Lesson 21: Missions Outside Our Solar System: Kepler

Summary
This learning module is meant for adaptation into any course wishing to introduce students to planets outside Earth's solar system. Students will learn about the 'habitable zone' and apply techniques used to find planets outside our solar system.

Learning Goals

Students will be able to:

- Identify and explain the "habitable zone"
- Explain and apply the planet transit technique of detecting planets outside our solar system in the Kepler Mission.
- Utilize software programs such as Planet Hunters and the Kepler Exoplanet Transit Hunt sponsored/created by NASA missions.

Context for Use
This learning module can be used in any course of instruction where instructors would like to introduce students to planets outside our solar system and the concept of the habitability zone.

Description and Teaching Materials
In-Class Activity

In-Class Activity 1: Seeing like Kepler

Homework/Lab

Homework 1: Light Grapher
Homework 2: Planet Hunters!

Teaching Notes and Tips

1. Purchase or order an orrery device in order to use *In-Class Activity 1* Seeing Like Kepler in your course
2. All Homework sets can be adapted for the classroom if desired.
3. Before students are assigned *Homework 1* "Light Grapher" provide a demonstration of how the software works and explain to students that they will need a webcam in order to do the homework
4. Create a planethunters.org account so you can demonstrate how the website interacts with the user in the *Homework 2* "Planet Hunters".

Assessment
Methods of assessment are within each individual *In-Class Activity* and *Homework*.

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References and Resources

1. Kepler Exoplanet Transit Hunt computer interaction: http://kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery/#
2. Orrery suggestions for building: http://kepler.nasa.gov/education/ModelsandSimulations/LegoOrrery/
3. Planet Hunters: http://www.planethunters.org

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In-Class Activity 1
Missions Outside our Solar System_MFE
Seeing like Kepler

Purpose: Understand how Kepler locates planets outside our solar system.

Preparation:
1. Purchase or make an orrery (model planet system)
2. Have Internet access in the classroom

Resources:
1. Orrery suggestions for building: http://kepler.nasa.gov/education/ModelsandSimulations/LegoOrrery/
2. Kepler Mission: http://kepler.nasa.gov
3. Kepler Exoplanet Transit Hunt: http://kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery/

Engage
Show students a model planet system (orrery) and ask students how they might be able to detect the planet orbiting its sun if it is thousands of light years away.

Explore
Ask students what problems might they encounter in trying to detect a planet orbiting a star.

- The star is far brighter than the planet and a scientist can't see it because planets are not as bright
- The planet is too small for detection

Have students interact with the online Kepler Exoplanet Transit Hunt simulation: http://kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery/?CFID=9187896&CFTOKEN=28729865

Students will:
1. Choose and record the star system they are observing.

2. Manually record and make calculations throughout the simulation. Record calculations below:

3. At the end of the simulation, what kind of planet did the students find? The programs offers an "artist's rendition" of the planet surface….what does it look like?

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4. Determine if their star system has a planet in the habitable zone. Explain the reasoning for why the planet is or is not in the habitable zone.

Explain

Transit method of detecting planets (http://www.nasa.gov/mission_pages/kepler/multimedia/images/kepler-transit-graph.html):

When a planet crosses in front of its star as viewed by an observer, the event is called a transit. Transits by terrestrial planets produce a small change in a star's brightness of about 1/10,000 (100 parts per million, ppm), lasting for 2 to 16 hours. This change must be absolutely periodic if it is caused by a planet. In addition, all transits produced by the same planet must be of the same change in brightness and last the same amount of time, thus providing a highly repeatable signal and robust detection method. Credit: NASA

Elaborate

Have students brainstorm

1. A detection method for determining an exoplanet
2. Criterion for the "habitable" zone (size of star, proximity of orbiting planet, size of planet etc.)

Evaluate

1. From students experience in the Kepler simulation what is the *habitable zone* and how does it relate to Earth? What criterion makes a zone "habitable"?

2. Ask students to explain the "transit method" of detecting planets.

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Homework 1
Detecting Planets_MFE
Light Grapher

Directions

1. Go to: http://kepler.nasa.gov/education/ModelsandSimulations/lightgrapher/

2. Read over the webpage for context.

3. Briefly describe the principle(s) being used in order to locate planets.

4. Read through the directions and hints.

5. Run the program at least 3 different times. For each iteration, change the parameters by trying different methods of interaction with the camera, objects, sizes of objects, spacing of objects from camera, light source, etc. Report each iteration as follows as in the example below.

   Ex:
   Iteration #1
   Parameters Used:
   Outcomes (describe the graph and cut/paste the captured images)**:**

6. From their different iterations, what did the students learn about the objects? Did the size, color, transparency, or opacity matter?

7. Consider the planet Mars (typically red-tones) and a planet like Neptune (lighter blue colors). If students were to pass it in front of the webcam which planet would yield a greater change in light? Have students explain your reasoning.

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Homework 2
Missions Outside our Solar System_MFE
Planet Hunters

Join Planet Hunters

1. Navigate to: http://www.planethunters.org. Register, and begin planet hunting by following the online tutorial.
2. What method is *PlanetHunters* using to detect planets?

3. What role do the students play? Will people use their findings? Why or why not?

Classifying the star

4. What types of stars might they encounter? How do the students discern the differences with the data provided? Draw examples of each star and the data they provide.

5. Draw below what a planet transit looks like below. From the students' observations, have most of the stars had a planet transiting? What does this tell them? Would it be possible for a star to have a planet but have an apparent transit?

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