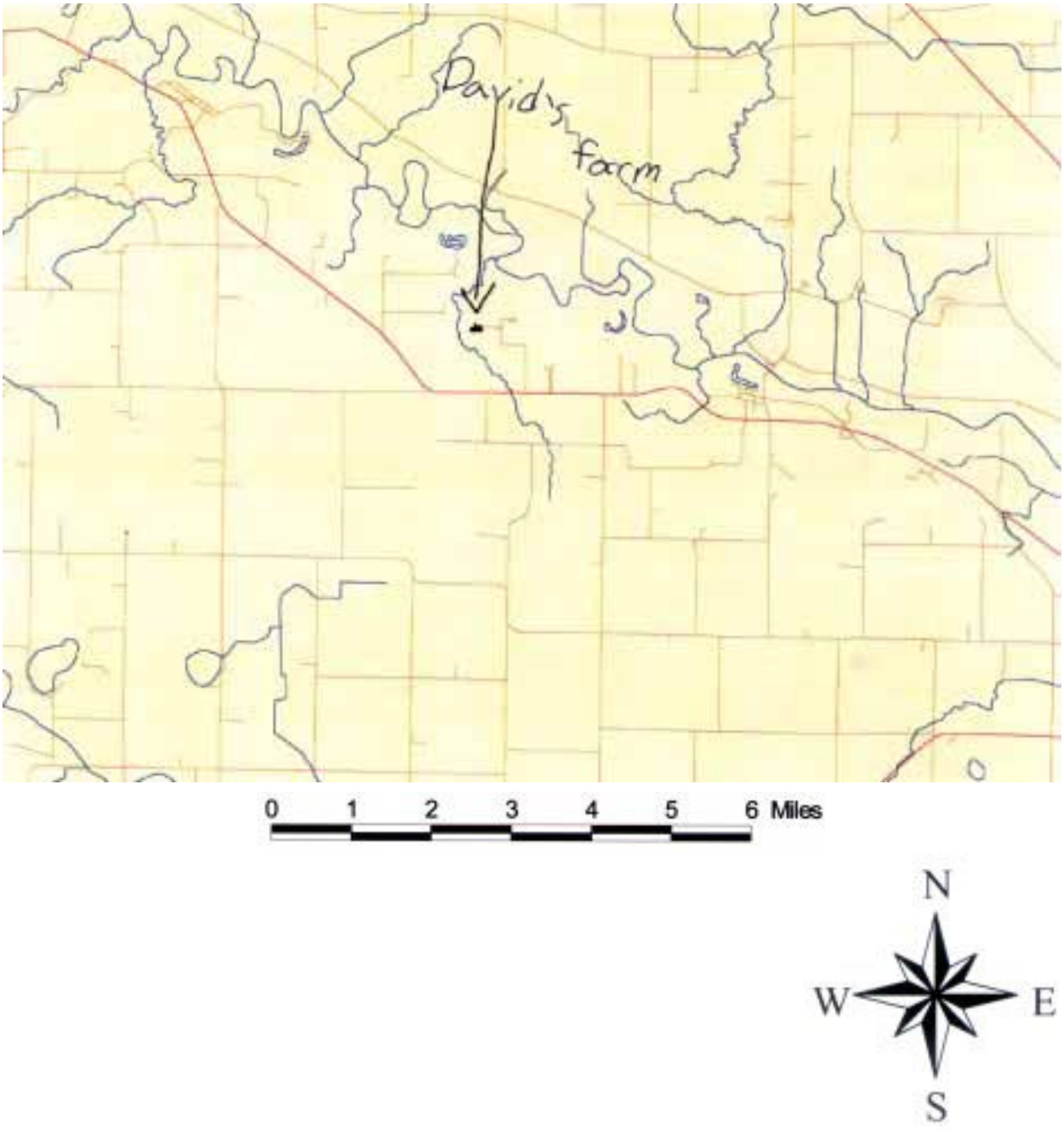
- Write a story or poem.
- Tell a story.
- Present a play.
- Draw a picture.
- Draw a map that tells a story.
- Choreograph a dance.
- Use pantomime.
- Build a 3-D model.
- Write a song.

5. Extra Credit: Ask students to imagine a famous person or event in history, and describe in word/song/picture how that person or event would have been different if GPS had been available. (For example: How would GPS have changed the explorations of Lewis and Clark? How would GPS have changed the lives of Harriet Tubman? Beethoven? Confucius? How would GPS have changed the lives of the early American pioneers? The victims/soldiers of WWII?)

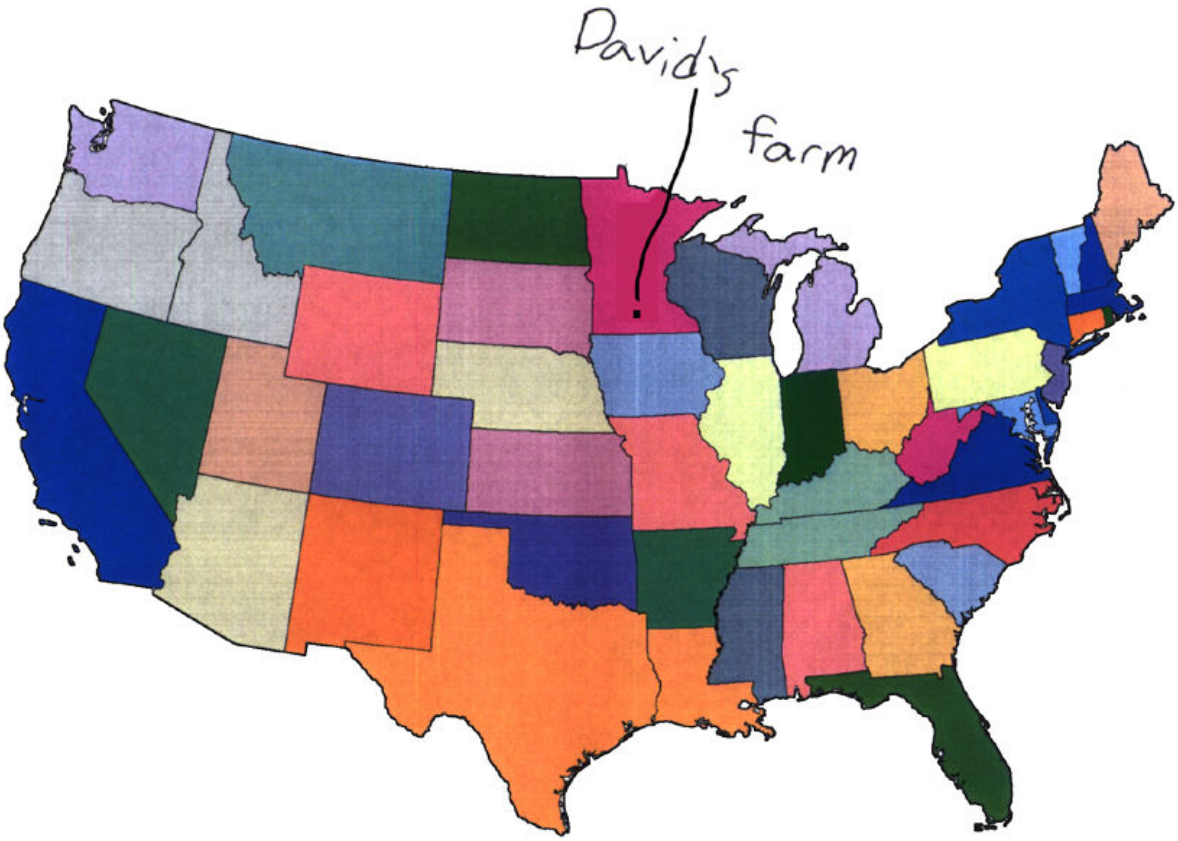
David's Map of His Farm



GPS Map of David's Farm



U.S. Map of David's Farm



LESSON 2: YIELD MAP MATH

SUBJECT: Math

OBJECTIVE: Students will study a yield map of a cornfield and learn many of the mathematical concepts used in its analysis. Younger students will color and count yield cells. Older students will average yield points within a cell and will be introduced to standard deviation.

MEASUREMENT: Students have seen and learned to read an actual corn yield map, and will have gained some insight into the math and technology being used by modern farmers.

BACKGROUND FOR TEACHERS:

Yield monitors are mounted in corn and other grain combines. They use sensors to measure the amount of corn as it is harvested, recording these values every 1-3 seconds. At the same time the amount of corn is being recorded, a GPS receiver is recording the exact field location. When those two pieces of information are combined, the amount of corn (usually reported in bushels) that was harvested can be mapped for every location in a field.

Farmers use yield maps to identify both good and poor-producing areas of their fields, and then try to take action accordingly. Low yields may be due to insects, diseases, poor fertility, a shortage or excess of water, and many other problems, which can be resolved through management.

Farmers also use GPS technology to apply varying rates of fertilizers and pesticides to specific areas of their field. They can target treatments to specific needs instead of treating entire fields. This has both economic and environmental benefits.

STUDENT ACTIVITIES:

Ask students to read the story David Explores New Worlds, paying close attention to the paragraphs that describe the ways farmers use GPS. ("…They could make maps showing where they planted different corn hybrids…and how much corn was produced in different parts of the field…then they could make better decisions…")

Students can follow the directions on-line, and answer the questions relating to the corn yield map. Or you can print copies. (Black and white copies will not work for yield maps, but can be used for the "cell" map. Younger students can color the map, either trying to match the real yields, or creating their own legends and "yields.")

LESSON 3: SATELLITE SCIENCE

SUBJECT: Science
OBJECTIVES: Students will construct a model of a Global Positioning System (GPS) satellite, and be introduced to GPS application in agriculture.
MEASUREMENT: Students will have a working knowledge of the components of a satellite, and will know that a GPS satellite sends signals to earth for pinpointing location, and that GPS is used by farmers to make maps of their fields.

BACKGROUND FOR TEACHERS:

A satellite is any object that orbits or revolves around another object. For example, the moon is a satellite of the Earth, and Earth is a satellite of the Sun.

Man-made satellites are increasingly important in our world. Their uses range from media and communications, to weather, scientific research, navigation and more. This unit is emphasizing the navigational uses of satellites, primarily GPS.

GPS, which stands for Global Positioning System, is the only system able to show you your exact location on the Earth anytime, in any weather, anywhere. 24 GPS satellites, the first launched in 1978, orbit at 11,000 nautical miles above the earth. They continuously transmit signals that are monitored by ground stations located worldwide. These signals can be detected by anyone with a GPS receiver!

Each satellite takes 12 hours to complete one orbit around the earth. They are equipped with very precise clocks that keep accurate time to within three nanoseconds—that's 0.000000003, or three billionths, of a second. This precision timing is important because the receiver on the ground must determine exactly how long it takes for signals to travel from each GPS satellite. The receiver uses this information to calculate its exact position.

The GPS receiver (in your hand, on your car, on the farmer's combine, etc.) calculates the difference between the time the signal is sent and the time it is received, and multiplies that by the speed of light. This allows it to calculate the distance to the satellite. It takes these readings simultaneously from three to four separate satellites, each one identifying a region on the earth. The intersection of these regions pinpoints the exact latitude, longitude and altitude of the receiver.

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STUDENT ACTIVITIES:

Ask students to read the story David Explores New Worlds. Ask if any of them have ever seen a satellite moving across the night sky as David did. Ask if they have ever seen a picture of a satellite (David had seen

one in his Weekly Reader). Talk to them about the "satellite receiver" that Kevin attached to the backpack he put on David. (A "receiver" receives the signals sent through space by the satellites…) Reread the paragraph in which Kevin says "…there are 24 GPS satellites that circle the earth…and the receiver needed to get a signal from at least three of them to pinpoint any location on earth…"

Explain that there are two basic parts of all satellites—the "payload" and the "bus." The payload is all the equipment a satellite needs to do its job. This can include antennas, cameras, radar, and electronics. The payload is different for every satellite. For example, the payload for a weather satellite includes cameras to take pictures of cloud formations, while the payload for a communications satellite includes large antennas to transmit TV or telephone signals to Earth.

The bus is the part of the satellite that carries the payload and all its equipment. It holds all the parts of the satellite together, and provides the power and propulsion to the spacecraft. The bus also contains the equipment used by the satellite to communicate with Earth.

Tell students they will be creating a model of a satellite, preferably a GPS satellite. Encourage them to be creative with their choice of materials. Tinker Toys will work, as will toothpicks and marshmallows, wood and paper, straws and clay, etc.

Ask students to use their models to explain how GPS works.

- For younger grades: 24 students with their satellites can "orbit" a central object (the earth), each satellite giving off a unique "signal." If the person on the earth has a receiver that knows the location of each satellite in relation to the earth, they can use that unique "signal" to figure out where they are on the earth.

See Lesson 2 to learn about GPS applications in agriculture.

- Invite a farmer, crop consultant, equipment dealership, input supplier, or other agricultural professional who uses GPS in their work, to speak to the class about GPS in agriculture. Ask them to bring their GPS satellite receiver!

LESSON 4: FINDING YOUR WAY

SUBJECT: Geography

OBJECTIVE: Younger students will learn their directions—north, east, south, and west. Older students will learn about latitude and longitude. All will study a map of the Evans family farm and use directions (latitude / longitude / north / south / east / west / elevation) to describe the field.

MEASUREMENT: Students will be familiar with the terms "latitude" and "longitude," as well as know their directions (north, south, east, and west). They can visualize a farm field and describe its location.

BACKGROUND FOR TEACHERS:

For the most part we sense our surroundings visually. We see rivers, hills, roads, buildings, or other landmarks, and understand our location as a collection of visible features.

We also think of our location in terms of its relationship to other places. For example, we know where we live in relation to a friend's house, the school, the ocean and so on. Distances and directions from other significant places are very important for our understanding of where we are in the world.

We also think of where we are in relationship to the sun, moon and stars.

Many tools and methods have been used over the years to measure locations. From a compass to a sextant to a GPS receiver, we have needed to be able to document and understand our location in order to find our way.

STUDENT ACTIVITIES:

1. Ask students to read the story David Explores New Worlds. See if they can list some of the ways that people over the centuries have been able to "find their way." (In the story it mentions early explorers like Lewis and Clark using the stars and a sextant. It also teaches about Global Positioning System satellites and receivers (see Lessons 1 and 3). But students should also be able to think of many other methods and tools for "finding their way," from use of simple landmarks and directions ("turn right at the big green house") to compasses and maps.

2. Tell students you're going to use an orange to illustrate the world.

- If you insert a long pin through the center, the top of the pin will be the North Pole, and the bottom of the pin will be the South Pole. (Or use two pins with different color heads.)

  Longitude lines (meridians) are north (up) to south (down). They are the vertical lines that cut the orange in equal halves from the North Pole to the South Pole. The most famous line of longitude is the prime meridian, which passes through Greenwich, England. The prime meridian is 0 degrees longitude. There are 180 degrees of longitude to the east (right) and 180 to the west (left) of the prime meridian.

  The equator divides the earth into two equal parts, the Northern and Southern Hemisphere. The equator is at 0 degrees latitude. There are 90 degrees of latitude to the north (above) and 90 degrees to the south (below). Some famous lines of latitude north of the equator are the Tropic of Cancer (23.5 degrees north) and the Arctic Circle (66.5 degrees north). Some famous lines south of the equator are the Tropic of CapriCORN (23.5 degrees south) and the Antarctic Circle (66.5 degrees south).

- Give each student an orange and a marking pen and ask them to draw the prime meridian and equator, as well as the latitude and longitude lines closest to their home. Place a pin close to their home, then ask them to explain their location using terms like "west of the prime meridian, north of the equator…"

3. Choose one of the following activities to increase students' understanding of navigational directions:

   - Label the walls of the classroom, north, east, south and west, then ask students to describe where objects are in relation to each other, using directional terms. (For example: "My desk is south of yours, but east of John's." "The bookshelf is northwest of the blackboard.")

   - Take students outdoors and use landmarks to point out which ways are north, south, east and west. Then play a game that incorporates navigational directions. One possibility is to split into two teams and ask each team to create a scavenger hunt for the other, using navigational directions. (For example: "Walk to the tree that is 15 steps to the east of the fence, then turn south and proceed to the northwest corner of the garage where you'll find a note buried under a rock…")

     Or, blindfold a student, lead them to a spot, and tell them the class will guide them to a particular location by giving directions. This is difficult, but most students will quickly learn which way is east (to their left) or south (when they're walking on grass instead of on pavement), etc.

   - Older students can use a compass to follow a map or navigational course.

4. Choose one of the following activities to increase students' understanding of latitude and longitude:

- Discuss the latitude and longitude readings in the story David Explores New Worlds, then see if students can find on a globe the approximate location on Earth where David was standing.

- Ask older students to complete a few calculations using these facts:
  1degree of change in latitude = 60 minutes = 364,560 feet = 69.05 miles
  1 minute = 1 nautical mile = 6076 feet
  1 minute of change in longitude = 1 nautical mile times cosign of latitude

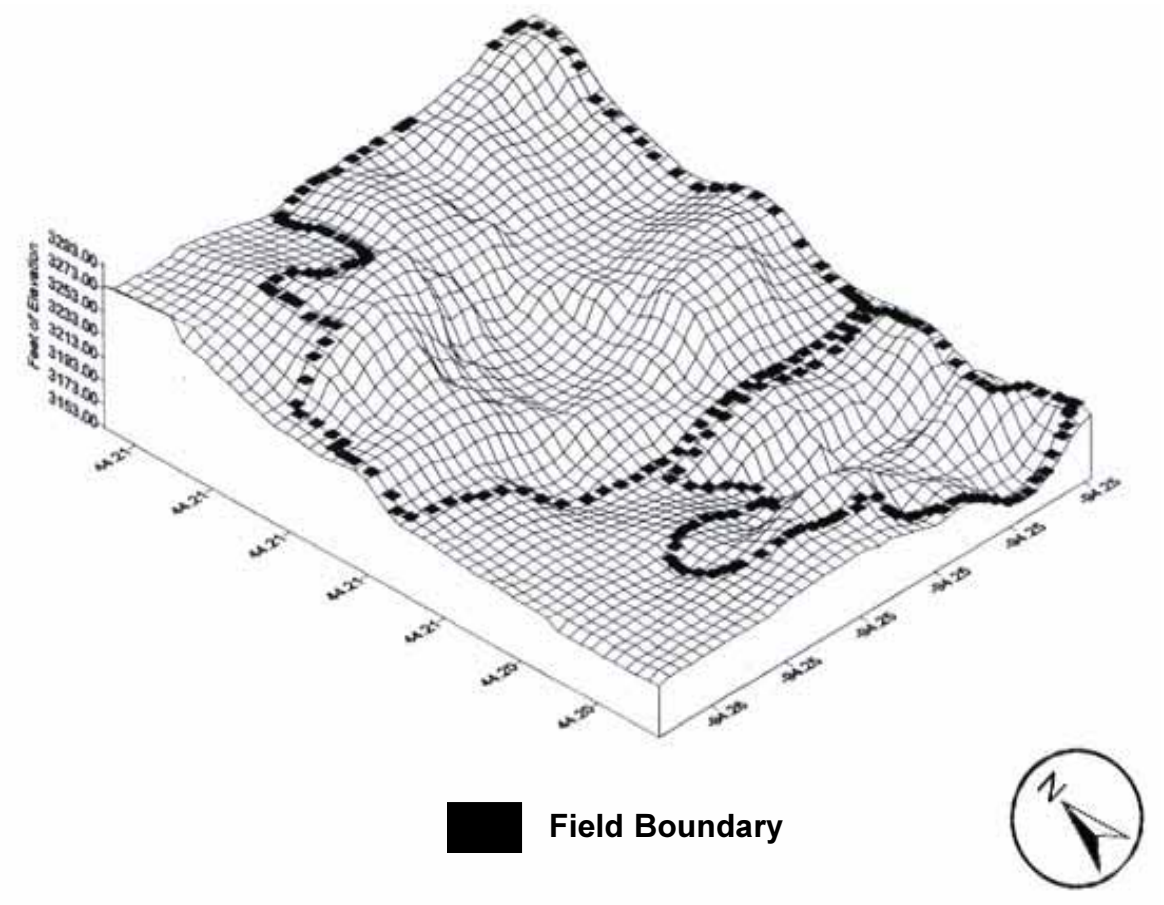
5. Distribute the following maps of Evan's field. (Example 1 & 2) One shows the elevation/hills, and the other shows the field in relationship to fields and rivers in the region.

   - Ask students to imagine they are walking across the field. Tell them to describe, or write a story, of their journey from one part of the field to another. (What do they see to the east of them? How tall is the hill to the north of them? Which direction from them is the sun? Etc.)

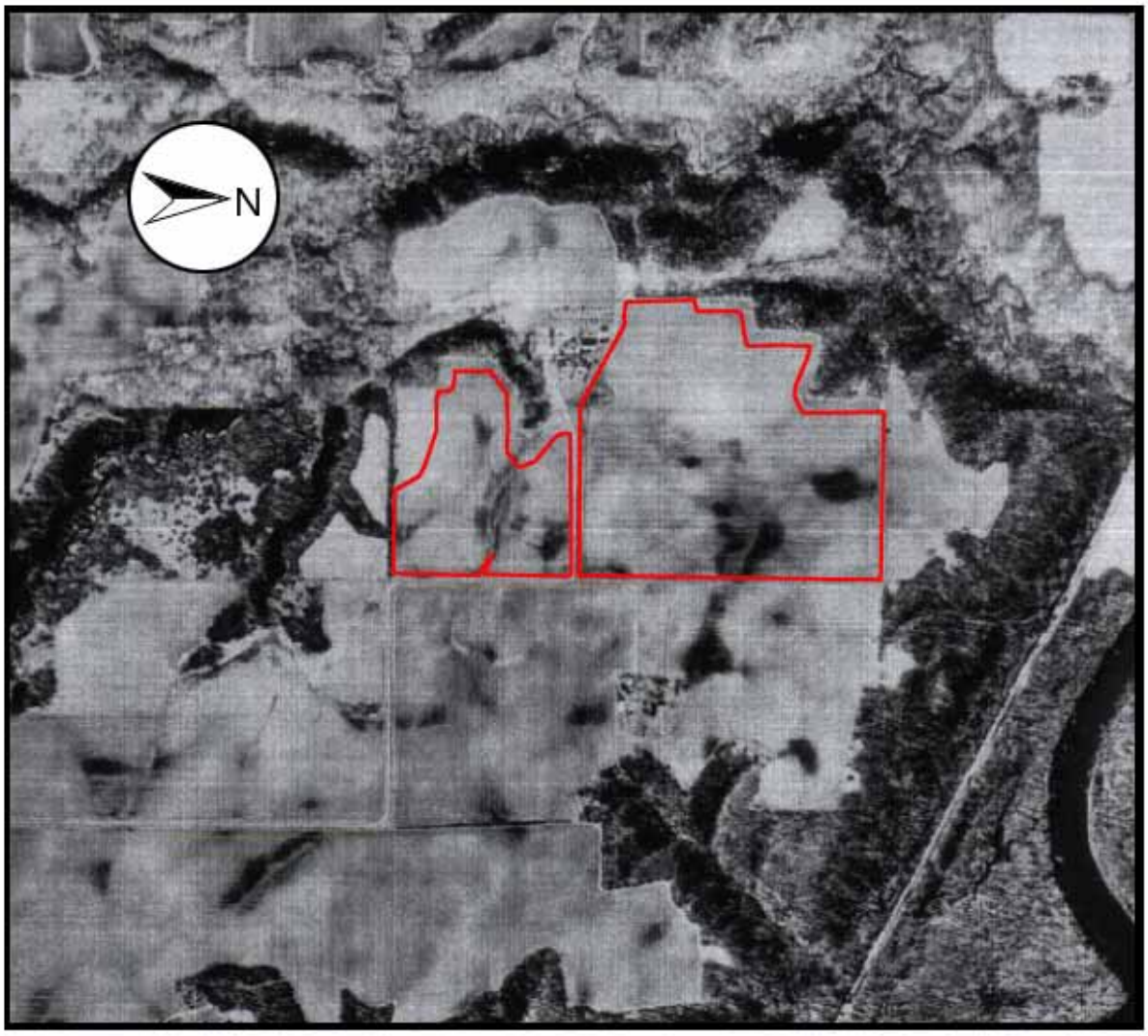
   - Break the students into two groups, and ask one group (using the regional map) to write directions from one point on the map to another. If they give the map to the second group, and point out the starting point, can the second group find the correct destination using the directions given? (Use the river, roads, building sites, and field sizes/shapes as landmarks.)

   - Ask students how a farmer could use these two maps. (For example, the elevation map might help a farmer determine how water will drain across the field. He or she can build terraces to prevent erosion from washing soil off the hills, and put drainage tile in the low ground so the water can drain away (See Unit 2, Lesson 3 & 4). It might also show the farmer where to put different rates of fertilizers (See Unit 2, Lesson 2). It might help explain different corn yields (See Unit 5, Lesson 2). A farmer might use the regional map to give directions someone delivering corn seed (See Unit 4, Lesson 1) or anyone else who needs to find the field.)

Elevation Map
Evan's Farm



Evan's Farm



Field Boundary