worldmoonproject.org

Teacher Handbook
September - December 2017

The **World MOON Project** is an activity of the I.V. STEM Classroom coalition of faculty at several universities worldwide.

The Summer 2007 issue of The Hoosier Science Teacher contains lots more information about the World MOON Project. If you don't already have a copy, just email walter.smith@ttu.edu with your snail mail address; and we will send a complimentary copy to any World MOON Project teacher.

Table of Contents

Overview

August 2017

Dear World MOON Project Teacher:

Thank you very much for agreeing to be a part of the World MOON Project this semester. We hope it will be a superb experience for you and your students.

Whenever you have feedback or questions, please contact us at
staff.worldmoonproject.educ@ttu.edu

What Can Your Students Learn from the World MOON Project:

The World MOON Project provides a scaffold for learning many things. You have complete control over what you choose to emphasize. While your pupils will be studying the Moon, learning about the Moon will not be the most important outcome in the minds of many teachers. Some teachers will emphasize their students' involvement in inquiry. Here's what one west Texas teacher said just after her students downloaded and studied the lunar observations made by children in other parts of the world:

"Omigosh! This morning's activity was so cool!

The matrix that you provided and the activity where students compare their data was incredible! My kids were so excited and learned a lot about so many things that are important in science . . . looking at real data, the importance of reporting accurately, different perspectives, comparing data and looking for patterns, figuring out which data might be wrong, and of course, how the Moon looks around the world. Just wanted to say thanks."

Cathy Box, 7th Grade Science Teacher, Tahoka, Texas

Alternatively or additionally, you might wish to emphasize the global aspect of the World MOON Project. Many teachers have their students go to the globe to see where the other students are located. More than one teacher has told us, "I just want my students to know that there are other places in the world besides our community."

Still others will emphasize writing. One of our strong World MOON Project teachers has a language arts background and she had never herself studied the Moon. One of her World MOON Project objectives is to provide her students an opportunity to practice authentic writing.

World MOON Project science teachers teach in an assortment of countries and states or provinces within those countries with a variety of state standards regarding lunar phases, so they need to tweak their instruction to reflect their own standards.

The World MOON Project is flexible. As long as your students make their daily observations and write and post their three essays on the Internet, we are happy. From that point on, build on the World MOON Project to fit your own purposes in your own classroom.

<u>First Things to Do</u>:

1. Please read the schedule overview and planning calendar to have an idea about the major steps of the project. Further details and explanation are provided in the handbooks.

2. Please read through this Teacher Handbook and the Student Handbook. If you have questions, please ask us.

3. If you are having your students take the CMPA-R (Comprehensive Moon Phases Assessment – Revised) as a pretest, have them take it before they start any of their study of the Moon. You should receive your log-in information via email.

4. Have your students start observing the Moon on September 11th or as soon thereafter as possible. Follow directions below for how the students should collect and record data about the Moon.

   Monday, September 18 is the latest date your students may start their observations. While we would like for all students to start their observations on September 11th, we know there are many reasons for why their observations will start later.

5. "Things to do" are listed in a weekly planning calendar starting on page 7.

Schedule Overview:

The Moon's phases, of course, follow their own schedule over which we have no control. School calendars are also beyond our control. Given those realities, the World MOON Project schedule will be as shown in this table:

Week	Date	Activity
Prior to 9/11	Prior to September 11	Start Observations/Pre-Assessment
1	September 11	Start Observations
2	**September 18**	**Key Observation Weeks** Target Dates a. 9/21 – 9/23 b. 9/25 – 9/27 c. 9/28 – 9/30
3	**September 25**	
4	October 2	Internet Chunk 1
5	October 9	Internet Chunk 1
6	October 16	Internet Chunk 1
7	October 23	Internet Chunk 2
8	October 30	Internet Chunk 2
9	November 6	Internet Chunk 2
10	November 13	Internet Chunk 3
11	November 20	Internet Chunk 3
12	November 27	Post Assessment

Your students' observations should start as soon after September 11th as possible (and after they've taken the CMPA-R pretest, if they take that test).

They must make moon observations the weeks of September 18 & September 25.

- By the end of September your students should have a pretty good idea of how the Moon behaves in their area, so we refer to the first few weeks of the World MOON Project as the "local phase." In October, your students will start posting essays on the Internet to be read by children around the world, so the latter weeks of the World MOON Project are collectively called the "global phase" during which students will study the Moon from a worldwide perspective.

- Your students will post their <u>first essay</u> (called "Internet Chunk 1" on the preceding table) during the weeks of <u>October 2 and October 9</u> (due by October 16).

- Your students will receive their first composite essay the week of October 23, and then they will post their second essay during the weeks of October 23 and October 30 (due by November 6).

- Your students will receive their second composite essay the week of November 13, and they will post their third essay during the weeks of November 13 and November 20 (due by November 27).

- If the students are taking the CMPA-R, please complete this no later than November 30.

Fall 2017 Planning Calendar

Prior to September 4th:

1. Read through the Teachers Handbook and plan for the World MOON Project.
2. Decide whether to have your students use the Student Handbook or a science notebook.
3. Schedule time in your school's Computer Lab, if advanced planning is necessary.
4. If you have chosen to have your students take the Comprehensive Moon Phases Assessment-Revised (CMPA-R), have your students go on line to take the CMPA-R before any instruction about the Moon.
5. If your students will take the CMPA-R, tell us so we can add your name to the list of teachers.

(1a) Week of September 11th or As Soon Thereafter As Possible:

1. After giving the CMPA-R, if you give it, instruct students about how to make and record Moon observations.
2. Have your students begin to observe the Moon each day and record their observations in their Student Handbook or science notebook.
3. Once your students have started to make lunar observations, ask your class each day to report their Moon observation from the previous day so the students come to consensus about what they saw, where they saw it, and when then saw it. They should record this "consensus" observation in their Student Handbook or science notebook and you may have your students record their consensus observation on a wall chart like that shown on page 14 in the Student Handook.
4. This discussion may take 15 minutes the first day, but soon the class should settle into a routine so this discussion should take five minutes and may even be bell work while you take attendance, etc.

(1b) Week of September 11:

1. Students should continue daily observations and recording of observations.
2. Suggest they look both at dusk and earlier (say, around 4 PM). (We want students to see that the Moon can sometimes be seen during daylight.)
3. Continue the daily development of a class consensus about observations the preceding day.
4. At least once this week, add in a discussion focusing on patterns in the Moon's behavior. For example, is the Moon the same shape (phase) on September 8th and 11th? How has it changed? Compare where the Moon was located at the same time (e.g., 7 PM) on two days a week apart –

say, September 8th and 15th. (When comparing the Moon's location at, say, 7 PM, it will be further east on September 15th than it was a week earlier on September 8th.)

<u>(2) Week of September 18</u>:

1. **This is an especially important week. Everyone needs to be observing the Moon this week.**
2. Continue the daily development of a class consensus about observations the preceding day.
3. Make very certain students have recorded the Moon shape and location and their time of making their observation for three times:
    a. **between September 21 – 23 with *September 22* being the target date,**
    b. **between September 25 – 27 with *September 26* being the target date, and**
    c. **between September 28 – 30 with *September 29* being the target date.**
4. Continue having students predict where and when they'll see the Moon and what shape it will be.

<u>(3) Week of September 25:</u>

1. **This is an especially important week. Everyone needs to be observing the Moon this week.**
2. Continue the daily development of a class consensus about observations the preceding day.
3. Make very certain students have recorded the Moon shape and location and their time of making their observation for three times:
    a. **between September 21 – 23 with *September 22* being the target date,**
    b. **between September 25 – 27 with *September 26* being the target date, and**
    c. **between September 28 – 30 with *September 29* being the target date.**
4. Continue having students predict where and when they'll see the Moon and what shape it will be.

<u>(4) Week of October 2:</u>

1. **This is a very important week. Everyone should be writing and posting their first (observation) essay to the Internet this week.** See directions starting on page 14 in Student Handbook.
2. Then they should submit their <u>observation essay</u> in the World MOON Project software.
3. Perhaps you will have your students continue their observations.
4. At the end of this week, students may stop their observations; but that is your choice. If they continue two more weeks, then they can compare their observations for two entire lunar cycles. It will be very valuable for them to discover these patterns.

<u>(5) Week of October 9:</u>

1. If your students didn't submit their observation essay already, then they need to do that this week, for this is the last chance to submit the observation essay.
2. Perhaps you will have your students continue their observations.
3. In class discussions emphasize students finding patterns in the data. (For example, from day to day does the Moon have the same shape? Is there a predictable pattern in this shape change?)

(6) Week of October 16:

1. Starting October 16, we will package the observation essays we've received into groups of approximately ten essays with each essay, to the extent possible, being from a different location in the world.
2. We will email you to let you know when the essays are ready to be downloaded.
3. We will also send you – and only to you – a set of ten essays with complete and accurate information. We refer to these essays as "correct essays" as opposed to the essays your students will receive that are "authentic" in that they really were written by other students, but past experience tells us the "authentic" will have errors of omission and commission. That is, the essay authors will forget to include some key data and/or they will make errors in what they write. The "correct" essays, to the extent possible, will stick to the words actually written by students but edited to make the essays complete and correct.
4. You have a decision to make. Do you want your students to work from "authentic" essays (with all their errors but from real students – after all, scientists have to figure out problems in their data, since problems almost always exit) or from "correct" essays (with no errors but also not entirely from real students); or do you want them to work with both "correct" and "authentic" essays. There is no right answer to this question; it's your decision based on your instructional goals.
5. As soon as you can after we let you know the essays are ready, your students should download their ten essays written by themselves and nine other students from other locations.
6. Whereas you heretofore have had students look for patterns in the Moon's appearance from their local perspective, you now should have students use the data they find in essays from other students in their group to identify global lunar patterns. (For example, on any given day in what way is the Moon's shape the same and how is it different for all observers around the world?)
7. The World MOON Project student handbook has directions and a matrix for the students to organize the data they obtain from these essays.
8. Once they've identified patterns, students should compose an essay about the global patterns they found. See directions starting on page 16 in the Student Handbook.
9. Then they should submit their global patterns essay in the World MOON Project software.

(7) Week of October 23:

1. If your students didn't submit their global pattern essay already, then they need to do that this week.

(8) Week of October 30:

1. If your students didn't submit their global pattern essay already, then they need to do that this week.

(9) Week of November 6:

1. Starting November 6, we will package the global pattern essays we've received into groups of approximately ten essays with each essay, to the extent possible, being from a different location in the world.
2. We will email you to let you know when the essays are ready to be downloaded.
3. As soon as you can after we let you know the essays are ready, your students should download their ten essays written by themselves and nine other students from other locations.
4. You should help them identify important global patterns and then try to explain those patterns. (For example, they might find several students writing that on any given day the Moon is the same shape for all observers but the orientation of the Moon is different in the United States and Brazil. Then they need to figure out why this occurs.)
5. Once they've developed explanations for the cause of one or more of the global patterns that can be found, your students should compose their essay about the explanations they developed. See directions starting on page 18.
6. Then they should submit their causal explanation essay in the World MOON Project software.

(10) Week of November 13:

1. As soon as you can after we let you know the essays are ready, your students should download their ten essays written by themselves and nine other students from other locations.
2. We suggest you hold a class discussion to work through the causal explanations the students find in those essays. Which explanations seem to fit the data? Which explanations are correct but don't go very far? For example, students may list all of the locations where the orientation of the illuminated portion of the Moon is the same; but instead of making a list, they could more succinctly say, "All of the observers in the Northern Hemisphere saw the waxing moon illuminated on the right or lower right, whereas the Southern Hemisphere observers at the same time saw the waxing Moon illuminated on the left or lower left side."
3. Once they've developed explanations for the cause of one or more of the global patterns that can be found, your students should compose their essay about the explanations they developed. See directions starting on page 18.
4. Then they should submit their causal explanation essay in the World MOON Project software.

11) Week of November 20:

1. If your students have not submitted their causal explanation essay in the World MOON Project software already, then they will need to this week.

(12) Week of November 27:

1. **If your students took the CMPA-R as a pre-test, have them take the CMPA-R as a post-test now that the World MOON Project instruction is complete.**

<u>Enrolling Your Students and the Pretest</u>:

You can enter your students into the World MOON Project in one of two ways:

1. You may send us a spreadsheet of student information. (See directions below.)

2. You may have your students take the CMPA-R (Comprehensive Moon Phases Assessment – Revised) as a pretest prior to engaging in any instruction about the Moon. When your students take the test, they will automatically be enrolled in the World MOON Project and you do not have to do anything more for them.

   The CMPA-R is an on-line multiple choice test that examines a student's understanding of lunar phases (for example, the order in which they occur, the cause of lunar phases, differences in the Moon's appearance at different times and locations, and so forth). It takes about 45 minutes to complete the test.

When you tell us whether you'll take option 1 or 2, we'll send you specific directions about how to proceed.

We are aiming for you to have yourself and all of your students enrolled by September 11th.

<u>Starting the Moon Observations</u>:

Suggest to your students that they look for the Moon at about sundown in the western sky. Depending on when they look, they'll see it in the southwestern to western sky in the Northern Hemisphere or the northwestern to western sky in the Southern Hemisphere. For the following 10 days or so, suggest they look for the Moon at dusk or early evening. Ideally they should look for the Moon at the same time. Unless they take a trip of more than 5000 miles (8000 km), the location from which they observe the Moon can be anywhere.

<u>What Should the Students Observe and Record</u>:

Each day your students should observe <u>and</u> record the **Big Five** about the Moon:

1. <u>Date and time</u> of their observation of the Moon.

2. The Moon's <u>shape</u>. You may wish to use the word phase or shape.

3. The <u>orientation</u> of the illuminated, visible portion of the Moon. For example, if its shape is that of a crescent, is that crescent straight up and down on the right or on the lower right or on the underneath side of the Moon or on the lower left or on the left or what?

4. The <u>compass direction</u> of the Moon. You may choose to have your students use words like Southeast or West or Northwest and so forth. Or you may wish to have you students record the

Moon's location in terms of number of degrees from North. Astronomers refer to this location as the Moon's azimuth.

5. The <u>angle</u> of the Moon above the horizon. You may choose to have your students use words like "close to the horizon" or "about halfway up" or "high in the sky." Or you may wish to have your students more precisely measure the Moon's location in terms of number of degrees above the horizon. Astronomers refer to this angle as the Moon's altitude.

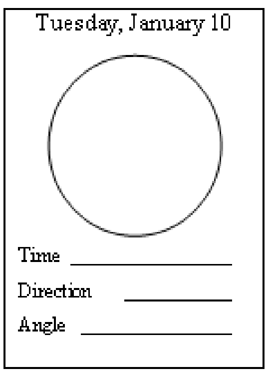
<u>Using the World MOON Project Student Handbook</u>:

The World MOON Project Student Handbook has two purposes:

1. It has <u>directions</u> for students to follow, and

2. It is a place where students can <u>record</u> the **Big Five**.

If you want your students to use the Student Handbook for both purposes, give each of your students a copy of the handbook.



Each day the student should **darken** in a part of the circle to represent the *shape* of the Moon observed that day and the *orientation* of that illuminated portion. The *date* is already printed and they should note the *time* of their observation. On the "Direction" line, they should note the Moon's *compass direction* and on the "Angle" line they should note the Moon's *angle* above the horizon. You need to decide how you want them to note the direction of the Moon (e.g., Southwest or 225º from North) and its angle above the horizon. Younger students may write "halfway" to mean halfway between the horizon and straight up. Other students may say that the Moon is at a 45º angle above the horizon. If they do not see the Moon on a particular day, they should write "too cloudy" or similar words across the Moon and note the time of observation.

There is a row for five days of observations and then two days, the weekend, on the next line. Then there is a "question of the week." We have tried to logically sequence those questions; but you may want to substitute other questions. Also, you may want to encourage students to answer the same question more than one time.

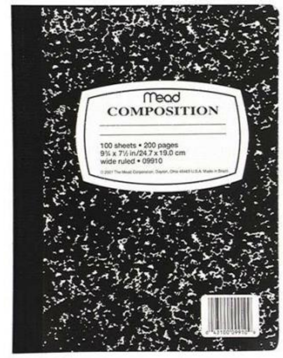
We are starting to have students from more countries. I've tried to make the questions apply to everyone; but I may have missed the mark. Please do not hesitate to ask better questions.

The Student Handbook also has directions. For example some pages ask students to record what they are thinking about the Moon. "Moon Thoughts" is a place for students to keep a diary about their lunar observations and related thoughts. We have placed these spaces at points where we believe they will logically mesh with what's happening in the World MOON Project; but you may find you need to change the timing of when students write their thoughts.

<u>Alternative Procedure for Recording Data</u>:

If you plan to use the World MOON Project Student Handbook that we provide, you may choose to skip this section and go to "Class Discussion."

In the World MOON Project, we are trying to get students used to observing nature and recording their observations. The Student Handbook aides that objective; but some teachers may wish to have their students use a bound "science notebook" composed of nothing but blank pages for recording all observations of nature, not just lunar observations. The advantages of students using a "science notebook" instead of the World MOON Project's Student Handbook are that the children get used to working just like a scientist all year long and they have more leeway in what they include in their science notebooks. For example, they can draw pictures of what they see, including trees and clouds and stars or planets and lunar craters and so forth. Some teachers like to have their students include a daily "dear diary" of their thoughts about the Moon. Some students may wish to compose poems; the more artistic may choose to include sketches. In short, the bound notebook of blank pages provides the students and teachers more degrees of freedom in how students keep track of their lunar data and undertake related activities.



Two cautions: Later on students will share their daily observations, via the Internet, with other children, so be sure your students are making and recording daily or nearly daily the **Big Five** noted above. Also, please read through the World MOON Project Student Handbook, as some of the directions for students are included in that handbook.

Class Discussion:

Classroom discussion of lunar observations is a very important part of the World MOON Project.

Classroom discussion of lunar observations is a very important part of the World MOON Project.

During this semester your students should learn from their observations and class discussions how the Moon changes location and shape (phase) in a regularly-repeating cyclical pattern from the point of view of your community. Then your students will share what they've learned about the Moon in your community and compare what they've found with the observations and findings of the other students from around the world.

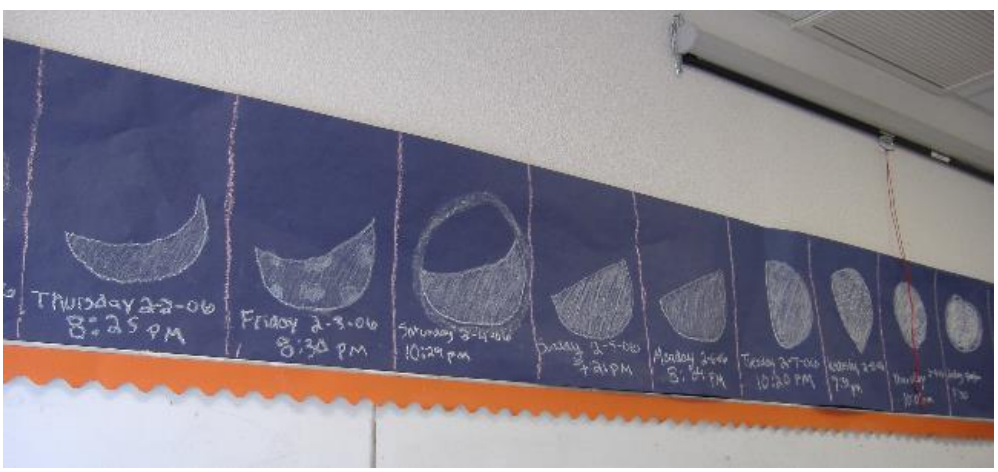
We envision your students starting each week with a lunar discussion. During your first discussion you can explain the process. One week later the students can share their observations for the preceding week and discuss the Question of the Week. Then you can continue from week to week in the same vein. As with "Moon Thoughts," you may find that you will need to adjust when your students consider certain "Questions of the Week."

Consider giving suggestions to your students about where to look and when to look for the Moon. You know your students better than we do, so you'll have to make the decision about how explicit your directions should be. Some teachers may say simply, "Look for the Moon and record your observations." Others may want to tell students when and where to look. (Students in the Northern Hemisphere in the latitudes of the United States and China should look in the southern sky; students in the Southern Hemisphere in the latitudes of Australia and Brazil should look in the northern sky; and students closer to the equator should look more overhead. In all cases they should scan the sky from east to west until they spot the Moon.)

<u>Classroom Consensus Observations</u>:

As part of your weekly discussions, please have your class reach a consensus about the Moon's shape (phase) and location (at a particular time) each day during the preceding week.

Perhaps you can dedicate a bulletin board to posting these consensus observations as was done by Cathy Box's seventh graders in a small town in western Texas. (Cathy Box has written a wonderful description of how the World MOON Project worked in her classroom in the Summer 2007 issue of <u>The Hoosier Science Teacher</u>, a complimentary copy of which is available to all World MOON Project teachers by emailing Walter Smith at walter.smith@ttu.edu.)



Each day Cathy Box had her students draw their consensus observations on the classroom room wall for all to see.
Used with permission from <u>The Hoosier Science Teacher</u>, 2007. <u>32</u>(4), p. 110.

There's space in the <u>Student Handbook</u> for students to record these consensus observations. Later during the World MOON Project's Internet phase, your students should refer to these consensus observations as well as to their own observations.

<u>Class Discussion – Part Two</u>:

Classroom discussions about the Moon's appearance between the key observation dates **September 21 – September 30** are particularly important, as the Moon will be waxing at that time; and when the Moon is waxing is a particularly good time for children to construct their ideas about this regularly repeating pattern of the Moon changing shape and reasons for why the Moon behaves as it does.[1]

By **September 30th**, we hope your students will have a good understanding of lunar phases from the viewpoint of their hometown and will be ready for the global phase when they will look for similarities and differences in the Moon's appearance around the world.

<u>Class Discussion – Part Three</u>:

This pattern of daily observations and weekly discussions should continue as long as you are asking your students to observe the Moon.

As you lead these weekly discussions, please emphasize **reporting of observations** by your students. Then, based on these observations, have your students figure out **patterns** in their observations. Finally, students should come up with **explanations of causes** for their observations; but these explanations come <u>after</u> the students have spent a great deal of time with observations and patterns.

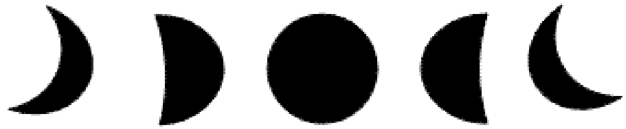
<u>Observations</u> First → Then Find <u>Patterns</u>→ Finally, <u>Causal Explanations</u> of Patterns

Instead of telling your students what the Moon is doing or "should be doing," encourage your students to figure out what patterns they find in the data. After – I emphasize <u>after</u> – they've figured out some patterns, you might introduce formal vocabulary words such as "waxing" or "gibbous" and ensure that they've come up with the kinds of conclusions that are listed later in this handbook in "Appendix A: Moon Observations: What Can You See? . . . . What Patterns Can You Find?"

Some students will already know many lunar vocabulary words such as crescent or waxing or gibbous. If those words are already part of their vocabulary, it is fine for them to use these words. The point is that they should be using their own vocabulary, whatever that might be. Then once they have developed the idea themselves, you should introduce the new vocabulary.

To help your students find patterns for themselves, ask students individually to look over their (approximately) six weeks of observations and pick out a distinctive shape and orientation that seems to be repeated more than once. Using the blank table found on page 19 of the World MOON Project Student Handbook, have them draw that distinctive shape in the first box in the left column titled "Shape of the Moon." Under "Date 1" in the second column they should write the date they observed that distinctive shape; and then under "Date 2" in the third column they should write the next time they saw that exact same shape. Then in the right column, "Days Between," they should calculate the number of days between "Date 1" and "Date 2." They then should repeat the same process for four more distinctive shapes and orientations. You might have your students look for:

[1] Of course, the Moon doesn't really change shape. What changes is the portion of the Moon that we can see from Earth. For some students, this may be a new idea.



They then should fill in the next table on that page of the Student Handbook, but this time the shapes from the first table should be inserted in chronological order, according to the dates in the Date 1 column of Table One.

Based on the second table, conduct a discussion about patterns in the shape of the Moon. Students should be able to figure out that the Moon's shape and orientation change in a regular pattern; and they should be able to use that information to predict the Moon's shape and orientation in the future.

Your students will calculate "days between" as being anywhere from about 25 to 31 days. With that amount of variability, some students will conclude – erroneously – that there is no regular pattern in the Moon's appearance.

Help your students realize that there is regularity, even though their calculations may include some variability. This variability is sometimes called "error."

To help your students understand why they didn't come up with the same figure for each repetition, have your students look very carefully at the dates they put down for each shape (phase). For example, for one month they may have written down the date for when they saw a "skinny" crescent; but for the next month the crescent might have been a little "fatter" or even "skinnier." Calculating the date of the full moon is particularly tricky. As can be seen in Appendix D, the Moon's shape (phase) stays close to a full moon shape for almost a week, so there can be a lot of variability in what date your students enter into the table for when the Moon was "full."

<u>Percent Error</u>:

If your students are comfortable with percentages, have them calculate "percent error." (If not, you can skip to the next section.)

Point out that, after all, the numbers for "days between" didn't swing wildly from, say, 7 to 52 to 28 to 81, etc., etc. All of the figures for "days between" cluster around 28-29 plus or minus a couple or three days.

In science we try to reduce variability as much as possible and we are careful to study what variability tells us about what is going on, but we are willing to accept some variability due to inevitable errors in every observation we make.

To calculate "percent error," have your students first compute a class average for the numbers of "days between;" and they should come up with a number close to 28-29. If we assume that the pattern repeats itself about every 28 days – the average number of "days between," then how much "percent error" is there in each calculation? For example, if a student calculates that there are 26 days between the repetition of a particular shape (phase), their calculation is 2 days off of the assumed actual repetition period.[2] This value of 2 is 7% of 28. In other words, the "percent error" of this particular calculation is 7%, so their calculated value of 26 is within 7% of the assumed actual value of 28. If they calculate between 25 and 31 days for the period of each repetition, their error is plus-or-minus 3 days, or, in other words, within a "percent error" of plus-or-minus 11%.

On the other hand, if they found that particular shapes repeated each 7, 52, 28 or 81 days, their error would have varied from zero to 190%. That's a lot more variability! By comparison, the zero to 11% "percent error" they got when they came up with periods of 25 to 31 days is minor compared to what the "percent error" would have been if the repetitions varied wildly.

This information will be very helpful to students when they engage in the Internet discussions with students from around the world.

Lunar Ideas:

Take a look at Appendix A titled "Moon Observations: What can you see? What patterns can you find?" But I lovingly call it a "cheat sheet," a list of ideas that **your students should discover themselves** about the Moon as a result of these activities. Please don't give the cheat sheet to your students. You can use the "cheat sheet" to remind yourself what ideas you can draw out of your students. Some of these ideas will come solely from local observations. Other ideas can emerge only after your students have compared their findings with the observations reported by other students on the Internet.

WITH YOUR GUIDANCE,
YOUR STUDENTS SHOULD DISCOVER FOR THEMSELVES THESE IDEAS ABOUT THE MOON.

Writing and Global Connections:

The World MOON Project uses the Internet as a vehicle for students to (1) share their best writing (2) with other students from around the world.

If you so choose, the World MOON Project provides an avenue for your students to hone their writing skills while also learning science. At the same time, by writing about the Moon, your students' thinking about the Moon will be sharpened. Some people have captured these ideas in the phrase: "Writing to Learn; Learning to Write."

All Internet groups will contain students from as many different locations as possible. We are expecting students from Australia, Brazil, China, Korea and various states in the United States. Each set of essays won't include essays from students from all of these locations; but within your classroom many, if not all, of these locations should be represented in one or another group.

[2] Period is the length of time between the same event repeating itself. In this case, the length of time between, say, two full moons.

Posting Essays to the Internet:

Starting the week of October 20th, the Internet phase will be organized into three "chunks" when your students will write and share their written essays via the Internet.

As soon as possible after the start of each chunk, we ask that you have your students write for 10-15 minutes (or longer; that's your choice) to produce an essay of at least 100 words – more is preferable – in response to a question provided below. For example, students may be asked to "describe how the Moon's appearance changed during the last two weeks." If your students are capable of writing longer essays and you desire for them to do so, please have them write longer essays.

If you are emphasizing writing, you might want to "workshop" the essays to polish them into final shape; but like a lot of other things in the World MOON Project, it's your choice about how much emphasis you want to place on writing.

These essays will be posted by each of your students to a spot on the Internet.[3] Directions for posting essays will be sent separately to you.

At the end of each three week "chunk," the essays will be divided into groups of ten and posted for all students in the group to read.

You and your students should discuss the contents of the essays they receive; and in some cases the Student Handbook can assist your students to interpret the essays contents.

This process of each student writing her or his essay, posting it to the web, receiving the essays from other members in their group, reading other students' essays, and thinking about what they learn from the essays will be repeated in each of the three three-week chunks.

You have a fair amount of leeway in how much you immerse your students in the Global Internet phase. At a minimum, we ask that your students write three brief essays and read what other students have written. Beyond that you can choose to conduct a brief or longer classroom discussion about what your students are learning about the Moon from a global perspective.

Since the Global Internet phase is organized in three-week chunks, we hope the schedule will be more accommodating to school holidays and other obligations. Thus, if your schedule doesn't allow your students to write their essays at the start of a particular three-week chunk, you have the leeway to have your students write as soon as your schedule allows.

<u>Questions for Your Students to Answer in Their Essays</u>:

Here are the directions to give to your students for their essays.

1. Essay 1: Emphasis on Observation of the Waxing Moon.

   Here's what to give to your students as directions for their first essay:

   Describe the Moon's appearance on three different days as close to sunset as possible.

   a. **between September 21 – 23 with *September 22* being the target date,**
   b. **between September 25 – 27 with *September 26* being the target date, and**
   c. **between September 28 – 30 with *September 29* being the target date.**

[3] All teachers will have access to all essays, so you will be able to monitor, if you choose, all the writing available to your students. You are not required to do this monitoring; but if you have any concerns about what you see written, please email walter.smith@ttu.edu to handle. Of course, you may deal directly with your own students face to face as you monitor their writing.

For each day, the students' essays should include the **Big Five**, that is:

1. The date and time of each observation,
2. The Moon's shape each date and time,
3. The orientation of that shape,
4. The compass direction of the Moon, and
5. The angle of the Moon above the horizon.

Emphasize that the essays should be precise and inclusive.

Remind students that other students are depending on them to provide enough information that the other student could visualize was your student saw when observing the Moon.

If, for example, a student writes that the Moon was a crescent shape, they should indicate whether it was a skinny or fat crescent and on which side of the Moon the crescent was visible. They shouldn't simply write that the illuminated portion of the Moon is a crescent on the left side of the Moon. Rather, they should write that the Moon was straight up and down on the left side or it was on the lower left side or whatever was observed. When describing location, students should write about the Moon's compass direction, such as East or South or Northwest, and how far it was above the horizon. Students should be as precise as possible so students in other parts of the world will know how, when and where the Moon appeared on each of these three days.

Once the essay is written, have students look at the checklist on page 16 of the Student Handbook. **For all three dates, every student should include the <u>Big Five</u>. Nothing should be omitted and the data should be as accurate and precise as possible.**

<u>Directions to Teachers</u>: We realize that many students will desire to draw pictures of what they've observed. We hope we are giving them practice in writing descriptive essays; and we believe that by having them express their ideas in words, they will be sharpening their own thinking about their observations.

As a practical matter, increasingly more states are requiring students to write this way on state high stakes tests, so students will be practicing skills they are expected to develop.

Prior to their writing, we suggest you have a classroom discussion in which you have the class describe what they have seen on each target date (or as close as possible to the target date). Have the class brainstorm words they might use to describe the Moon.

Once your students write they essays, you may choose to have them share their essays with a classmate, a "critical reader," who will give them feedback, <u>both</u> positive feedback and suggestions for improvement. You may choose to have your students revise their writing prior to posting it on the Internet. It's not "cheating" to have your students polish their writing prior to posting; we encourage them to write as well as they can and you have time and resources to help them improve their writing.

For security reasons we do not ask students to write about their own location. However, when we group and send out the essays, I will send to you a list of the approximate location – latitude and longitude – of each class involved in the World MOON Project. Then when your students read essays from other students, they'll know the approximate locations of those other students.

> I'll send you a list of locations that will look something like this:
>
> Michigan, USA. 42° N; 83° W
>
> Queensland, Australia. 27.5° S; 153° E

2. Essay 2: Emphasis on Global Lunar Patterns.

   We will email you to let you know the first essays we received are now grouped and ready for your students to access them. These essays, which we call "authentic," are the exact essays submitted by the students. Some of these essays will be better than others; but we've found over the years that almost all essays will contain errors. Either students will omit some of the "Big Five" bits of data for one or more dates and/or some of the data they do include is incorrect.

   This situation causes a dilemma. On one hand, this data with all of its warts and blemishes is real in the sense that this data is what the various students claim to have observed. Also, this data comes from students spread around the world and thus provides a certain amount of connectedness between students in different parts of the world.

   However, on the other hand, students need to use this data to figure out global patterns in the Moon's appearance. If the essays they read contain errors – and they almost inevitably will contain errors, then your students will have difficulty figuring out correct global patterns.

   We could say, "Well, that's what really happens in science, so my students will find out that they have to be very cautious about the use of data they receive." That's a good lesson; but it leaves us in the predicament of how our students will learn correct ideas about the Moon's appearance.

   Because of this dilemma, at the same time students can access essays about the lunar observations of other students, we will send to you a set of "correct" essays for which the data is both complete and accurate.

   Then you have a choice. You can have your students use only "authentic" essays. Or you can have your students use only the "correct" essays. Or you can have your students use both sets of essays. The choice is yours to make based on what you wish to accomplish from this global collaboration.

   Once you have decided which essays your students should use, here's what to give to your students as directions for their second essay:

Using what other students wrote about the Moon's appearance on three different days in late September and early October, describe any similarities and differences you found in how the Moon appears to students around the world. (We use the word patterns to refer to these similarities and differences that you find.)

You should think about these characteristics as seen by students around the world:

1. The shape of the Moon as seen on or about the same day by students around the world.
2. The orientation of the Moon on or about the same day by these students. Here are some questions to think about.
   a. Did they say that the right or lower right side of the Moon was illuminated?
   b. Did they say that the left or lower left side of the Moon was illuminated?
3. The compass direction of the Moon on or about the same day. Here are some questions to think about.
   a. Did all of the students see the Moon more or less in the northern sky or the southern sky?
   b. In the evening, did all of the students see the Moon more or less toward the west or the south or the north or the east?

For each pattern that you find, state your evidence and rationale for that pattern. For example, if you say that "the part of the Moon that people all around the world see seems to be growing larger between October 3th and 7th," then follow that statement with the evidence you have to support that claim.

Remember that you should be writing about worldwide patterns, so compare observations in your country with observations being made in other countries.

Directions to Teachers: Again, prior to the students' writing, conduct a class discussion of similarities and differences your students found in the Moon's appearance worldwide. Resist the temptation to tell your students what patterns there are to be found in the data; let them figure that out on their own. Prior to your whole class discussion, you might have pairs of students examine their worldwide data to find patterns they can share with the class.

To help in their process of finding patterns in the data, we strongly urge you to give a matrix, like the one found on the next page, to your students. (Or use the matrix in the Student Handbook starting on page 16.) Ask your students to read the composite essay found in their student Internet group and use that information to fill in the matrix cells. If a student doesn't have much data in their composite essays, it is OK for students to share and use each other's composite essays. Once the matrix is filled in, students can look down columns and across rows to find patterns in the Moon's shape (called phase), orientation and location over time.

Have your students look on a map or globe for each of these locations. Make sure they notice that some students are located in the Northern Hemisphere and some are located in the Southern Hemisphere. This could be a jumping off point for a geography lesson about topics such as climate, history of the region, types of plants and animals found there, and so forth.

Resist giving new vocabulary words such as phase or waxing or gibbous until after the students have come up with the idea themselves. For example, once the class has agreed that the Moon is growing larger you can introduce the term “waxing.” Let your school’s curriculum and/or state or national standards be your guide for what words you introduce and the kinds of ideas you want your students to figure out. Of course, if words such as gibbous are already part of the students’ vocabulary, then allow them to use them, but be sure all students have that word as part of their working vocabulary. That is, if asked, they could give a definition for the word and/or use it appropriately in a sentence.

Throughout the discussion, emphasize that the students need to both find patterns in the data and state a rationale (explanation) for why they believe that pattern exists.

Location	Week 1	Week 2	Week 3
Michigan, USA 42 degrees N 83 degrees W	*In each cell, include date and time of observation, Moon’s shape (phase), orientation and location (direction and angle above the horizon).*		
Tennessee, USA 35 degrees N 85 degrees W	*Group the rows by country.*		
California, USA 34 degrees N 118 degrees W	*Arrange the rows in sequence with the most northerly latitude at the top.*		
Bequia, St. Vincent and the Grenadines 13 degrees N 60 degrees W			
Queensland, Australia 27.5 degrees S 153 degrees E			
Each of your students will receive approximately 10 essays – nine others plus their own. Each of your students will receive a different set of essays.			

3. Essay 3: Emphasis on Explaining Causes of Global Lunar Patterns.

Here’s what to give to your students as directions for their third essay:

Pick out one global pattern that students from around the world wrote about and try to explain what caused that pattern to occur.

For example, if you say that one pattern you found is that the "Moon's shape (phase) changes around the world in the same order from day to day," then explain what causes the Moon to behave in that way. Include in your explanation the evidence you used to come to your conclusion about the cause.

Directions to Teachers:

After students have read the essays about patterns from other students in their group, a class discussion prior to the students' writing would be in order. One way to approach this discussion would be to have your students individually identify one or more patterns they find in the essays they received. Then they could compare notes with a partner; and then there could be a class discussion in which they agree on some important patterns.

Various patterns will be found, but please be sure to highlight patterns that lead to your students' understanding of three big ideas.

1. The Moon's appearance changes in a regular pattern that repeats itself approximately each four weeks as seen from vantage points all over the world.

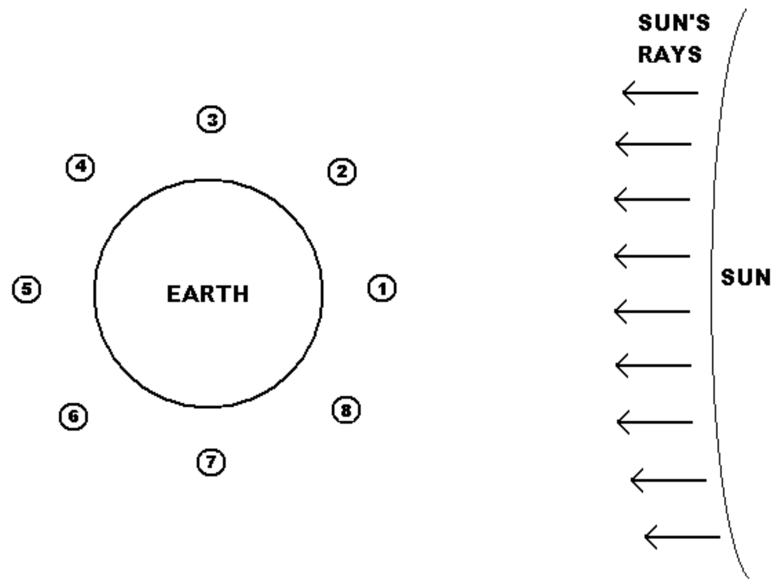
   Even if they don't know what causes the changes, they should notice that the Moon changes shape in a regular pattern. (Of course, the Moon doesn't really change shape. What changes is the shape of the portion of the Moon that we can see. We could say that the Moon's appearance changes.)

   And they should be able to apply this knowledge by predicting, for example, that no matter where you are in the world, if the Moon is thus and such a shape today in the western sky at dusk, then in seven days the Moon will be thus and such a shape and found at dusk further east in sky.

2. This cyclical change in the Moon's phase (shape) is caused by changes in the relative position of the Moon, Earth and Sun.

   Probably a lesson on causes of lunar phases would be in order – to include a strong light source to stand in for the Sun and a number of spheres (i.e., balls) to stand in for the Earth and Moon.

When the lesson is over they also should be able to predict, for example, which Earth-Moon–Sun geometry, 1-8, in this drawing would produce a full Moon. Or a waxing crescent or whatever. In this drawing we are looking down on the Earth from a position in space above the North Pole.



And they should be able to explain, in terms of the relative position of the Moon, Earth and Sun, why their prediction is correct.

Please note that this drawing is extremely out of proportion. For example the diameter of the Moon is about 1/4th the diameter of Earth, so the eight moons in the drawing are much too small. Also, for example, the Sun is about 400 further from Earth and the Moon, so in this drawing the Sun is located much too close to Earth.

What is correct about the drawing is that the Moon really does revolve around Earth in a counterclockwise direction as seen from a point in space above the North Pole. Thus, once each lunar cycle there is a time when the Earth, Moon and Sun line up as is shown with the Moon in position one. At that time the illuminated half of the Moon is pointing directly away from Earth, so we see nothing of the Moon and in our culture we call that a "new moon."

As the Moon revolves from position 1 to 2, we slowly but surely see a wee bit of the illuminated half of the Moon. When the Moon is in position 2 there will be a waxing crescent moon with less than half of the part of the Moon facing Earth illuminated. If the Moon in position 2 were close to 1, we'd see a skinny crescent. A few days later when 2 is closer to 3, we'd see a fat crescent.

When the Moon arrives in position 3, we see a first quarter moon (or what some people call a waxing half moon). That is, we exactly half of the illuminated half of the Moon. This is a good place to point out that the half of the Moon facing the Sun is always illuminated. The shape we see depends on the amount of that illuminated portion is pointing toward Earth and thus is visible to us. When the Moon is in position 3 we see half of the half of the Moon that is illuminated.

When the Moon is in position 4, we see a waxing gibbous moon. That is, we see more than half but not all of the illuminated half of the Moon. Finally, in position 5 we see a full moon. Again the Earth, Moon and Sun are lined up. Since when we look at the Moon, the Sun is behind us, at this point we can see all of the illuminated half of the Moon and we call that a full moon. The Moon is “full” in the sense that we can never see any more than half of the Moon.

This is a good point to mention eclipses, starting with lunar eclipses. I just said that in position 5 the Moon, Earth and Sun are lined up; but usually they don’t precisely line up. Like any other opaque object, sunlight cannot penetrate through Earth, so Earth casts a shadow away from the light source, which is the Sun. On those occasions – about once or twice a year – when the Moon, Earth and Sun precisely align, the Moon moves through the Earth’s shadow and the sunlight that would have struck the Moon is blocked by Earth and we don’t see all of the potentially illuminated part of the Moon. We call this a lunar eclipse. Sometimes the entire Moon is in the Earth’s shadow and we call that a total lunar eclipse; but other times only part of the Moon is in the Earth shadow and we call that a partial lunar eclipse.

A second kind of eclipse is called a solar eclipse. In this case the Moon is in position 1. The Moon is opaque so like the Earth, it casts a shadow. Usually when the Moon is in position 1 it’s shadow is just above or below Earth and we have the usual new moon; but sometimes the Moon’s shadow strikes Earth and blocks some of the sunlight from getting to Earth. We call that a solar eclipse. Sometimes the Moon entirely blocks the sunlight from striking Earth and we call that situation a total solar eclipse. Other times the Moon only partially blocks the sunlight from striking Earth and we call that situation a partial solar eclipse.

As the Moon moves from position 5 to 6, we start to see less of the illuminated half of the Moon; and when the Moon is in position 6, we called it a waning gibbous moon. If position 6 is very close to 5, the moon is a waning gibbous but it is very hard to distinguish between that shape and a full moon. As a result, as the Moon moves from 4 (close to 5) to 5 to 6 (but still close to 5), the Moon appears to be full for a few days. The Moon isn’t full for all of those days; but with our naked eye it’s hard to see that it isn’t full.

In position 7 we say we have a third quarter moon (or what some people call a waning half moon). As with position 3, we see half of the illuminated half of the Moon. What’s different between 3 and 7 is that the opposite sides of the Moon are seen in the two positions. I’ll return to this “opposite side” phenomenon in a couple paragraphs.

When the Moon is in position 8, we see what we call a waning crescent moon. And then the Moon will get back to position 1 and we again have what we call a new moon.

When we use the adjective waxing in conjunction with the Moon, we mean that from day to day we are seeing more and more of the Moon. On the other hand, when we are seeing less and less of the Moon from day to day, we say the Moon is waning.

A good time to look for the Moon in positions 2-5 when it is waxing is at dusk. A good time to look for the Moon in positions 5-8 when it is waning is in the morning. Note that when the Moon is in position 5, it can be seen both in the evening when it rises in the east and in the morning when it sets in the west.

3. The Moon's appearance in the northern and southern hemisphere is similar in some respects but different in others.

   Still referring to positions 1-8, students in the Northern and Southern hemisphere will see the same shape on any given day, but the orientation of that shape will differ in the two hemispheres. In the Northern Hemisphere the waxing moon is illuminated on the right side and the waning moon is illuminated on the left side. In contrast, in the Southern Hemisphere the waxing moon is illuminated on the left side and the waning moon is illuminated on the right side.

   Students should conclude that these differences in the Moon's orientation in the two hemispheres is due to differences in the point of view of the observer and not to any actual difference in the Moon's appearance.

   This left-right difference doesn't suddenly occur when one passes over the Equator. If a traveler started going south from Toronto on a day when the right side of the Moon was illuminated and quickly traveled to the Panama Canal (closer to the Equator), they'd see the illuminated portion of the Moon rotate from straight up and down on the right in Toronto to on the lower right when they got to the Panama Canal. Continuing the trip south to a spot on the Equator, the illuminated portion of the Moon would have moved to the bottom of the Moon. The shape of the part of the Moon we see wouldn't have changed, but the orientation of the illuminated part of the Moon would have moved from straight up and down on the right to the bottom of the Moon. As the trip south continued into the Southern Hemisphere, the Moon's orientation would have changed so when the traveler arrived in Rio de Janeiro, the illuminated part of the Moon would be on the lower left; and when the traveler arrived in Tierra del Fuego at the southern tip of the Southern Hemisphere, the Moon would be straight up and down on the left side. Again, throughout this very quick trip of a few minutes, the shape of the Moon would have remained constant, but the orientation of the illuminated portion of the Moon would have moved from right to left.

   Why is the Moon's shape the same on any one day for observers all over the world? Think about the Moon being about 240,000 miles (about 400,000 km) from Earth with two observers in, say, Wuhan, China and Capetown, South Africa (about 8000 miles; about 12,500 km apart), looking at it. The distance between Earth and Moon (240,000 miles) is about 30 times greater than the distance between the two observers. Thus, when these two observers look at the Moon, relative to the distance to the Moon, the two observers are practically standing next to each other; so they see the same shape.

As your students figure out explanations for the Moon's behavior, caution them that these **are tough ideas** to figure out; they'll really need to put on their thinking caps. Even some adults do not correctly understand how the world, including the Moon, works.

Also, this is a very good time to reinforce what you are teaching students about the nature of science. For example, you can point out that scientists understand that at any point in time their explanations are tentative. These explanations may be changed in small or big ways in the future; we just don't know whether that will happen. But explanations are not simply guesses. They are based on evidence, such as the lunar observations made in this project, which have been collected over and over again.

<u>Preparing to Write about the Moon</u>:

Prior to having your class write their essays, we hope you'll have your students do some pre-writing exercises. For example, you can have your students, as a group, refer back to their lunar observations and agree about how the Moon appeared on particular days. Or you could have students brainstorm approaches to writing each essay. You might have students sketch an outline of what they plan to write and share their plans with a partner.

We hope that Student Handbook pages such as "Moon Thought" will help students compose their essays for each chunk.

If you want your students to compose on the computer, that's fine. However, we want the students' writing to be their best writing; so if their ability to compose on the computer is weak, then we ask that you have your students handwrite and polish their essays. Then they can type their essays on the computer.

<u>Logging into the World MOON Project Community</u>:

We will send these directions to you.

<u>Internet Security and Related Issues</u>:

We have taken every precaution we can imagine to protect your students. To wit:

1. Each World MOON Project teacher will have access to all essays. If you choose, you can read every essay sent this semester in the World MOON Project. Or you can read only those essays sent to and by your students. Or you can read none of the messages.

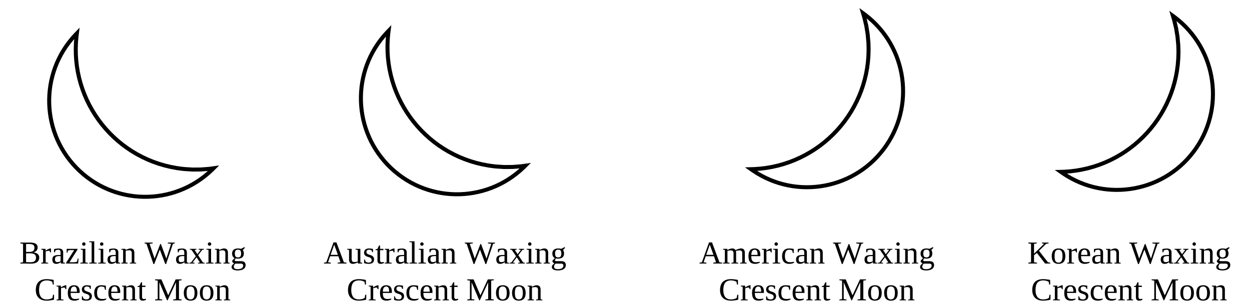
2. We are using students' first names, so they will have some identity; but we are using their state or province or nation as their last name so they will remain anonymous.

3. The World MOON Project software operates behind a strong firewall. I suppose every computer system can be hacked some way; but chances of hacking the World MOON Project software are remote.

4. Your students' personal email addresses are not used by the World MOON Project, so personal emails cannot be exchanged.

<u>Looking at the Moon in the Southern and Northern Hemisphere</u>:

The World MOON Project includes students from both southern and northern hemispheres, so your students will be able to compare what is observed by students in the two hemispheres. They'll find that since the northern hemisphere students generally are facing south as they observe the Moon and the southern hemisphere students are facing north, they are facing each other. Thus, what appears to be on the left for the northern hemisphere student will appear to the right for the southern hemisphere student. For example, as shown in this illustration, the waxing crescent Moon at dusk is generally seen on the right or lower right by the northern hemisphere student but generally on the left or lower left by the southern hemisphere student. (Students near the Equator will see the Moon closer to the lower side of the Moon.)



Waxing Crescent Moon Viewed by Brazilian and Australian Students in the Southern Hemisphere and American and Korean Students in the Northern Hemisphere

In other words, all four students are viewing the exact same Moon; but because of the difference in their frames of reference, the Moon appears differently to the four students. The Northern Hemisphere students will see the Moon in the same orientation; and the Southern Hemisphere students will see the Moon in the same orientation.

This idea is elaborated on in Appendix B, "Viewing the Moon in the Southern and Northern Hemisphere;" which includes a lesson plan that focuses on the importance of frame of reference.

<u>Other Goals – Social Studies and Culture</u>:

I hope the science and language arts (writing) aspects of the World MOON Project are obvious; but as you read the above questions/topics, I hope you've also noticed the World MOON Project's social studies opportunities. Perhaps your students can find other students' locations on a map or globe. Your students can learn how around the world we have differences; but at the same time we share commonalities among our cultures. For example, calendars and religious celebrations (e.g., Easter and

Ramadan) are set by the Moon in the Christian and Muslim faiths;[4] words like month and lunatic have a lunar origin; the Chinese calendar is set by the Moon; and the Moon is the second most-often found topic (next to love and romance) in music.

Teaching to Standards:

At the end of this handbook is a list of Indiana standards – called indicators in that state – which the World MOON Project was originally designed to address. Most World MOON Project teachers are located outside Indiana; but the Indiana standards (indicators) are roughly modeled after Project 2061's Benchmarks, which are one form of national guidelines in the U. S. Thus, the Indiana standards (indicators) are fairly representative of what teachers in other states and countries are asked to teach. We have built sufficient flexibility into the World MOON Project for you to focus on standards that particularly apply to you. Yes, the World MOON Project is about the Moon; but much more importantly it focuses on students observing, finding patterns, and coming up with explanations. We're focusing on a global inquiry.

THE WORLD MOON PROJECT IS ABOUT THE MOON; BUT MORE IMPORTANTLY IT'S ABOUT ENGAGING STUDENTS IN LONG TERM, INTERNATIONAL, COLLABORATIVE INQUIRY.

Community Conceptions of the Moon:

While your students observe the Moon, we also hope they will talk about the Moon with their parents and other adults.

Parental Assistance:

The World MOON Project provides an excellent opportunity to involve your students' entire families. Encourage your students' parents and other adults and family members to watch the Moon together. A sample letter to parents appears in Appendix G. Please feel free to use the letter as is or adapt it in any way you see fit.

We have found that if students and other family members observe the Moon for a semester, they develop habits that continue long into the future.

Astrolabe:

Appendix C contains directions for making an astrolabe from rather simple materials and information about the astrolabe's history. With an astrolabe, your students can be more precise in their estimation of

[4] Easter is celebrated on the first Sunday after the first full moon after the vernal equinox. Each month in the Muslim calendar starts with the new Moon. Since the Muslin calendar is based on the Moon and the Western (Gregorian) calendar is based on the Sun, the two are not synchronized. Each (western) year the Muslim months start slightly earlier. Thus, for example, the month of Ramadan started on October in 2005, in September in 2006 and 2007, and in July in 2012.

the Moon's angle above the horizon. It's your choice whether you have your students make and use the astrolabe (pronounced with a long a between l and b).

Feedback:

We have learned a great deal from the teachers who have been part of the World MOON Project in the past, and we hope we can learn from you. Please give us your feedback at any time at staff.worldmoonproject.educ@ttu.edu.

Finally, thanks, thanks, thanks. We couldn't do this without you.

Walter S. Smith
Director, World MOON Project
walter.smith@ttu.edu

P.S. If you are a member of the National Science Teachers Association, at nsta.org you can access articles about the World MOON Project that appeared in the May 2003 Science Scope and in the March 2006 issue of Science and Children; and there's more in the Summer 2007 issue of The Hoosier Science Teacher, a complimentary copy of which can be sent to each World MOON Project teacher by asking Walter Smith for it.

APPENDIX A

MOON OBSERVATIONS
WHAT CAN YOU SEE? . . . . WHAT PATTERNS CAN YOU FIND?

As you watch the Moon, these are some things you might observe. (Unless otherwise noted, directions are from the perspective of someone in the continental U. S. Some ideas (e.g., point 1) are true all around the Earth; but some ideas (e.g., point 5) need to be modified a little or a lot, depending on the location of the observer.

These ideas emphasize observation and patterns in observations. Interpretations of why the Moon does what it does are de-emphasized.

1. The Moon is not visible at all times, even when the sky is clear.

2. Sometimes the Moon can be seen during daylight hours; sometimes it can be seen when it's dark.

3. The Moon changes shape from day to day.

   When you look at the Moon for two days in a row, you may not be able to see this change; but when you compare the Moon's shape for, say, 3-5 days, you can see that its shape changes.

   The various Moon shapes are called phases. You can learn more about Moon phases at http://www.EnchantedLearning.com/subjects/astronomy/moon/Phases.shtml

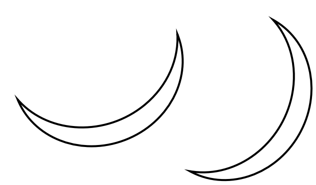
4. The Moon has many shapes often called "phases."

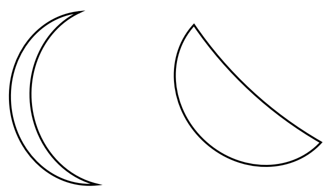
   The idea of "phases" is something invented by people to name a few of these basic shapes. For example, we refer to a "crescent Moon;" but sometimes the crescent is quite skinny and sometimes it's sort of fat and sometimes it's in between. The Moon has all of these shapes, but we tend to use one word, "crescent," to name this basic shape.

5. When the Moon is illuminated on the right side, as in these drawings, it is growing larger in size.

   When referring to a side of the Moon (e.g., "right side"), I'm referring to the side relative to the observer on Earth.

   If the drawings to the right are how the Moon appeared to you, you'd say it was illuminated on the right side.



6. 

   When the Moon is illuminated on the left side, as in the drawings to the left, it is growing smaller in size.

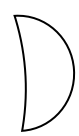
   Points 5 and 6 are true in the Northern hemisphere, but the reverse is true in the southern hemisphere.

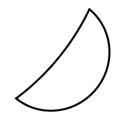
A Moon that is illuminated on the right side, which is growing in size from day to day (see point 5), is called a *waxing* Moon.

(Think about how candles are made. A wick is dipped into melted wax; and then the wax is allowed to dry. The candle is re-dipped into the melted wax and the new layer is allowed to dry. This process is repeated several times until the candle “grows” [waxes] to the desired size. In other words, this growing candle is waxing. And that’s why we call the growing Moon a *waxing* Moon.)

7. A waxing crescent Moon (i.e., a crescent Moon that is illuminated on the right side) can best be seen in the southwest to western[5] sky at dusk or shortly thereafter.

8. A first quarter moon (sometimes called a waxing half Moon),[6] that is illuminated on the right side can be seen around dusk in the southern sky. Later --- after sunset --- it can be seen in the southwest and then western sky.



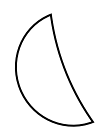


   Two weeks after the new, skinny waxing crescent Moon appears[7] in the western sky it has grown (waxed) to a full Moon.

9. The full Moon appears in the eastern sky at dusk; and as the night goes on, the full Moon moves to the southern sky and then to the western sky.[8]

10. The full Moon, which rose (appeared) in the eastern sky, sets the next morning in the western sky.

11. After the Moon is full it starts to shrink in size over the next few days.

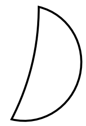


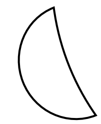
12. The part of the shrinking Moon that is missing is on the right side of the Moon. (Thus, the part you can see is on the left, as in this drawing.[9])

13. The Moon that is growing smaller (see point 6) is called a *waning* Moon.

14. You can tell right away by looking at the Moon whether it is waxing or waning.

[5] Northwest to western sky in the southern hemisphere.
[6] When in the northern hemisphere the right half of the Moon is illuminated, astronomers call this a first quarter moon to indicate that the Moon is one quarter of the way through its cycle; and by the same logic, when the Moon is illuminated on the left in the northern hemisphere it is called a last quarter moon. I personally prefer the terms “waxing half moon” and “waning half moon,” since these terms describe its appearance, but I will defer to the experts.
[7] Be careful about the word appears. A new, skinny, waxing crescent Moon is up most of the daylight, but it's hard to see this skinny Moon before the Sun goes down, because the Sun is so bright.
[8] In the southern hemisphere the full Moon will be seen to move from east to west, but instead of moving from east to south to west, it will move from east to north to west.
[9] In the southern hemisphere the left side is missing and the right side of the waning Moon is visible.

If the Moon is illuminated on the right side, it is waxing.	

If the Moon is illuminated on the left side, it is waning.	

15. The waning Moon rises later and later each night.

16. Both the Sun and Moon always rise in the east.

17. Both the Sun and Moon always set in the west.

18. A good time to view the Moon is when the Moon is full or close to full. Look for it in east as it is rising at dusk or shortly thereafter. The full Moon rises in the east as the Sun is setting in the west.

19. Other good times to see the Moon are in the evening in the West when the Moon is a new waxing Moon or in the morning in the west when it is a full Moon or close to a full Moon.

20. The side of the Moon that is illuminated is on the side facing the Sun.

    When the Moon is full, you see all of its illuminated side. (Look for the full Moon at dusk. It will be in the east and the Sun will be in the west, so the Moon's illuminated side is facing the Sun.)

    When the Moon is a waxing crescent, half of it is illuminated (as it always the case), but you can see only a sliver of the illuminated portion. We call that sliver a crescent.

    Although the waxing crescent is visible in the sky for most of the daylight hours, the Sun is so bright that it's difficult to see the waxing crescent. The best time to see a waxing crescent is at dusk in the western sky after the Sun has set and the sky is getting a bit darker.

    Think about where the Sun is in relationship to the Moon. They're close together. So the side of the Moon that is facing the Sun is the Moon's side that is facing away from us. Since the illuminated side is facing away, we can see only a portion of it. (If the illuminated side is entirely facing away, we cannot see any of it; and in our culture, we call that a "new Moon.")

21. The Moon doesn't stay in the same place.

22. From hour to hour the Moon moves toward the west.

    This fact is easiest to observe when looking at a full Moon or close to a full Moon. The full Moon rises in the east and sets in the west. If you observe the Moon between these two extremes, you'll see the Moon move from the east around to the south[10] and then to the southwest and then finally to the west.

23. From minute to minute the Moon moves toward the west.

    This fact is easiest to observe when looking at the Moon over a 30-minute period when the Moon can be seen relative to a fixed object like a tree, flagpole or edge of a building.

24. This minute to minute movement (point 24) follows the same path as the hour to hour observations (point 23).

25. From day to day the Moon moves toward the east.

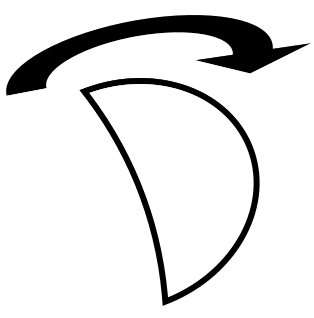
    This fact is easiest to observe when watching the waxing Moon shortly after sundown. A waxing crescent shortly after sundown is seen in the west. A week later the first quarter moon (sometimes called a waxing half Moon) is seen shortly after sundown in the south.[11] And a week after that the full Moon is seen shortly after sundown in the east.

26. The waning Moon continues day to day to move toward the east and, thus, rises later and later each day; but it's more difficult to make these observations, since we tend to have gone to bed by the time the waning Moon rises. (However, night owls or those who wake up before sunrise can help verify these observations.)

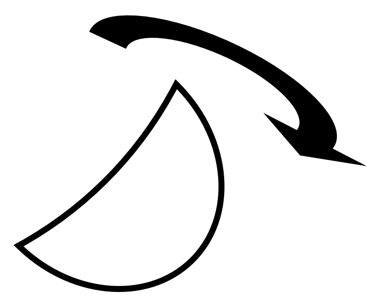
27. If you could poke a hole in the middle of the Moon, you would see that the Moon rotates in a clockwise direction as it moves across the sky.

    This can be seen with a first quarter moon (sometimes called a waxing half Moon). When first seen in the late afternoon or evening, the straight edge of the waxing half Moon is on the left or bottom left of the Moon. Later on, as it moves toward the west, that straight edge moves (rotates) in a clockwise direction; and when this half Moon is close to setting, the straight edge is on the top left or top of the Moon.

    Note that this is a tricky idea. Here we're talking about how the Moon <u>appears</u> to us and NOT about whether the Moon is actually rotating.



The Moon's orientation rotates clockwise
in the northern hemisphere



[10] To the north in the southern hemisphere.
[11] In the north in the southern hemisphere.

APPENDIX B

VIEWING THE MOON IN THE SOUTHERN AND NORTHERN HEMISPHERES

In the preceding section we indicated that the Moon appears differently to viewers in the Southern and Northern Hemispheres. For example, the waxing crescent might appear at dusk on the lower right side to the viewer in, say, Chicago, Illinois, but the same Moon will tend to appear on the lower left when viewed at dusk on the same day in Sydney, Australia.

How can we help students understand how that happens? After all, both viewers are looking at the same Moon, so how can its shape be different for the two viewers.

Australian Waxing Crescent Moon

Waxing Crescent MOON in Chicago

Waxing Crescent Moon Viewed by Australian Students and Students in the Continental U.S.

Start by pairing your students. One student per pair should draw a heavy arrow on a piece of paper. The arrow needs to be heavy enough so that it can be seen from both sides of the paper. As the students face each other one meter apart, one student should hold the paper between them so that both students can see the arrow.

Ask them which direction – right or left – the arrow is pointing. For one student, the arrow will be pointing to the right. For the other, the arrow will be pointing left. It's the same arrow, but to the two viewers, it appears to be pointing in opposite directions. Ask why it appears to be pointing in opposite directions. The students should figure out that the direction the arrow points is dependent on both the arrow – the object being viewed – and the perspective of the viewers. In this case, the viewers are facing each other, so there is a 180º difference in their perspective relative to the arrow.

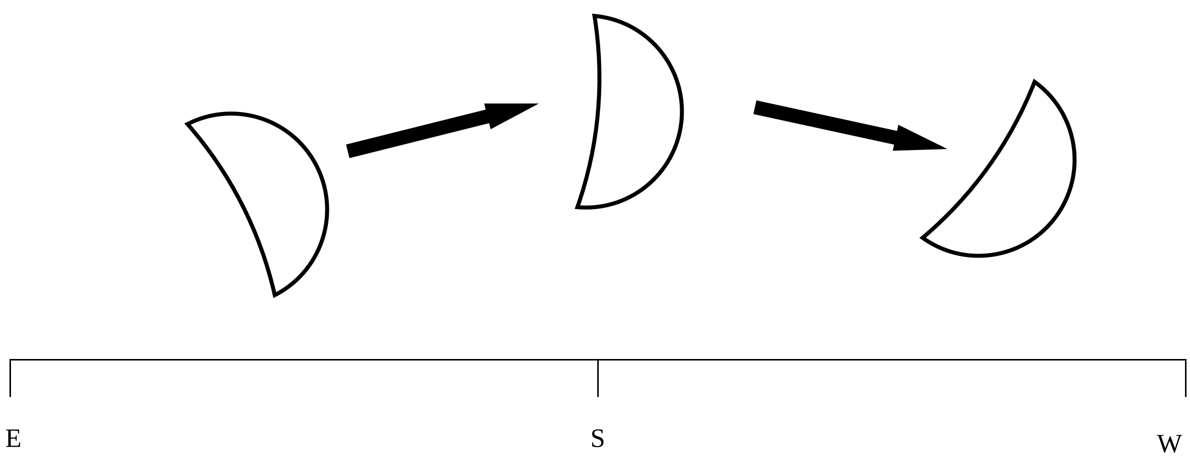
Next, while the students continue to face to other, have one of the students hold the paper above his/her head so that the arrow is pointing to the student's right and so both students can see the arrow, as if they both were looking skyward. Again ask them which direction – right or left – the paper is pointing. For one, the arrow is pointing to the right; but for the other, the arrow is pointing left. Why might that be?

Again, students should recognize the importance of each viewer's perspective. Ask the students to hold on to that idea while doing the next activity.[12]

[12] Based on Ginns, I. S. (1993). Extension activities in astronomy for primary school children. *The Queensland Science Teacher*, *19*(3), 32-34.

Before doing this next activity, Northern Hemisphere students should have viewed the Moon for several hours and observed that the waxing crescent tends to appear on the right side, and also figured out that it moves across the sky from East to West (in the Northern Hemisphere) from hour to hour, just as the Sun moves from East to West from hour to hour as the day goes by. They also should have discussed with Southern Hemisphere students the Moon's appearance and should have found out from their Southern Hemisphere partners that the waxing crescent in the Southern Hemisphere tends to appears on the left side; and the Moon moves from hour to hour from East to West in the Southern Hemisphere. Finally, they should have figured out that in the hour to hour timeframe the Northern Hemisphere viewer will see the Moon moving from left to right (i.e., from East to West). But the Southern Hemisphere viewer in the same timeframe will see the Moon move from their right to left (i.e., from East to West). How can it be moving from right to left in the Southern Hemisphere but from left to right to the Northern Hemisphere viewer?

Again, pair the students. One of the students should draw three half moons on a blank sheet of white paper, as shown in this drawing. Below the Moons they should draw a horizontal line with marks to show where East, South and West are. Finally, they should draw arrows to show how the Moon moves from East to West in an hour to hour time frame. When they are making these observations, the two students should stand shoulder to shoulder with the paper on the desk in front of them so that they are looking at the Moon from the same perspective.



Next students should face each other while one of them holds the drawing between them so that one student is viewing the Moon as drawn and the other student is viewing the paper from behind. The first student viewing the front side of the piece of paper is observing the Moon as seen from the Northern Hemisphere, but the second student, looking at the paper from behind, is viewing the Moon as seen from the Southern Hemisphere. (The second student is looking North; so in her or his mind, she or he needs to change the S [South] to N [North]. Otherwise the drawing and directions are correct for both viewers.

Which way is the Moon moving across the sky for both students? Both see the Moon moving from East to West; but that's left to right for the Northern Hemisphere viewer and right to left for the Southern Hemisphere viewer.

Which side of this waxing crescent half moon is illuminated? The Northern Hemisphere student will see the right half illuminated but the Southern Hemisphere students will see the left half illuminated.

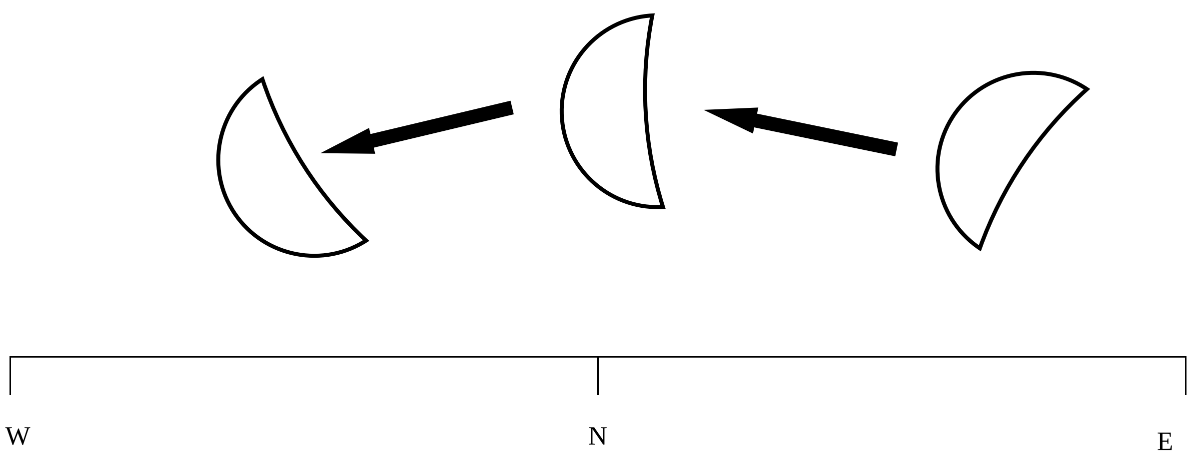
Are the two students seeing two different parts of the Moon? No. They are seeing exactly the same part of the Moon; but because of the two viewers' differing perspectives, one sees the illuminated part to the right and the other sees it to the left.

Finally, as the students continue to face each other, have the students hold the paper above their heads and between them so that both can see the front of the paper. The paper should be oriented so that East is to the left of the "Northern Hemisphere" student and to the right of the "Southern Hemisphere" student. Again, the drawing and labeling are correct for both students except that the "Southern Hemisphere" student is looking north, whereas the "Northern Hemisphere" student is looking south (as the drawing is labeled. Also, the drawing of the Moon from the "Southern Hemisphere" student's perspective will seem to rise high, dip down, and then set high, so the "Southern Hemisphere" student will have to mentally realize that the Moon rises at the eastern horizon, moves to the top of its arc across the sky, and sets at the western horizon.

Which way is the Moon moving from hour to hour? Both will say the Moon is moving from East to West; but from the "Northern Hemisphere" student, this is left to right whereas for the "Southern Hemisphere" student, this is right to left.

Which side of the Moon is illuminated? The "Northern Hemisphere" student will see the illuminated part on her or his right; but the "Southern Hemisphere" student will see the illuminated on his or her left.

Southern hemisphere teachers should modify this activity by having their students draw the Moon as their students have been viewing the Moon (as shown in this drawing).

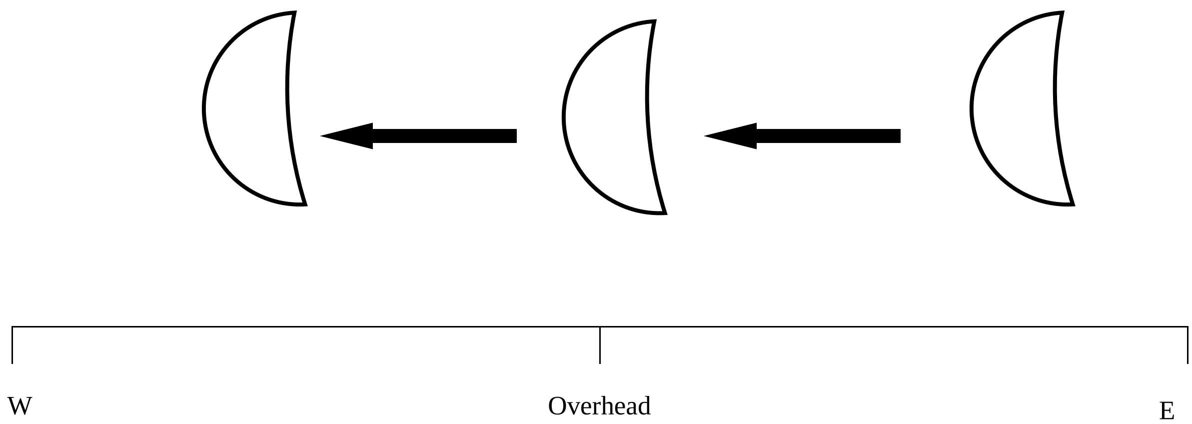


Having had your Southern Hemisphere students draw the Moon and label directions in this way, you can have students make the same observations as made by Northern Hemisphere students and you can ask the same questions.

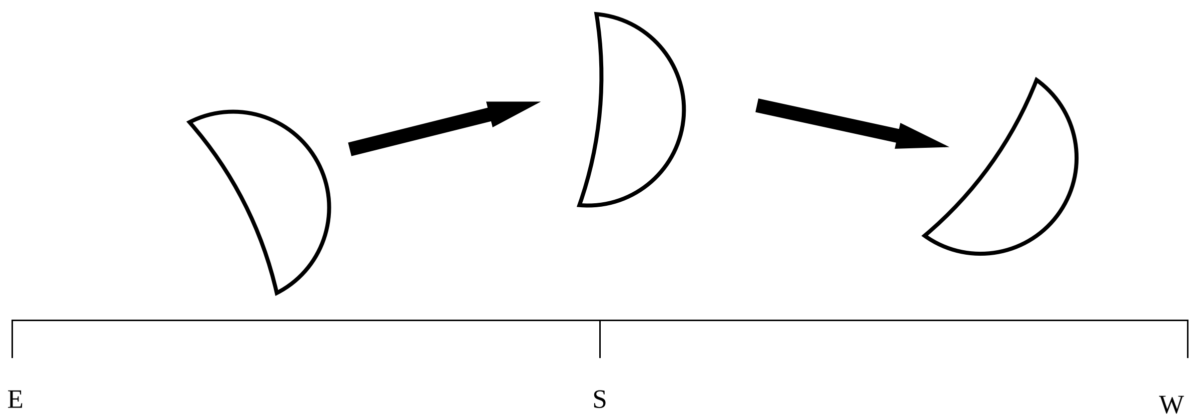
If you and your students really "get into" this topic, you might be interested that . . .

When writing these directions I have been envisioning teachers and students living at about 30-40º north or south of the Equator. The closer you get to the Equator, the more the Moon may be directly overhead at certain times.

If your school is located in, say, Brisbane at about 27º South, at some times the Moon passes nearly directly overhead. Thus, instead of seeing the Moon in the Northern sky, as shown in the drawing above, the Moon will move across the sky more like this drawing.



This time when the students hold the paper over their heads, the "Southern Hemisphere" student (who is standing in Brisbane when the Moon is passing more or less overhead) should hold the paper directly over his or her head. The "Northern Hemisphere" student should stand a meter away. For this student, standing in, say, Chicago, Illinois, the Moon they see will look more like this drawing.



Both students will see the Moon moving from East to West. The "Northern Hemisphere" student will see the right side of the Moon illuminated. The "Southern Hemisphere" (Brisbane) student will see the lighted surface of the Moon on the left side and more or less on the top of the moon when first viewed looking toward the East and more or less on the bottom of the moon when seen as it sets in the West. (Of course, when the Moon is "on top" in Brisbane, the Sun will also be out and bright, so observers will have to look hard for the Moon at this time.)

The great big message to learn from all of this goes back to the arrow exercise. What you see depends on what is happening AND on the perspective of the viewer.

In this particular case, the Moon is doing whatever the Moon is doing. Any differences in what we see is due to the differing perspectives (or frames of reference) of the viewer in different parts of the world.

APPENDIX C

WHERE IS THE MOON? CONSTRUCTING AN ASTROLABE

National and state standards in various ways call for students to learn that people have invented instruments (sometimes referred to as tools) that have helped humans learn more about the natural world. The standards also call for students to learn how to use simple instruments/tools such as magnifying glass, compass, and microscope.

World MOON Project students use their eyeballs and possibly their fists to measure the Moon's angle above the horizon. Following these directions, your students can make a tool/instrument called an astrolabe to help them make those measurements more precise. Once made, they should continue to use their astrolabe as they make their Moon measurements.

(Photo courtesy Adler Planetarium and Astronomy Museum. The Mariner's Astrolabe was used to determine the latitude of a ship at sea by measuring the noon altitude of the Sun or the meridian altitude of a star of known declination.).

It was not possible to determine longitude at sea in the early days of European transoceanic navigation, but it was quite easy to determine latitude. To go to a place of known latitude, the ship sailed to that latitude and then sailed east or west along the latitude line until the place was reached. To find the latitude of the ship at sea, the noon altitude of the Sun was measured during the day or the altitude of a star of known declination was measured when it was on the meridian (due north or south) at night. The Sun's or star's declination for the date was looked up in an almanac. The latitude is then 90° - measured altitude + declination.

A number of devices were used to measure the Sun's noon altitude. Among them were the quadrant, cross staff and, later, the back staff and the mariner's astrolabe. All these devices had a single use; to measure the altitude of a celestial body above the horizon. The Mariner's Astrolabe, which was popular in the late 15th and early 16th centuries, was a simple brass ring, graduated in degrees with a rotating alidade for sighting the Sun or a star. The ring was cast brass, quite heavy and cut away to keep it from blowing around in the wind. It was not a very good instrument and errors of four or five degrees were common.

It should be noted that **any instrument used to measure altitudes above the horizon can be called an *astrolabe***. The term astrolabe is often used in a context that is not the same as the classic planispheric astrolabe.

http://www.astrolabes.org/MARINER.HTM viewed on 2.28.01

Materials needed to make a simple astrolabe:

1. A piece of cardboard (approximately 8.5" x 11" [i.e., approximately 22 x 28 cm]).
2. A drinking straw.
3. A piece of string (about a foot [30 cm] long).
4. A weight (such as a nut or washer) to which you can tie the string.
5. The reverse protractor – see drawing on the next page.
6. Glue.
7. Sharp object to punch a hole in the cardboard.
8. Scissors to cut the cardboard.
9. Scotch tape.

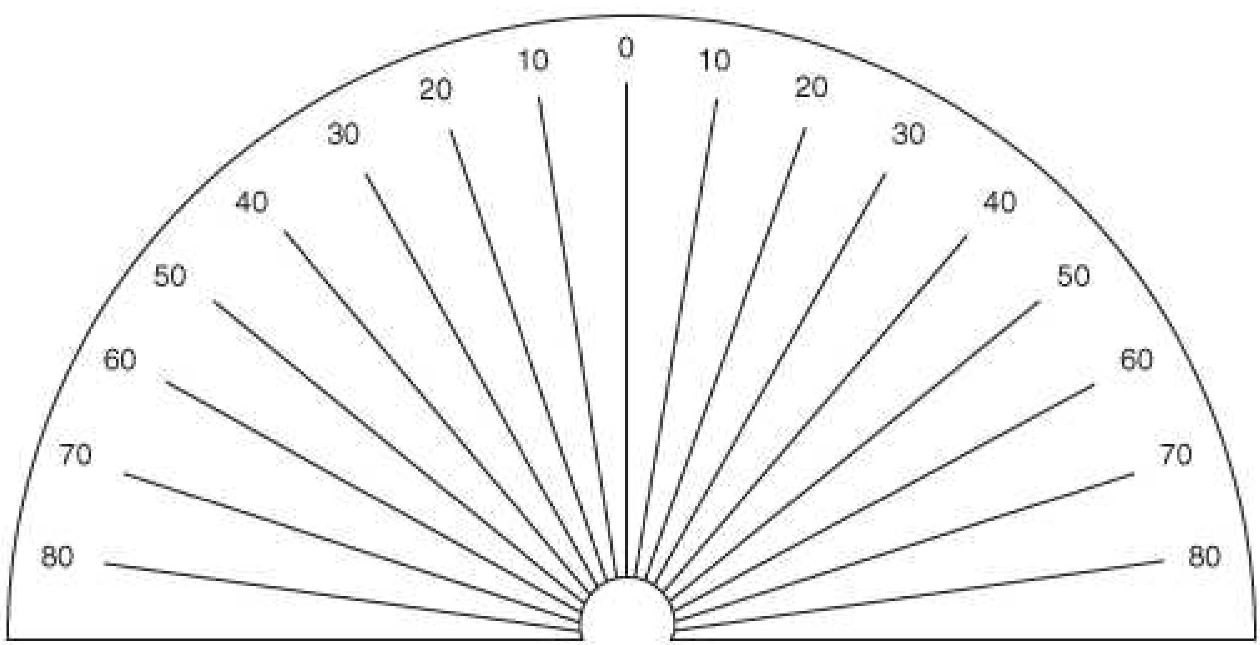
Directions for making the astrolabe:

1. Using a photocopier, make a copy of the reverse protractor on the next page such that the straight edge of the protractor is the same length as the longer straight edge of the cardboard (i.e., about 28 cm or 11 inches).
2. Use a few dabs of paste to paste the protractor to the cardboard with the straight edge of the protractor lining up with the longer straight edge of the cardboard.
3. Cut out the cardboard around the protractor.
4. Poke a hole in the cardboard about ¼ inch (.5 cm) from the straight edge of the cardboard, directly above the 0° mark. It may be helpful to start the hole with a straight pin and then widen the hole with scissors. Make the hole as close to the straight edge as possible.
5. Tie the weight to one end of the string. (Once tied to the string, the weight should not extend beyond the curved edge of the protractor.)
6. Thread the other end of the string through the hole and tie it in place.
7. Tape the straw to the straight edge of the cardboard.
8. Trim the two ends of the straw so that the ends do not extend quite to the end of the straight edge.

Directions for using the astrolabe to measure the angle of the object above the horizon:

1. Hold the astrolabe with the straight edge of the cardboard on top, parallel to the ground, with the string hanging down. (If the straight edge is parallel to the ground, then the string should cross the 0° mark on the protractor.)
2. Use one eye to look through the straw at the Moon (or whatever celestial body you're trying to position), allowing the string to hang free.
3. With the cardboard astrolabe still in place and the straw pointing toward the Moon, when the string stops swinging, use your index finger and thumb to pinch the string against the cardboard. Your thumb should be on the back side of the cardboard opposite your index finger so that the string will be held in place against the cardboard.
4. Use the lines radiating from the point toward the curved edge to estimate the angle between the object you're observing and the horizon. (For example, if the string is positioned half way between the 40° and 50° lines, the object you're observing is about 45° above the horizon.)

Because of the crudeness of this tool, you probably cannot measure any more accurately than within 5-10° of the object's actual position, but your estimate is probably better than "eyeballing" the object's position or using your fist to make the estimate.



Appendix D
Fall 2017 Lunar Phases – Northern Hemisphere

Please visit http://www.moonconnection.com/moon_phases_calendar.phtml for up to date calendars and images of the lunar cycle.

APPENDIX E

INDIANA SCIENCE STANDARDS ADDRESSED BY THE WORLD MOON PROJECT

Although these standards are written for use in Indiana, these standards were based on the Project 2061 Benchmarks developed by the American Association for the Advancement of Science (AAAS), so they are applicable around the country and, we think, the world.

The first number in, for example, 4.2.7, refers to the grade level. The second to the standard and the third to the sub-standard, which we call indicators in Indiana

(The Scientific View of the World) 4.1.1 Observe and describe that scientific investigations generally work the same way in different places.

(Critical Response Skills) 4.2.7 Identify better reasons for believing something than “Everybody knows that...” or “I just know” and discount such reasons when given by others.

(The Universe) 4.3.1 Observe and report that the moon can be seen sometimes at night and sometimes during the day.

(The Earth and the Processes that Shape It) 4.3.8 Explain that the rotation of the Earth on its axis every 24 hours produces the night-and-day cycle.

(The Earth and the Processes that Shape It) 4.3.9 Draw or correctly select drawings of shadows and their direction and length at different times of day.

(Model and Scale) 4.6.3 Recognize that and describe how changes made to a model can help predict how the real thing can be altered.

(Scientific Inquiry) 5.1.2 Begin to evaluate the validity of claims based on the amount and quality of the evidence cited.

(Manipulation and Observation) 5.2.4 Keep a notebook to record observations and be able to distinguish inferences* from actual observations.

(Communication Skills) 5.2.7 Read and follow step-by-step instructions when learning new procedures.

(Reasoning and Uncertainty) 5.5.7 Explain that predictions can be based on what is known about the past, assuming that conditions are similar.

(Reasoning and Uncertainty) 5.5.8 Realize and explain that predictions may be more accurate if they are based on large collections of objects or events.

(Constancy and Change) 5.6.4 Investigate, observe, and describe that things change in steady, repetitive, or irregular ways, such as toy cars continuing in the same direction and air temperature reaching a high or low value. Note that the best way to tell which kinds of change are happening is to make a table or a graph of measurements.

(The Universe) 6.3.3 Explain that the Earth is one of several planets that orbit the sun, and that the moon, as well as many artificial satellites and debris, orbit around the Earth.

(Physical Setting) 6.3.6 Use models or drawings to explain that the phases of the moon are caused by the moon’s orbit around the Earth, once in about 28 days, changing what part of the moon is lighted by the sun and how much of that part can be seen from the Earth, both during the day and night.

(Common Themes) 6.7.2 Use models to illustrate processes that happen too slowly, too quickly, or on too small a scale to observe directly, or are too vast to be changed deliberately, or are potentially dangerous.

APPENDIX F

INDIANA WRITING STANDARDS ADDRESSED BY THE WORLD MOON PROJECT

As is the case with the science standards, these standards were adopted in Indiana, but around the world similar goals are held for students.

Standard 4: WRITING: Process

The writing process includes prewriting, drafting, editing, and revising. Students progress through these stages to write clear, coherent, and focused paragraphs and essays.

Students discuss and keep a list of writing ideas and use graphic organizers to plan writing. They write clear, coherent, and focused essays. Students progress through the stages of the writing process and proofread, edit, and revise writing.

Organization and Focus:

4.3: Write informational pieces of several paragraphs that:

- engage the interest of the reader.
- state a clear purpose.
- develop the topic with supporting details and precise language.
- conclude with a detailed summary linked to the purpose of the composition

4.4: Use a variety of effective organizational patterns, including comparison and contrast, organization by categories, and arrangement by order of importance or climactic order.

Research and Technology:

4.7: Use a computer to compose documents with appropriate formatting by using word-processing skills and principles of design, including margins, tabs, spacing, columns, and page orientation.

Evaluation and Revision:

4.8: Review, evaluate, and revise writing for meaning and clarity.

4.9: Edit and proofread one's own writing, as well as that of others, using an editing checklist or set of rules, with specific examples of corrections of frequent errors.

4.10: Revise writing to improve the organization and consistency of ideas within and between paragraphs.

Standard 5: WRITING: Applications

Through the exploration of different types of writing and the characteristics of each, students become proficient at narrative (stories), expository (informational), descriptive (sensory), persuasive (emotional appeal), argumentative (logical defense), and technical writing. Writing demonstrates an awareness of the audience (intended reader) and purpose for writing.

At Grade 6, students write narrative (story), expository (informational), persuasive, and descriptive texts (of at least 500 to 700 words). Student writing demonstrates a command of Standard English and the research, organizational, and drafting strategies outlined in Standard 4 - Writing Process. Writing demonstrates an awareness of the audience (intended reader) and purpose for writing.

5.2: Write descriptions, explanations, comparison and contrast papers, and problem and solution essays that:

- state the thesis (position on the topic) or purpose.
- explain the situation.
- organize the composition clearly.
- offer evidence to support arguments and conclusions

5.3 Write research reports that:

- pose relevant questions that can be answered in the report.
- support the main idea or ideas with facts, details, examples, and explanations from multiple authoritative
- sources, such as speakers, newspapers and magazines, reference books, and online information searches. include a bibliography.

5.5 Write persuasive compositions that:

- state a clear position on a proposition or proposal.
- support the position with organized and relevant evidence and effective emotional appeals.
- anticipate and address reader concerns and counterarguments.

6.5.6 Use varied word choices to make writing interesting.

6.5.7 W rite for different purposes and to a specific audience or person, adjusting tone and style as necessary.

Standard 6: WRITING: English Language Conventions

Conventions include the grade-level-appropriate mechanics of writing, such as penmanship, spelling, grammar, capitalization, punctuation, sentence structure, and manuscript form.

<u>Sentence Structure</u>:

6.1 Use simple, compound, and complex sentences; use effective coordination and subordination of ideas, including both main ideas and supporting ideas in single sentences, to express complete thoughts.

- Simple sentence: sentences with one subject and verb, such as *The pine tree is native to many parts of America.*

- Compound sentence: sentences with two equal clauses, such as *The giraffe has a long neck and long legs, but it is a very graceful animal.*
- Complex sentence: sentences that include one main clause and at least one subordinate clause, such as *I just sat at my desk, not knowing what to do next, although others around me were writing furiously*.

Grammar:

6.2 Identify and properly use indefinite pronouns (*all, another, both, each, either, few, many, none, one, other, several, some*), present perfect (*have been, has been*), past perfect (*had been*), and future perfect verb tenses (*shall have been*); ensure that verbs agree with compound subjects.

- Indefinite pronouns: *Each should do his or her work.*
- Indefinite pronouns: *Many were absent today.*
- Correct verb agreement: *Todd and Amanda were chosen to star in the play.*
- Incorrect verb agreement: *Todd and Amanda was chosen to star in the play.*

Punctuation:

6.3 Use colons after the salutation (greeting) in business letters (*Dear Sir:*), semicolons to connect main clauses (*The girl went to school; her brother stayed home.*), and commas before the conjunction in compound sentences (*We worked all day, but we didn't complete the project.*).

Capitalization:

6.4 Use correct capitalization.

Spelling:

6.5 Spell correctly frequently misspelled words (*their/they're/there, loose/lose/loss, choose/chose, through/threw*).

APPENDIX G

SAMPLE LETTER TO PARENTS EXPLAINING THE WORLD MOON PROJECT

Dear Parents and Family Members,

Welcome to the World MOON Project. We're glad to have you and your child involved.

For the next couple months your child and other children from around the world will be observing the Moon each day and recording those observations. We invite you and your family to join your child in making those observations.

It may not be possible or easy to find the Moon each day. First, you'll need to figure out where and when to look. You may have some ideas yourself about where and when to observe; and your child's teacher will give to your child's class some hints about where and when to look. As time goes by, your child and you will find it easier to predict when and where to watch for the Moon. Please join your child in making these predictions; but please let your child take the lead. That's part of what the World MOON Project is about. We want your child to make observations, draw conclusions and make predictions based on those conclusions.

Your child will have a student handbook in which to record observations. Please encourage your child to make entries in the handbook every day. As the days pass, talk with your child about any patterns that seem to be emerging.

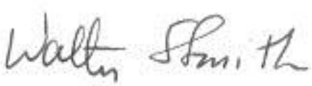
Starting in April, your child will write essays in school about the Moon to share on the Internet with approximately a dozen other children around the world. A university student will facilitate this sharing. For example, your child will write about her or his moon observations, read what the other children have observed, discover worldwide patterns in the data, and develop explanations for those patterns.

This Internet sharing is carried out in a protected environment housed on a Texas Tech University computer. We have built a firewall around this exchange so the only people who can see what your child writes are your child and other children about the same age under the leadership of a college student. Additionally, your child's teacher and the other teachers plus the World MOON Project staff can observe the communication. Students are known to each other only by first names; and email addresses and other contact information are not exchanged. Students do not communicate directly with each other. Rather, communication among students is filtered through a college student who is preparing to become a teacher, so your child is working in as safe an environment as is possible.

We also want the children to share ideas about how people in their various communities think about the Moon. They may find that in some places the Moon is quite important but in other locations people rarely think about the Moon. They'll find that classical to contemporary music has been written about the Moon. Indeed, the Moon is the second most frequently written about topic in songs. Some people think of the Moon in a romantic way; others find the Moon to be scary. As ideas about the Moon come to mind, please share these ideas with your child. You may find that the Moon is more prominent in our thinking than we might have believed.

If you have ideas you'd like to share with us about this project, feel free to be in touch with us. My email address is walter.smith@ttu.edu. We want you to feel you're a part of the project.

Thanks for your involvement. We definitely hope you will be immersed in the World MOON Project along with your child.



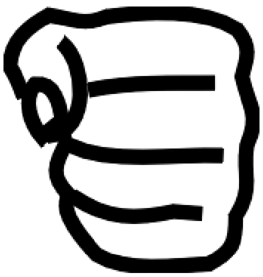
Walter S. Smith

Appendix H

Angle and Direction
(Altitude and Azimuth)

In the Student Handbook, each day the student is supposed to enter “Direction” and “Angle” along with the time they made their observation and a drawing of the lunar phase (shape) they observed.

Angle or Altitude: Another name for “angle” is altitude. The altitude of a heavenly object is the angle of the object above the closest horizon. If a an object, such as the setting sun about 20 minutes before sunset, is close to the horizon, you might estimate that it’s 5 degree above the horizon; and we’d say its altitude is 5 degrees. As the object goes higher and higher in the sky, its altitude increases. If an object were precisely overhead, it would be at 90 degrees above the horizon; or said another way, its altitude is 90 degrees. 90 degrees is the biggest altitude any object can have.

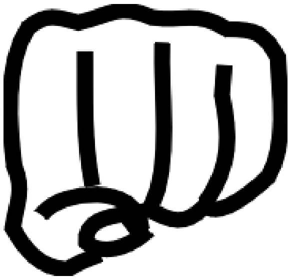


In the World MOON Project, students can roughly measure the Moon’s altitude with their fist which is about 10 degrees wide from little finger to index finger. If the Moon were three fists above the horizon, it would be about 30 degrees above the horizon; or we could say its altitude is 30 degrees.

To obtain more precise measurements of altitude, use the Astrolabe described in Appendix C of the Teacher Handbook.

Direction or Azimuth: Another name for “direction” is azimuth which could be expressed in terms of cardinal directions – north, south, east or west – or finer gradations like southeast or northwest. Or the azimuth could be expressed in degrees from north. In this case face north and draw an imaginary circle of 360 degrees around you. To help visualize this circle, I find it useful to face north, point my right hand north, and then sweep my hand around me in a clockwise direction. Of course, my arm begins to break when it points behind me toward south, so I have to mentally sweep my arm the rest of the way around to west and back to north. By convention north is located at zero degrees on this imaginary circle. Then, sweeping my hand in a clockwise direction, east is located at 90 degrees from north. Continuing to sweep my hand in a clockwise direction, south is located at 180 degrees from north. And continuing to sweep my hand in a clockwise direction, west is at 270 degrees from north.

It might be tempting to describe west as 90 degrees from north in a counterclockwise direction; but by convention we always draw this imaginary circle in a clockwise direction from north.



We can be more precise. For example, an object in the southeast sky is 135 degrees from north; and an object midway between east and southeast would be at about 112 degrees from north.

Again we can use our fist which is about 10 degrees wide. If we turn the fist so it’s parallel to the ground and if an object is two fists south of east, the object is at about 110 degrees from north.

But, you say, the Moon won't be located precisely on the horizon. The trick here is to locate the Moon and then look down to the closest point on the horizon. It's the angle from north of this point on the horizon that is the Moon's azimuth or direction.

This website (http://www.astro.cornell.edu/academics/courses/astro201/alt_az.htm) has a nice illustration of azimuth and altitude shown here with altitude on the left and azimuth on the right.