Astronomy Learning in Digital Virtual Environments Preliminary Study

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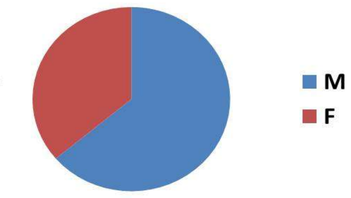
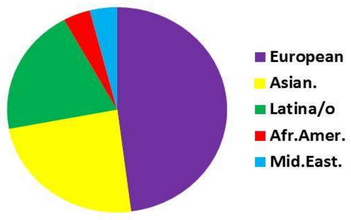
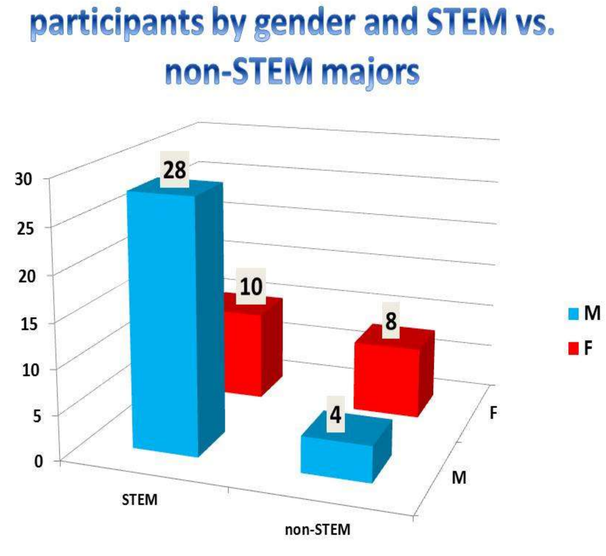
Our objective is to develop and test the didactic effectiveness of an interactive virtual solar system using digital immersive virtual environment technology (IVE) for undergraduate introductory astronomy ("Astro 1"). We conducted a pilot study with 50 UCSB students during the spring quarter, 2014, using the desktop Planck Mission in Virtual Reality simulation. The specific learning objective was understanding of the phases of the Moon and the necessary conditions for a solar eclipse., Students were initially instructed to 'fly' outside, inside, and above the Earth's orbit while observing Earth-Moon-Sun interactions from these perspectives. Students were subsequently instructed to 'fly through' the Earth and track the Moon as it orbited the Earth, noting Moon light changes as the Earth-Moon-Sun angle changes. Finally, students were instructed to focus on the Sun as the Moon passed and to stop the simulation when they thought they had 'created' a solar eclipse.

- **50 students over the course of 3 weeks**
- **32 male, 18 female**



- **24 European**
- **12 Asian**
- **10 Latino/a**
- **2 Middle Eastern**
- **2 African American**

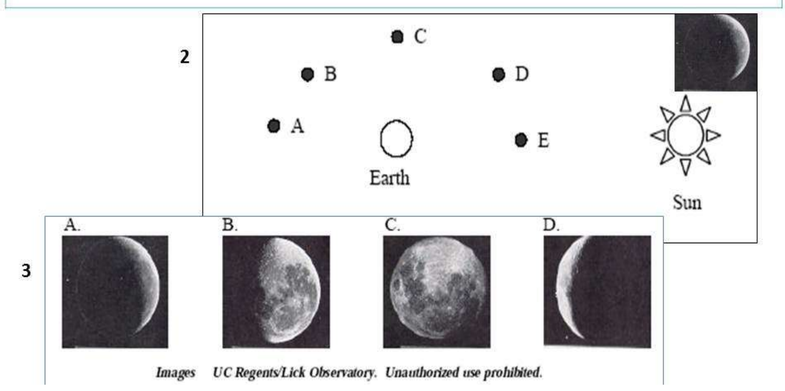




Participants were undergraduate volunteers who were solicited from STEM and non-STEM departments at UCSB. Only 3 had taken any previous astronomy.

Participants were given a pre- and post-test with questions from the National Astronomy Diagnostic Test (www.compadre.org/astronomy/items/detail.cfm?ID=1432):

1: What phase must the Moon be in for a total solar eclipse? (new)
2: Where is the Moon, relative to the Sun and the Earth, when it looks like this: (D)
3: If the Moon is full when it rises, what will it look like after 6 hours? (C)



After learning to navigate in the virtual solar system, participants were guided through the following exploration:

1) Observing the Moon from outside the Earth's orbit, looking towards the Sun – Moon is in shadow;

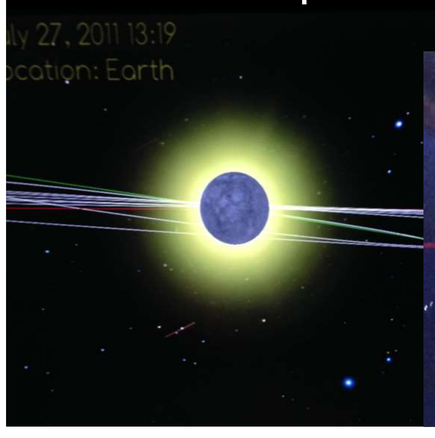
2) Observing the Moon from inside the Earth's orbit, looking away from the Sun – Moon is lit;

3)Tracking the Moon from inside the Moon's orbit, observing the way the light changes on the Moon as the Earth-Moon-Sun angle changes – Phases of the Moon;

4) Observing the rotation of the Moon – once/orbit;

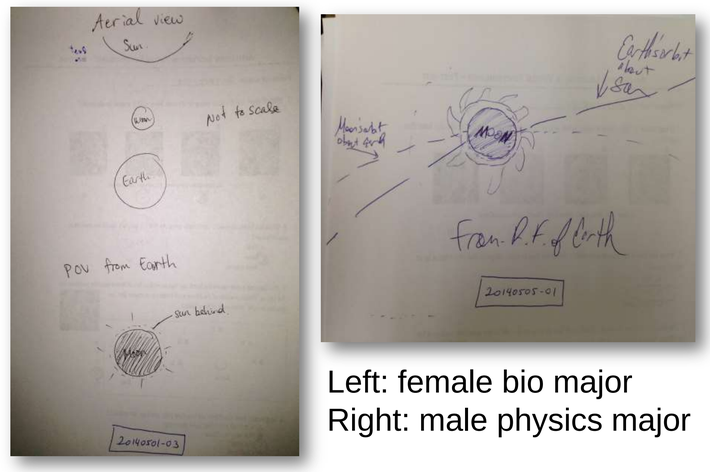
5) Finally: Finding the conditions for a solar eclipse (Moon must be in NEW phase and the Moon, Sun, and Earth must align when/where the orbits of the Moon and Earth intersect.

Stopping time to observe a total solar eclipse.



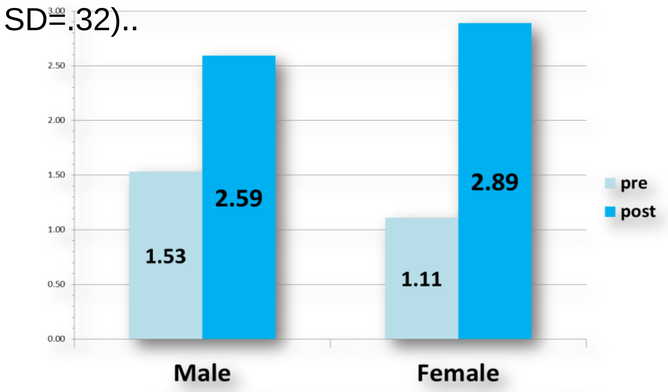
Observing the Earth and Moon from above the plane of the Earth's orbit.

After completing the post-test, students were asked to draw the alignment of the Earth, Moon, and Sun during a solar eclipse, from any perspective. All drew the correct alignment of the Earth, Moon, and Sun, with the correct phase of the Moon (new), although some students had difficulty drawing the intersecting orbits.



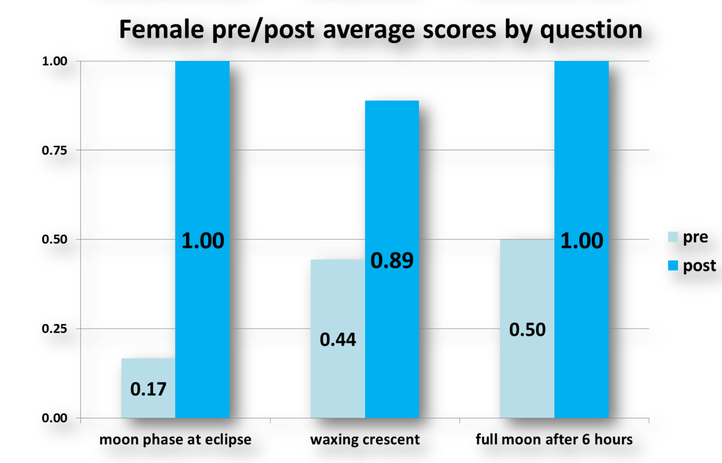
Left: female bio major
Right: male physics major

All participants showed substantial pre-post test gains. However, males and females had significantly different scores on the post-test ($t(47.87)=2.22$, $p=.03$), with males scoring lower (M=2.59, SD=.61) than females (M=2.89, SD=.32)..



Male pre/post average scores by question

Female pre/post average scores by question



Our results suggest that having students conduct guided explorations in a virtual solar system promotes their comprehension of spatial thinking in astronomy. Further, our results suggest that navigating in a virtual solar system may have the potential to close the gender gap in astronomy learning for females.