Interactive Tutorial Activities in ASTR 310: Exploring the Solar System

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To assess the impact on student learning of interactive tutorial activities in ASTR 310, we conducted a pre-test in January and incorporated an isomorphic post-test into the Final Exam in April. We compare the student scores on the Final Exam questions to the pre-test questions for each of the students who wrote both tests.

Tutorial 1: Human Orrery Students build and explore a working, scale model of the Solar System.

Learning goals compare terrestrial and solar scales • state Kepler's Laws of Planetary Motion and use them to derive missing orbital elements

Pretest (HO1) Mars' orbit around the Sun is 1.5 times bigger than Earth's orbit. Approximately how many times further from Earth is Mars when the two planets are on exactly opposite sides of the Sun, compared to when they line up on the same side of the Sun?

A) 0.2 B) 1 C) 1.5 D) 2.5 E) 5

Posttest (HO1) Spacecraft on Mars communicate with scientists on Earth with radio waves. What is the least amount of time it takes for a radio wave to travel from Mars to Earth? What is the most amount of time? (Recall Mars orbits the Sun at a distance of 1.5 AU and radio waves take 8 minutes to travel 1 AU.)

A) 4, 12 minutes B) 4, 20 minutes C) 8, 12 minutes D) 8, 40 minutes E) 16, 24 minutes

Tutorial 2: Lunar Phases Holding up styrofoam balls in a dark room with one bright, central light, students explore phases of the Moon.

Learning goals use the geometry of the Earth, Moon and Sun to illustrate the phases of the Moon and predict rise/set times • illustrate the geometry of the Earth, Moon and Sun during lunar and solar eclipses; explain why there are not eclipses every month

Pretest (LP1) Today is Wednesday, January 14, 2009. The Moon is waning gibbous, 3 days past being Full. If you go outside right now, at about 12 noon, and the sky is clear, can you see the Moon?

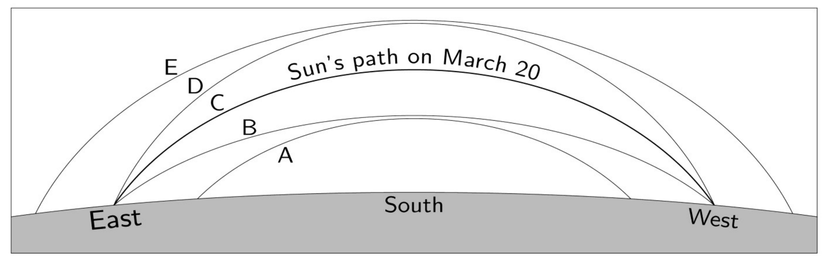
A) yes, the Moon is up
B) no, the Moon is below the horizon
C) you can never see the Moon during the day

Posttest (LP1) Today is Tuesday, April 14, 2009. The Moon is waning gibbous. If you go outside after the exam at about 6:00 PM and if the sky is clear, can you see the Moon? A simple yes or no gets you no marks – draw an appropriate diagram and explain your answer.

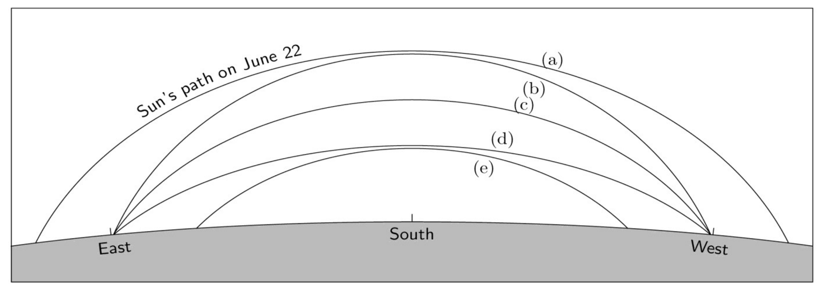
Tutorial 3: Celestial Sphere Using a model of the celestial sphere, students track seasonal changes of the Sun's path across the sky and the times of sunrise and sunset.

Learning goals describe the daily rotation of the celestial sphere • trace the Sun's motion on the celestial sphere throughout the year • predict how latitude affects the apparent motion of the Sun across the sky at different times of the year

Pretest (CS1) Here is the Sun's path across the sky on March 20 as seen by someone looking South from Vancouver. Which is the Sun's path on June 21?



Posttest (CS1) Here is the Sun's path across the sky on Summer Solstice (June 22) as seen by observers in Vancouver. Which path does the Sun follow on the Vernal (Spring) Equinox?



Pretest (CS2) When does the Sun rise at the North Pole?

A) midnight B) 6:00 a.m. C) noon
D) Spring equinox E) Summer solstice

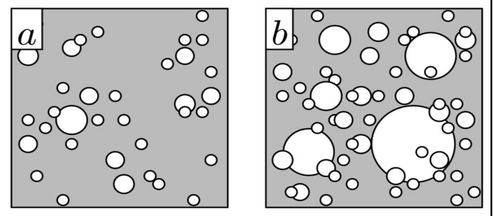
Posttest (CS2) Which of the following best describes the pattern of sunrises and sunsets at the North Pole?

(a) the Sun rises every day at 6AM and sets at 6 PM
(b) the Sun rises on Spring Equinox, stays up all summer, sets on Fall equinox, stays down all winter
(c) during the summer, the Sun rises each day at noon; during the winter, the Sun rises each day at midnight
(d) the Sun rises on Summer Solstice and sets on Winter Solstice
(e) In winter, the Sun is up for 24 hours each day; in summer, the Sun is down for 24 hours each day

Tutorial 4: Craters Students drop ball bearings into a bucket of sand to discover the relationship between the size of the ball bearing (meteorite) and the crater that forms and how surfaces evolve.

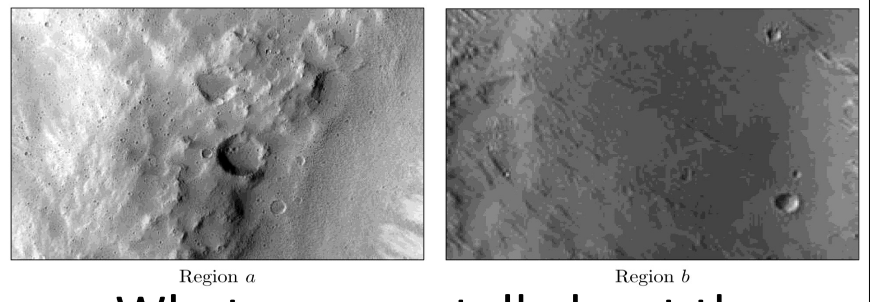
Learning goals deduce the formation and evolution of planets, moons and asteroids from the presence (or absence) of craters

Pretest (CR2) The pictures show two cratered regions, *a* and *b*, of the same size on the Moon. What can you tell about the two regions?



A) *a* is younger than *b* because *a* has had recent floods and/or volcanic eruptions
B) *a* is younger than *b:* its planet formed more recently
C) *a* and *b* are the same age, the age of the Moon
D) *a* is older than *b* because *a* has had many floods and/or volcanic eruptions
E) *b* receives more impacts than *a* so there is no way to tell from these pictures which region is older

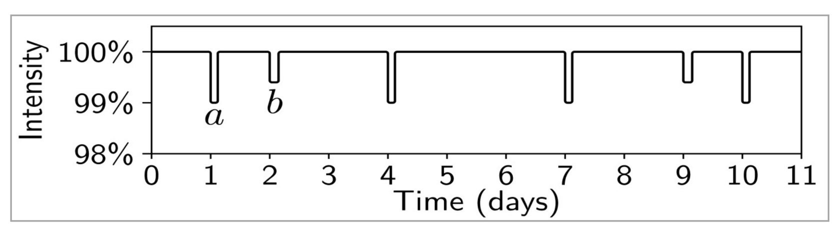
Posttest (CR2) The images show two different regions of the same size on the surface of Mars. What can you tell about the ages of the surfaces in these regions?



Tutorial 5: Extrasolar Planets With a photometer, students explore how the brightness of a bulb dips when it is blocked by a styrofoam ball; then explore an actual extrasolar planet observed by UBC's *MOST* telescope.

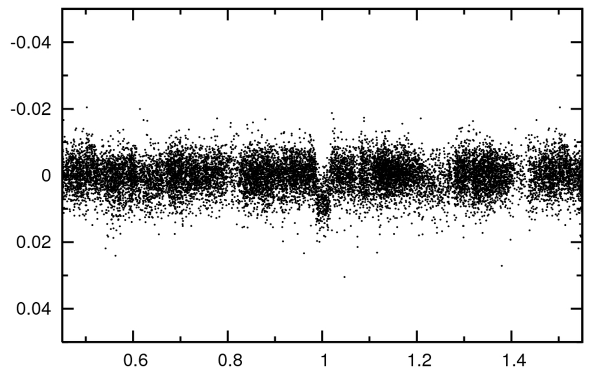
Learning goals illustrate how extrasolar planets are detected and extract properties of the planets and stars from observations • compare extrasolar systems to our own

Pretest (EX1) The curve shows the changing amount of light observed from a nearby star with 2 planets, a and b, which periodically pass between us and the star and temporarily block some of the star light from reaching us. What can you tell about the 2 planets?

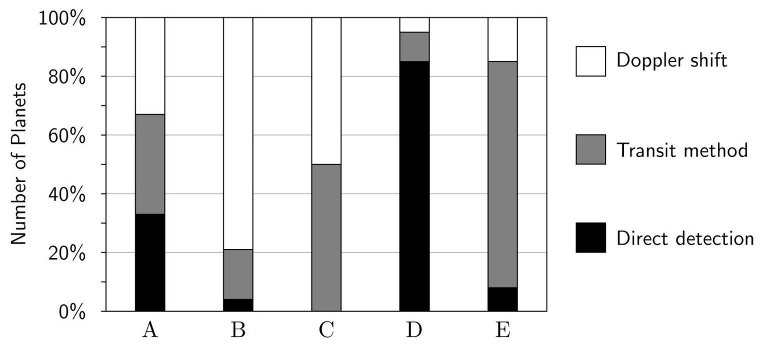


A) *b* has a larger diameter, takes longer than *a* to orbit
B) *b* has a smaller diameter, takes the same amount of time as *a* to orbit
C *b* has a larger diameter, takes less time that *a* to orbit
D *b* has a smaller diameter, takes longer than *a* to orbit
E *b* has the same diameter as *a*, takes less time to orbit

Posttest (EX1) This plot shows the brightness (y-axis) versus time (x-axis). Provide a plausible explanation for the dip in the stellar brightness at time 1.



Pretest (EX2) Nearly 350 planets orbiting other stars have been discovered, using one of three detection methods: Doppler shift of the star, analysing periodic changes in the brightness of the star (transit method) and direction detection of the planet. What portion of the discoveries were made by each method?

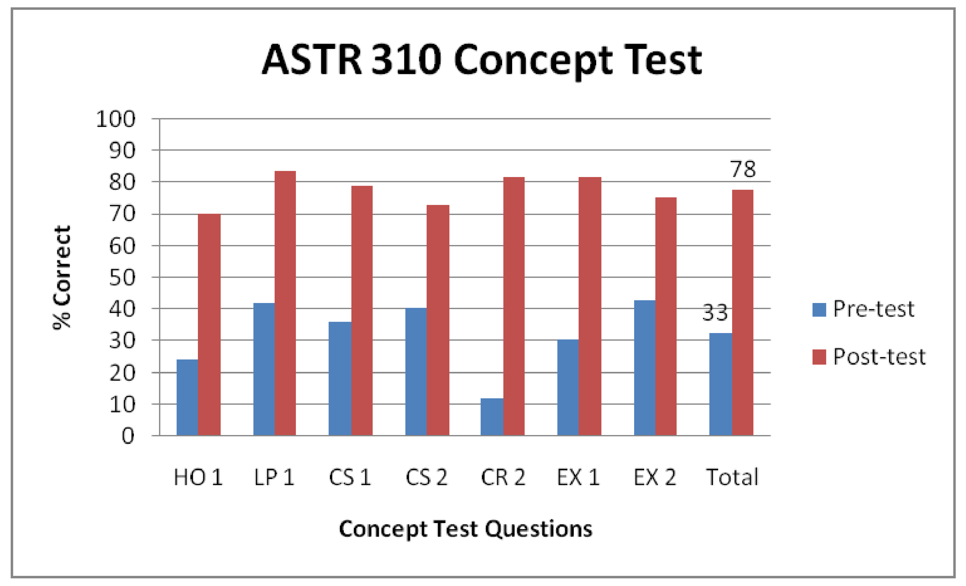


Posttest (EX2) Nearly 350 planets orbiting other stars have been discovered using one of three methods: measuring Doppler shifts of the star, observing dips in the lightcurve of the star or seeing the extrasolar planet directly. Which of the following best describes the number of discoveries made by each method?

(a) about equal numbers using each method
(b) mostly the transit method, and very few by the Doppler shift of seeing the planet directly
(c) almost all extrasolar planets have been seen directly
(d) mostly the Doppler shift, some by the transit method and very few seen directly
(e) about equal by the Doppler shift and transit methods, but none have been seen directly

Results

	matched pairs	mean score	standard error
pretest	186	32.57%	1.32
posttest		77.89%	1.45
gain		0.67	



Concept Test Answers:
HO1 Pre: E Post: B
LP1 Pre: no Post: no, the Moon doesn't rise until 9 p.m.
CS1 Pre: E Post: c
CS2 Pre: D Post: b
CR2 Pre: A Post: b is younger because it has fewer craters
EX1 Pre: D Post: star has a transiting planet
EX2 Pre: B Post: d