Follow the Drinking Gourd:
A Lesson on Celestial Navigation

Grade Level(s): 9-12	Subject(s): Astronomy, History

In-Class Time: 40-50 Minutes	Prep Time: 15 Minutes

Materials

- In class internet access
- Computers for each group of 3-5 students
- Photocopies of:
  - Follow the Drinking Gourd lyrics with interpretation (or projected from Internet). Suggested link: http://quest.arc.nasa.gov/ltc/special/mlk/gourd2.html.
  - Latitude/Longitude handout
  - Location Chart worksheet (or projected from PowerPoint)
  - RA/Dec handout (or projected from PowerPoint)

Objective

In this lesson plan, students will learn about how African Americans escaping slavery on the Underground Railroad used their knowledge of astronomy to find their way to freedom. They will learn about geographic and equatorial coordinate systems through the introduction of angular distance, angular size, longitude, latitude, right ascension (RA), and declination (Dec). Using the Big Dipper, Little Dipper, and North Star, stars used in the navigation of escaped slaves on the Underground Railroad, students will learn about how astronomers today identify the location of stars in the sky.

Introduction

In the early nineteenth century, many slaves in the United States sought freedom by fleeing to Canada. There, slavery was abolished in 1833, three decades before the United States would do so in 1865. In order to reach what was called the "promised land," freedom seekers would follow the "Underground Railroad," a network of people and safe-houses that extended throughout fourteen northern states where travelers could find shelter and assistance. About one thousand African Americans found freedom using the Underground Railroad, a small percentage of the more than 3 million people enslaved in 1850. Despite their small numbers, those that chose to make the journey were remarkable in their bravery and posed a significant threat to slave owners.

The era leading up to the Civil War was an extremely dangerous time for African Americans. In the 1840s, slave owners pushed for the Fugitive Slave laws which granted rewards for the capture of "fugitive slaves." The Fugitive Slave Laws not only threatened fugitive slaves, but free African Americans as well. Solomon Northrup biography provides once such example: he was a free African American from New York who was kidnapped in 1841 and lived for twelve years as a slave in Louisiana. He was able to escape, unlike many others that suffered similar fates, and wrote a memoir recounting his time called *Twelve Years a Slave*, now a major motion picture.

In 1857, the Supreme Court ruled in the famous Dred Scott case that black people were "so far inferior that they had no rights which the white man was bound to respect." Even scientists were often on the side of the slave owners. In fact, the 18th century American physician Samuel Cartwright wrote in 1851 about a mental disease called "Drapetomania" which he thought was responsible for causing enslaved African Americans to flee. One of the most famous "conductors" on the railroad was Harriet Tubman, formerly enslaved in Maryland, who reportedly made nineteen trips to the South and helped some three hundred African Americans escape slavery. At one time, it was rumored that the reward for Harriet Tubman reached as high as $40,000.

In order to impede African Americans ability to escape slavery, they were denied access to knowledge about geography and navigation. In addition, slaves were not permitted to read or write. Despite all this, those who traveled the Underground Railroad used astronomy in order to navigate to freedom. Specifically, freedom seekers followed the North Star, also called Polaris, to find their way north. By using two asterisms called the Big Dipper and the Little Dipper, travelers could identify Polaris and avoid being captured. These groupings of stars are part of larger constellations known respectively as Ursa Major (Big Bear) and Ursa Minor (Little Bear). Thus, while it was only recently that the first African Americans received their doctorates in astronomy and astrophysics – Harvey Washington Banks being the first African American to receive a Ph.D. in astronomy in 1961 – African Americans have long had deep connections with the stars, including bringing their own cosmologies and understandings of constellations from their various cultures in Africa. In this lesson plan, students will examine how the stars helped lead slaves north and how astronomers today identify the location of stars in the sky.

Instructions

Engage: 10 Minutes

In this section of the lesson plan, students will recall what they have learned about the Underground Railroad. They will read the lyrics and an interpretation of the song "Follow the Drinking Gourd" to get an idea of how slaves used the stars to navigate their way north.	
What is the teacher doing? Prompt the students to recall what they have learned about the Underground Railroad. Fill in any major gaps in what the students mention using the information from the introduction.	**What are the students doing?** List what they have learned about the Underground Railroad.
Hand out the lyrics and an interpretation of "Follow the Drinking Gourd". If possible, play the song for the students. One possible link is: https://www.youtube.com/watch?v=pw6N_eTZP2U Pause after each verse to discuss the interpretation of the lyrics, make sure that students understand that this song gave slaves directions on how to navigate their way north using the stars. One such place you can find the lyrics and an interpretation is: http://quest.arc.nasa.gov/ltc/special/mlk/gourd2.html	Listen to/reading the lyrics to "Follow the Drinking Gourd". Discuss the lyrics and understand that the song served to direct slaves on how to navigate their way north.

Explore: 20 Minutes

In this section, students will read about latitude and longitude and explore how the stars appear to move across the sky. They will complete an activity that illustrates how the sky looks from different places on Earth and how the stars can be used for navigation.	
What is the teacher doing? Pass out the Latitude and Longitude handout or project the Latitude and Longitude slides of the PowerPoint.	**What are the students doing?** Read the Latitude and Longitude handout or take notes on the Latitude or Longitude slides.
Rotating Sky Explorer activity: 1. Place students in groups of 3-5 and give each student a copy of the Location Chart (found in the Supplemental Materials). Put each group at a computer or give them a laptop. A main computer projected at the front of the classroom can help orient students. 2. Students will start by identifying the latitude and longitude of historic sites on the Underground Railroad. This can be done using the website http://itouchmap.com/latlong.html. 3. Students should write in the Latitude and Longitude of those locations on the Location Chart. Students should then go to the	Complete the Rotating Sky Explorer activity: In groups of 3-5, students will complete the Location Chart worksheet. They will use the University of Nebraska-Lincoln Rotating Sky Explorer to understand how the sky looks from different places on Earth and how it changes over time. They will think about how the stars could be used for navigation.

University of Nebraska-Lincoln Rotating Sky Explorer at http://astro.unl.edu/naap/motion2/animations/ce_hc.html. (If simulation will not load, ensure Flash plug-in is enabled or try alternate internet browser) 4. Type the Latitude and Longitude of your school into the "Observer's Location" section of the Rotating Sky Explorer Simulation. 5. In the Appearance Settings section, select "show labels". 6. In the Star Controls section, select "Big Dipper" in the Star Patterns drop-down menu. 7. Click "Start Animation." 8. Let the students play with the different options in the simulation. 9. Prompt the students to think about how the sky looks from different locations, how it changes over time and how the stars could be used for navigation.	

Explain: 5-10 Minutes

The students will explain what they have observed in their activity. They will also explain, in their own words, how the stars could be used for navigation.	
What is the teacher doing? Mix up the groups so that students that were not working together can share their experiences.	**What are the students doing?** Talk to students that they did not work with about what they did/noticed in their groups.
Have the students explain aloud what they looked at and what they noticed about how the sky looks from different locations, how it changes over time and how the stars could be used for navigation. Use the discussion questions and answers (found below) for reference.	Explain to the class what they did and what they noticed about how the sky looks from different locations, how it changes over time and how the stars could be used for navigation.

Elaborate: 5-10 Minutes

The students will learn how astronomers today identify the location of stars. They will be introduced to the concepts of right ascension and declination.	
What is the teacher doing? Give out the Right Ascension and Declination handout or project the RA/Dec slides of the PowerPoint.	**What are the students doing?** Read about right ascension and declination or take notes on the right Ascension and declination slides of the PowerPoint.
Either in their original groups or in their newly mixed groups, have the students go back to the	In groups, "add a star randomly" in the Rotating Star Explorer. Click on the star that was added. In

Rotating Star Explorer website. Have them select "Add star randomly" in the Star Controls section. Click on the star that was added. In the "Celestial Sphere View", set right ascension = 2.5 h and declination to 89.2^0 in the Celestial Sphere View. This star is Polaris, the North Star. Now they can see how what the Big Dipper and Polaris look like on the celestial sphere. They can also see that as the Earth rotates and the Big Dipper moves across the night sky, the North Star remains relatively constant making it useful for navigation. Have the students add other stars and move them around, taking note of their changing RA and Dec values so that they can get a feel for what RA and Dec physically represent.	the "Celestial Sphere View", set right ascension to 2.5 h and declination to 89.2^0 in the Celestial Sphere View. This star is Polaris, the North Star. See what the Big Dipper and Polaris look like on the celestial sphere. Notice that as the Earth rotates and the Big Dipper moves across the night sky, the North Star remains relatively constant making it useful for navigation. Add other stars randomly and move them around, taking note of their changing RA and Dec values, getting a feel for what RA and Dec physically represent.

Evaluate:

Students can be evaluated on their contributions to class discussion.

Required/Recommended Reading and Resources

- Find your latitude and longitude: http://itouchmap.com/latlong.html.
- University of Nebraska-Lincoln Rotating Sky Explorer: http://astro.unl.edu/naap/motion2/animations/ce_hc.html.
  (If simulation will not load, ensure Flash plug-in is enabled or try alternate internet browser)

Discussion Questions

1. **How does the sky look from different places on the Earth?**
   Possible Answers: Depending on your latitude, the paths of stars will look more like circles in the sky or more like lines across the sky. You can see different stars and constellations in the northern hemisphere than you can in the southern hemisphere.
2. **How does the sky change over time?**
   Answer: Stars appear to move across the sky in the opposite direction from the Earth's rotation. This is caused by the Earth spinning on its axis.
3. **How can the stars be used for navigation?**
   Possible Answers: Different constellations can point you in different directions. For example, the Big Dipper can point you to Polaris which is always to the north. Throughout the night, stars will appear to move from east to west.
4. **Why would someone need to know the celestial coordinate system (right ascension and declination)?**
   Possible Answers: Astronomers use the RA/Dec of celestial objects (stars, galaxies, etc.) to identify them, both when they are first discovered and when astronomers reobserve them to gather more information. Sailors can also use this information in nautical navigation, when they are finding their way at sea and they need more detailed information than which direction is north.

Further Reading and Additional Resources

- The Nebraska Astronomy Applet Project provides online laboratories targeting the undergraduate introductory astronomy audience. Each lab consists of background materials and one or more simulators that students use as they work through a student guide. Pretests and posttests can be used to gauge student learning. For more information, visit http://astro.unl.edu/naap/.
- For more information on Right Ascension and Declination, visit http://www.education.com/study-help/article/astronomy-help-right-ascention-declination/.
- For a history of the Underground Railroad provided by NASA, visit http://quest.arc.nasa.gov/ltc/special/mlk/gourd1.html.
- For more historic sites on the Underground Railroad, visit http://www.pbs.org/black-culture/shows/list/underground-railroad/locations/.

Extensions

- Angular Measurements: Big Dipper Activity (see supplemental materials)

Common Core Standards

For more information on Common Core Standards, visit http://www.corestandards.org/.

Reading: Literature	
CCSS.ELA-LITERACY.RL.9-10.4	Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
CCSS.ELA-LITERACY.RL.11-12.4	Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including words with multiple meanings or language that is particularly fresh, engaging, or beautiful. (Include Shakespeare as well as other authors.)
Language	
CCSS.ELA-LITERACY.L.9-10.5	Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.
CCSS.ELA-LITERACY.L.11-12.5	Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.
History/Social Studies	
CCSS.ELA-LITERACY.RH.9-10.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.

CCSS.ELA-LITERACY.RH.9-10.4	Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history/social science.
CCSS.ELA-LITERACY.RH.9-10.7	Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.
CCSS.ELA-LITERACY.RH.11-12.2	Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.
CCSS.ELA-LITERACY.RH.11-12.4	Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines *faction* in *Federalist* No. 10).
CCSS.ELA-LITERACY.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.
Science & Technical Subjects	
CCSS.ELA-LITERACY.RST.9-10.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
CCSS.ELA-LITERACY.RST.9-10.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
CCSS.ELA-LITERACY.RST.9-10.7	Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
CCSS.ELA-LITERACY.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
CCSS.ELA-LITERACY.RST.11-12.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
CCSS.ELA-LITERACY.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Next Generation Science Standards

For more information on the Next Generation Science Standards, visit http://www.nextgenscience.org/.

Dimension One: Practices	1. Asking questions (for science) and defining problems (for engineering) 4. Analyzing and interpreting data 5. Using mathematics and computational thinking

	6. Constructing explanations (for science) and designing solutions (for engineering) 8. Obtaining, evaluating, and communicating information
Dimension Two: Crosscutting Concepts	1. Patterns. 4. Systems and system models. 7. Stability and change.
Dimension Three: Disciplinary Core Ideas	Core Idea ESS1.B: Earth and the Solar System