Appendix A

Comic Book Lab Investigation: What's at the Center?

Introduction.
When reading the Optics Adventures Comic Book we met Galileo, and in his story, one thing we learned from the "Tools of Astronomy" song was that people did not always know or believe that the Earth was not the center of the universe. See the song here: https://www.youtube.com/watch?v=olk5fjbygX8 And the full comic book here: https://joom.ag/9jyp

Because of Galileo's studies with the telescope he discovered that the planet Jupiter had four moons that were orbiting it. This went against everything that people knew! Why would moons be orbiting Jupiter instead of the Earth if the Earth was the center of the universe? What did this mean for everything else in the universe? Are there other things that do not orbit the Earth specifically?

If we believed that the Earth was the center of the universe how would that have impacted our studies in science, history, and other fields? Would we have gone to the moon? Or would we be sending probes to other planets? If we were, would we even be able to get to those places thinking that the Earth was the center of everything?

The Task.
Investigate the phases of the moon. How do they work? What is their pattern? What causes them? And can the phases of the moon help us understand what the center of the universe is? Let's take a look at another planet! You will need to acquire images of the planet Venus at different times of the year taken with telescopes from planet Earth. Finally, you will take a look at Jupiter itself during different times of the year for comparison.

The guiding question of this investigation is: ***How can the phases of the moon as well as pictures of Venus and Jupiter help us understand if the Earth is or is not at the center of the universe?***

Materials.
You may use any of the following materials during your investigation:

Consumables	**Materials & Resources Cont'd**
• Galileoscopes (for students to take home and use with their own observations of the moon) • Differently sized Styrofoam globes • Rods • Pencils and Papers • Glue **Materials & Resources** • Images of Moon Phases with Dates	• Library access • Internet access • Light Source • Dark room for conducting experiments

• Images of Venus with Dates • Images of Jupiter with Dates	

Safety Precautions.
Students should be aware of their surroundings if planning to make lunar observations at night and should always have parental supervision.

Investigation Proposal Required: X Yes ☐ No

Getting Started.
Before you can design and carry out your investigation, you must determine what type of data you will need to collect, how you will collect it, and how will you analyze it.

To determine ***what type of data you need to collect*** think about the following questions:

- Will you observe the moon yourself? Or will you gather data from records of the moon?
- Where will you gather images of Venus and Jupiter? (Remember you will need images from all different times of the year.)
- Will you build a model of the sun-earth-moon relationship to experiment with how the phases of the moon are created?
- Will you build a model of any other planetary relationships to test them?

To determine ***how you will collect your data***, think about the following questions:

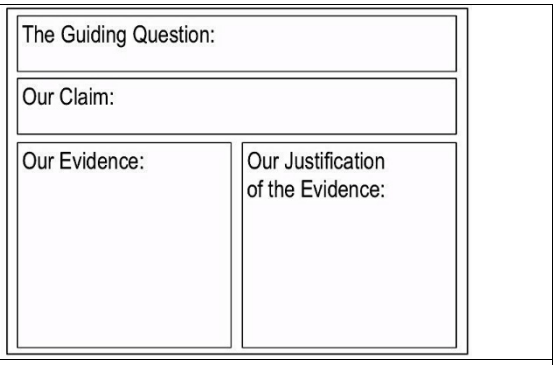
- Will you use a model? Research? Or direct observations to investigate lunar phases? Or will you use a combination of methods?
- Since we cannot see Venus or Jupiter's moons very easily with the Galileoscope available to us how will you investigate their images at different times of the year?
- Will you keep a notebook with your findings or use digital technology to track your information?

In order to determine ***how you will analyze your data*** think about the following questions:

- Will you keep a lunar log of the phases of the moon to track your observations?
- Will you use investigations into the images of Venus and Jupiter and record the differences?
- Would you like to analyze your data visually or with numbers?

Connections to Crosscutting Concepts and the Nature of Science and Scientific Inquiry.
As you work through your investigation, be sure to think about:

- MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- (MS-ESS1-1) Patterns can be used to identify cause-and-effect relationships
- (MS-ES1-3) (MS-ESS1-4) Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small
- (MS-ESS1-2) Models can be used to represent systems and their interactions
- (MS-ESS1-1) (MS-ESS1-2) Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation



Argument Presentation on a Whiteboard

Initial Argument.
Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a claim, evidence to support your claim, and a justification of the evidence. The claim is your groups' answer the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why you group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. You group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in figure at right.

Argumentation Session.
The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the other arguments. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes in your classmates' arguments so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this in order to develop new ideas.

In order to critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Some good questions to ask might be:

- What did your group do to collect the data? Why do you think that way is the best way to do it?
- Is there other data that your group would like to have? If so, what is it?
- What did your group do to analyze the data? Why did your group decide to analyze it that way?
- What did your group do to make sure that these observations are correct?
- Why did your group decide to collect your data in that way?
- How sure are you that your group's claim is accurate? What could you do to be more certain?
- What investigations did you do into past research and discoveries? What did you find? What did it mean for your findings?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the best argument possible.

Report.
Once you have completed your research, you will need to prepare an ***investigation report*** that consists of three sections. Each section should provide an answer for the following questions:

1. What question were you trying to answer and why?
2. What did you do during your investigation and why did you conduct your investigation in this way?
3. What is your argument?

Your report should answer these questions in 2 pages or less. This report must be typed and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable or valid!