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Kinesthetic Learning with Elementary Students in the Planetarium

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Abstract:

This study explores the use of kinesthetic learning techniques in a presentation designed to help early elementary students understand the motions of the sun, moon and stars in the sky. Pre- and post-visit interviews were conducted for 10 second grade students to look for changes in their ideas. The interviews were conducted in a setting that allowed the students to express their three-dimensional understanding of celestial motion. Students interviewed in this study showed improvement in their understanding of topics recommended in the National Science Education Standards (NSES), including understanding of the paths that objects take across the sky and overall understanding of the range of motion of celestial objects. This result supports having young children use movement of their own bodies to help them learn about the motion of celestial objects in the planetarium. This work represents a small piece of a larger study in which I have interviewed 73 students from eight classes that attended the program.

Introduction:

The National Science Education Standards (NSES) and Benchmarks for Science Literacy (Benchmarks) recommendations for children in the early elementary years of school includes the motions of the sun, moon and stars in the sky as seen from the earth. Students should learn that these objects all have properties, locations, and patterns of movement that can be observed and described. Learning about these motions is necessary for a full understanding of concepts studied later such as rotation and revolution. However little research addresses the commonly held beliefs of young children on the topic of the apparent motion of celestial objects, nor does it include ways to help students learn these challenging concepts. The research that has been reported suggests that students have a hard time understanding and explaining the apparent motion of celestial objects in terms of their own observations (Viglietta, 1986). This study aims to explore the use of a planetarium show developed specifically to help young children learn these concepts of celestial motion.

At present, there is little research reported in this concept area, especially not for students in early elementary grades. We need to understand what children already know about these concepts and related concepts to better address them in the curriculum we use in schools and other educational venues. Describing the location and motion of celestial

objects will present a challenge to students beyond their normal ability to describe the location and motion of earth bound objects that they deal with on an everyday basis. Part of the problem (pointed out by Viglietta, 1986) is that celestial motion is on a much longer time scale than students normally observe motion. An observation of the location of the sun does not immediately reveal that its location in the sky is changing. This will presumably create a problem for young children when they are trying to understand the patterns of motions of the sun, moon and stars.

We should also consider at what age level these concepts are appropriate, based on developmental issues. Jeanne Bishop (1976) applied the research of Piaget to astronomy concepts typically taught to elementary students. Bishop suggests that up to about second grade, children practice transductive reasoning (reasoning from one particular even to another particular event) and are thus unable to understand the idea that the sun stays up for half the time because the Earth rotates (though they may be able to parrot this idea back to us). She also suggests, "Until about age seven (second grade), most children are unable to correctly reconstruct a succession of perceived events. They are also unable to comprehend simultaneously moving objects which are advancing at different rates" (p. 5). By age seven, children should be able to understand relations between separate events. Ideas of direction and horizontal and vertical are also problematic. Students are still developing the concept of left and right and the ideas of horizontal and vertical as based on the surface of the earth are still developing until about age nine (Bishop, 1976). Children in the second grade and younger have an egocentric viewpoint and are unable to imagine other viewpoints. Children do not develop the ability to imagine what something might look like from different locations in space until late third or fourth grade.

For these reasons, in early elementary grades students should focus on topics that are centered on the student's own earth-based (geocentric) perspective. Helping children learn about the motions of the sun, moon and stars, as they would view them in the sky is appropriate if we consider the children's developmental stage.

The planetarium is a wonderful setting to use in the teaching of celestial objects and their motions in the sky from the geocentric perspective. We can create an artificial environment to help the students identify and learn about the familiar objects of the day and night. This environment also allows us to manipulate time – we can speed up or stop the motion of celestial objects to observe their patterns of motion in a useful amount of time.

Constructivist theory asserts that students are active participants in constructing their understanding of concepts by incorporating new information into pre-existing frameworks. In designing science instruction, we should be mindful of providing opportunities for students to actively engage with phenomena in order to construct their understanding of the concepts. In the literature of planetarium education, *participatory programs* describe a presentation style that actively engages learners in ways that potentially allow for construction of new understanding. A more traditional style of planetarium program is the lecture format. Examples of participatory programs have involved the audience actively engaged in thinking about the subject matter through

activities in which they discover meaning for themselves, predict possible outcomes, and engage in extensive verbal interaction.

Another method for involving students in actively constructing understanding is through their own motions: kinesthetic learning. Zubrowski (1991) argues that the need exists to incorporate "total-body experiences" into science education. Astronomy learning experiences using kinesthetic techniques have been developed for grade six through adults (Morrow, 2000). Field-testing of these activities suggests that these kinesthetic astronomy techniques allow learners to achieve a good intuitive grasp of concepts that are much more difficult to learn in more conventional ways. This suggests that students have the potential to improve their understanding of celestial motion during their planetarium visit if they have used physical motions in the process of assimilating and understanding the new information, especially at a very young age, compared to just observing the phenomena. The benefits of using kinesthetic techniques may be due to either the existence of separate processing of kinesthetic information or it may be due to double feedback (kinesthetic and visual). This study will address how these kinesthetic techniques can be incorporated into a planetarium program for early elementary grade students.

Purpose of the Study

There is little research that addresses how we can help students understand these core concepts concerning the patterns of motion of celestial objects with students. Planetarium technology provides us with a potentially ideal setting for helping students learn these concepts, if we provide instruction that addresses how children learn. The purpose of this study is to examine how a planetarium program that engages students through opportunities to predict and describe motion can improve understanding. The results will be useful in designing future instruction both in and out of the planetarium.

This study asks the following research question:

1. Will incorporating kinesthetic learning techniques in a participatory planetarium program improve early elementary students understanding of the motions of celestial objects?

Description of Planetarium Program

The planetarium programs took place at the small planetarium located in the Exhibit Museum of Natural History. The 45 minute programs were delivered live by a planetarium operator (the author) with 11 years of planetarium experience.

The key topics included in the program were chosen from topics suggested for early elementary students in NSES and Benchmarks:

- the apparent motion of the sun in summer and winter
- the apparent nightly motion of the stars
- daily and monthly motion of the moon
- the moon's appearance in the day and night-time skies

- apparent change in the shape of the moon

The development of this planetarium program was guided by the following pedagogical approach:

1. The program will be **participatory** in order to actively engage students in constructing new knowledge.
2. The students will participate in **kinesthetic learning techniques** to reinforce concepts of celestial motion.
3. Topics covered in the program will be **developmentally appropriate** for children in early elementary grades.

Kinesthetic learning techniques (KLTs) include any type of motion a student performs to engage in the subject they are learning. The students used KLTs during the program to make predictions, follow the motion of the sun, moon and stars, and reinforce concepts of motion and change, by:

- describing the motion of the sun across the sky by pointing and moving their arm before watching the motion in the planetarium
- following the motion of sun with their arms in the summer and winter
- predicting where the sun will rise, where it will be at noon, where it will set
- following the motion of a star through out the night with their arm
- predicting the motion of the moon across the sky with their arms
- following the motion of the moon across the sky with their arms
- spinning around to mimic the rotation of the earth on its axis

A full description of the program script is included in Appendix A.

Description of Program Assessment

To assess the students understanding before and after the planetarium program interviews were conducted in a setting that allowed them to describe three-dimensional concepts. This could not be done in a reliable fashion with paper pencil tests, two-dimensional images, or simple interview questions. Therefore, the students were interviewed under a small a transportable dome which allowed the student to pretend they are looking at the real sky. The dome sits on a 4 ft high structure that is open so the student and interviewer are visible from outside of the dome. The students were given a small flashlight which they used to represent the sun, moon, and a star during the interview. The students used the flashlight to indicate the position and movement of these objects in the sky.

Figure 1: Exterior of the dome used for the interviews

Figure 2: Interior of the dome used for the interviews

The interview was semi-structured using questions designed to give the student an opportunity to express their own ideas about the motion of celestial objects in as open-ended manner as possible while still covering the same topics with each student. This sometimes resulted in confusion in the student at which point additional questions or prompts were provided.

For this paper, I will present the results from interviews with ten students from a class of second grade students who participated in the program. These students attended an elementary school in a small Midwestern town. A future publication will address the full data set of 73 students sampled from eight classes that participated in the planetarium program. The 10 students from this class were interviewed 8 days before and 7-8 days after their planetarium visit. The interviews ranged from 9 minutes to 15.5 minutes long. The participants are evenly split by gender: 5 boys and 5 girls.

Analysis Methodology

The students' responses have been coded for each specific content area covered by the planetarium program. This paper addresses the following content areas:

- Path of the sun in the summer
- Comparing the path of the sun in summer and winter
- Path of the moon across the sky
- Motion of the stars at night

Additional content areas will be addressed in future work on these interviews.

Detailed scoring criteria have been developed to analyze the interviews, based on the types of content knowledge exhibited by the students. Each content area was broken down into smaller conceptual units. Each of those conceptual units was coded for a series of accurate, partially accurate and non-normative ideas that one or more students

exhibited in their interview. For example, the content area "Path of the sun in the summer" includes the question "Does the student show the path of the sun accurately?" In this case, an accurate depiction of the path of the sun would be a smooth curve from one side of the sky to the other, passing below the zenith. The full range of codes for this topic includes:

- Accurate – path of the sun is curved and does not pass through the zenith
- Partially accurate – curved path through the zenith
- Partially accurate – student shows an accurate path of the sun and a non-normative path of the sun at different times during the interview
- Non-normative – path of the sun includes a sharp turn of more than 45 degrees
- Non-normative – path of the sun is indistinct
- Non-normative – path of the sun is only on one side of the sky

Each student's scores were then compared by content area across the pre- and post-visit interviews to look for pre/post treatment change.

For the analysis in this study, the following questions about student ideas were examined:

1. *Does the student demonstrate improved understanding of the path of the sun across the sky in summer?* Improved understanding includes demonstrating that the sun rises on one side of the sky and sets on the other, and that the sun does not pass through the zenith in Michigan.
2. *Does the student demonstrate improved understanding that the path of the sun is shorter and lower in the winter than the summer?* Improved understanding includes demonstrating that the sun's path is longer and higher in the summer than the winter, and that the sun is higher at its highest point in summer than in winter.
3. *Does the student demonstrate improved understanding of the moon's motion across the sky?* Improved understanding includes demonstrating that the moon moves across the sky much as the sun does and that the moon's motion is smooth and continuous across the sky.
4. *Does the student demonstrate improved understanding of the motion of the stars in the night sky?* Improved understanding includes demonstrating that the stars move across the sky and that we do not see the same stars over the course of one night.

Results

Four main conceptual areas covered in the planetarium program are examined below. The tables show how student's concepts changed from before to after attending the planetarium program. The conceptual changes (or lack of change) are listed as:

- Retained an accurate understanding of the concept (**ACC**)
- Improved understanding of the concept (**IMP**)
- Retained a partially accurate understanding (**RPA**)
- Retained a non-normative understanding (**RNN**)
- Regressed from accurate or partially accurate to non-normative (**REG**)

In some cases the students changed from one partially accurate idea to another partially accurate idea or from one non-normative idea to another. This is shown in the tables by indicating the number of students who changed within the category in parenthesis (see Tables 4, 6 and 7).

1. Does the student demonstrate improved understanding of the path of the sun across the sky in summer?

Table 1: Path of the Sun in the Summer					
Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	5	3	0	2

Five students showed improved understanding of the path of the sun in the summer (4 moved from partially accurate to accurate and 1 from non-normative to partially accurate). Three students retained the partially accurate idea that the sun passes through the zenith at noon.

For two students their understanding was coded as a regression - from accurate to partially accurate for Cory, and partially accurate to non-normative for Jon. In the pre-visit interview, Jon showed the sun's overall motion as a straight line across the sky through the zenith. In the post-visit interview he showed two different paths for the sun. First, he drew an incorrect path for the sun. He showed the sun rising to about 80 degrees altitude at 10AM and then continuing on to the opposite side of the sky at noon. Then in the afternoon he back-tracked the sun's motion to take it near the 10AM position and at the end of the day indicates the sun disappears rather than sets. However, when asked to show the entire motion of the sun throughout the day, he shows the accurate path of the sun, a smooth arc across the sky from one horizon to the other not passing through the zenith. It would appear that he learned the correct path of the sun in summer, but may have been confused when asked to show the sun's location at specific times of day. He showed the same alternative idea for the path of the sun in the winter (questions on the sun's path in winter will be addressed in a future publication).

In the case of Cory's interview, he showed the sun moving in a smooth arc across the sky, not passing through the zenith, in the pre-interview. However, he also indicated that when the sun is highest in the sky it is overhead which contradicts what he showed visually. In the post-visit interview, he showed the sun passing through the zenith as it moved across the sky. But when asked about the sun's highest position in the sky he said that it was not overhead. Based on his verbal answers he seems to have incorporated new information within his understanding of the sun's position in the sky at noon but was not able to show this correctly.

2. Does the student demonstrate improved understanding that the path of the sun is shorter and lower in the winter than the summer?

Table 2: Comparing the Path of the Sun in Summer and Winter					
Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	6	0	4	0

Table 3: Comparing the Noontime Altitude of the Sun in Summer and Winter					
Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	6	0	3	1

Prior to attending the planetarium program, none of the 10 students were able to show the correct comparison of the sun's path in the summer and the winter. After the planetarium program, six students were able to demonstrate that the path of the sun is longer in the summer compared to the winter, while the other four retained a non-normative comparison.

Six of the students improved their understanding of the noontime altitude of the sun, showing that it is higher in the summer than the winter. For three of the students, their understanding remained non-normative. The final student, Alex, regressed from an accurate understanding before the planetarium show to a non-normative understanding in the post-visit interview. In his pre-visit interview he showed the sun at the zenith at noon in the summer and at 60 degrees altitude in the winter. However, he was unable to show a complete path for the sun in the winter sky. In the post-visit interview he was able to show a complete path for the sun in both summer and winter and was also able to show that the path of the sun was shorter in the winter. But he also indicated that the altitude of the sun was the same in both seasons. Overall Alex's understand of these concepts improved, but on this particular topic he has not mastered the scientific understanding.

3. Does the student demonstrate improved understanding of the moon's motion across the sky?

Table 4: Understanding the path of the moon across the sky					
Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	6	4 (1)	0	0

Table 5: The moon has a uniform motion across the sky, like the path of the sun					
Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	8	2	0	0	0

Students' understanding of the path of the moon across the sky were coded according to the accuracy of the path the shown, where 'A smooth curve across the sky that does not pass through the zenith' was counted as accurate. Students who demonstrated the motion of the moon as being a smooth path that passes through the zenith or one that does not rise and set were counted as partially accurate. In the pre-planetarium visit interviews none of the students were able to show an accurate path for the motion of the moon. In the post-visit interview five of the students had improved to an accurate understanding and an additional student had moved from the non-normative to partially accurate category.

Three students did not show significant change in their partially accurate understanding of the motion of the moon while another student, Trent, showed change in his understanding, though did not reach an accurate understanding. Trent demonstrated that the motion of the moon is a smooth curve across the sky through the zenith, in the pre-visit interview. However, in the post visit interview he initially showed the accurate path for the moon, and then changed his mind to show an entirely different and non-normative path (the moon circled the zenith).

Only 2 of the students interviewed showed evidence that they did not understand that the moon moves continuously across the sky during the night. In the post interview, those two students had moved to an accurate understanding of the continuous nature of the moon's motion. The other eight students retained their accurate understanding.

4. Does the student demonstrate improved understanding of the motion of the stars in the night sky?

Table 6: Stars move across the sky during the night

Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	6	0	4(4)	0

Table 7: We do not see the same stars all night long

Student's Concept	**ACC**	**IMP**	**RPA**	**RNN**	**REG**
Number of Students	0	4	0	5(2)	1

Students were initially asked if the stars move in the sky at night. None of the students showed an accurate understanding of the motion of the stars in the pre-interview. An accurate understanding would have included that the stars move and they have a coherent pattern to their motion. After the planetarium program, six of the students improved their understanding of the motion of the stars to an accurate or partially accurate understanding. Partially accurate understanding includes students who know that the stars move across the sky but are unable to show or describe this accurately. The one student, Jon, that moved from non-normative (stars only seem to move when we are

moving, such as on a boat) to a partially accurate demonstrated that he had improved his understanding about the motion of the stars during the planetarium program.

> Interviewer: Do the stars move in the sky at night?
> Jon: Yeah, cause that's why you can't see them all the time. You don't see the same ones.
> I: Can you make a star [with the flashlight] and show me what a star might do in the sky?
> J: I can't make [the flashlight] into a star shape. Only a circle.
> I: Can you pretend that is a star shape?
> J: Uhm, I think stars go around. Some of them take turns going to the other side of the earth. And some just stay. Like here's a star but then the next day it will be over here.
> I: Do we see the same stars in the sky in the sky all night long?
> J: No. Because they move around. Like the sun.

The other four students did not gain a more accurate understanding of the motion of the stars at night but they did change from one non-normative idea to another.

I was also interested in learning whether they understood that we do not see the same stars in the sky through out the night. This appeared to be a challenging concept for the students. Prior to the planetarium visit none of the students understood this concept. After the visit, only four students improved their understanding. Three students retained the same non-normative understanding while two students changed from one non-normative idea to another.

Finally one student, Trent, regressed from accurate to a non-normative understanding. This case is interesting because he told me in his first interview that he has a home planetarium that projects the stars on his ceiling.

> I: Can we see the same stars in the sky all night long?
> T: No. I have like thing that you can, it orbits. Different stars come out each night.
> I: Do you have this at home that you can see?
> T: Yeah.

During his post interview he changed his answer to the question of whether or not we can see different stars on the same night.

> T: Each night you probably can see different stars.
> I: Would you see the same stars in the sky all night long?
> T: Yes, but not every month or so. Cause they change.
> I: Why do they change?
> T: Because like, everything moves except the sun.
> I: Do the stars rise and set?
> T: It looks like they do but everything like in this like... the earth goes around and around.
> I: The earth spins around.
> T: Uh-huh.

So, he seems to understand that the stars rise and set because earth rotates. But he does not connect this with the concept that we see different stars through out the night.

Conclusions

This study investigated how students understanding of the motion of celestial objects would change after attending a planetarium program that used kinesthetic learning techniques to reinforce the concepts covered. Through out the planetarium shows, the students appeared to be engaged and happy to participate by moving their arms, pointing to make predictions, and spinning around like the earth. The students' engagement in the material is also evident by the improvement in their understanding of the motions of the celestial objects. The results of the interviews showed that half of the students moved to an accurate understanding of the path of the sun in summer, where none of the students were able to demonstrate the correct path before the planetarium program. They showed an ability to translate the motion they did in the planetarium (tracing the path of the sun with their arm) to interview condition using a flashlight and a small dome. Similarly, six of the students were able to show an accurate path of the moon across the sky compared to none in the pre-visit interview.

The improvement in the students' ability to differentiate between the path of the sun in summer and winter is promising for future instruction relating to understanding the cause of the seasons. More than half of the students were able to show that the path of the sun is higher and longer in the summer and the winter. In the planetarium program, the students actively traced out the path of the sun in both the summer and the winter. They also compared where the sun was at noon on each day by pointing. These kinesthetic activities appear to have helped the students retain the new information from the planetarium program through the motions they mimicked with their bodies.

Since the NSES and Benchmarks suggest students should be learning about the patterns of motion of the stars, I was interested in learning whether they understood that we do not see the same stars in the sky all night long. In the planetarium program, this concept was addressed by having the students play a game. Each student picked a star and followed it across the sky during the night as the stars rose and set. The watched to see which stars set first and which stayed up the longest. This appeared to be a challenging concept for the students as only four of the students improved their understanding in this area. However, following the motion of the stars during the planetarium did help six students improve their understanding of the motion of the stars, though none reached an accurate understanding. It is likely that at this age the students have not had enough real world experiences observing the stars to tie into what they observed in the planetarium and thus they had difficulty making the connections with their understanding of the motion of the stars.

While we did not expect that one 45-minute planetarium program would be enough to address all of the topics that the NSES and Benchmarks recommend for students at this age, it is encouraging to see that this program helped most students improve their understanding of some central concepts. The planetarium program was designed to help students learn through its participatory design, kinesthetic learning techniques, and developmental appropriateness. During the program the students actively participated by bringing up their own prior knowledge through prediction activities and reinforced new ideas in motion of celestial objects through the kinesthetic learning techniques. In the post-visit interviews, students showed improvement in their ability to accurately describe

the motions of the sun, moon and stars across the sky suggesting that the program was successful in changing or positively building on their prior concepts of celestial motion. In addition, students who did not improve to a correct understanding still often showed change in their understanding during the post-interview.

The positive results of this study suggest that instruction designed to be participatory in nature, involve kinesthetic learning techniques and considers developmental appropriateness will promote learning in our students in other areas of astronomy education and planetarium programming.

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Appendix A: Layout of Kinesthetic Learning Techniques program:

Introduction • Explain that the dome is going to be the sky • Ask students to think about what they see in the sky   o “What objects do we see in the sky?” • Explain that the planetarium projector will show us all of the things that we would see in the sky during the day and the night. I will be pushing buttons on the other side of the console to turn on the lights that show these objects and then move the objects across the sky. • Explain to the students that in the planetarium we can show things happening very quickly that really happen very slowly. • Explain that the planetarium machine will spin like the earth spins so that we will see the same thing just like we see because the earth rotates (use earth globe)
The Sun • Tell the students that we are going to pretend that it is the first day of summer, June 21. • Intro questions:

- What makes it daytime? Why is it light outside during the day?
- Where would you look for the sun, first thing in the morning?
- Would it be low or high in the sky?
- Does anyone know what direction the sun is when it rises in the morning?"

- Turn on the sun and point it out in the sky.
- "Does the sun seem to move in the sky during the day?"
- Use your hands and arms to show me how the sun moves in the sky.
- Turn on daily motion- Remind students that we are watching time go by quickly and that the motion we see is because the earth is rotating.
  - Students trace motion with hands and arms.
  - Show the sun rising in the east, passing through the south and getting low in the west.
- Ask the students "What time of day is it when the sun is low in the sky like this?"
- Ask them "what will happen now? Show me what will happen by pointing."
- Turn on daily motion. Show the sun setting. Remind the students that this motion is caused by the earth spinning. The sun sets when we spin away from the earth.

The Stars

- After the sun sets, turn down blues and turn on stars. Do this slowly. Students should watch for the first stars to come out. These are the stars we see just after sunset.
- "Do we see the same stars late at night?"
- Run daily motion – show the sky at midnight.
- "Point to where new stars **rise**. Point for where the stars **set**."
- Stars rise and set because the earth spins around to face them or face away from them.
- "Trace with you arms what the stars are doing. Pick one star bright star and follow it."
- Stop just before the sun is about to rise.
- "At the end of the night, what happens?" The sun rises. "Where is the sun going to rise? Everyone point to where they think we will see the sun again."
- "Show me what the sun is going to do over the course of the day."

Motion of the Sun, Repeat

- Run daily motion again. Observe the sun to rise and set again. Students trace the motion with their arms.
- Stop at noon.
  - "What time is it?
  - "How high is the sun? This is where overhead is in the planetarium sky. Is the sun up there? No, so it's not directly overhead even in the summer." Have students point to the zenith and the position of the sun.
- "Where is the sun going to be in the afternoon when school gets out?"
- "Where is the sun going to set?"
- Run daily motion. Watch the sun set again.

The Stars, repeat

- Find the Big Dipper. Students trace the shape in the sky. Students count the stars along with me.
- Find the North Star. Students follow the pointer stars to the North Star. Find the directions N, S, E, and W.
- Tell the students we are going to play a little game. But first they will need to learn some constellations. Good summer constellations/stars to use: Dolphin, Vega & the Harp, Arcturus & Bootes, Antares & the Scorpion.
- Run daily motion. Watch the motion of each of these objects. Students pick one of the objects and trace it's motion until it sets
- Stop just before sunrise
  - "Could you see your star or constellation all night long?"
- Let the sun rise.
- We have now seen the sun rise and set twice so how many days has it been? Two days.

The Moon – Shape and Orbit

- Haven't seen the moon yet. Some days we don't see the moon in the sky at all.
- Bring out moon ball. Have volunteer hold the earth globe. Show moon's orbit around the earth.
  - Moon's orbit is about 28 days or one month.
  - Moon moving slowly around the earth

- At the same time the earth is rotating. So half of the time our side of the earth is facing the moon.
- Everyone stands up to pretend they are the earth spinning around.

The Moon – Motion in the sky

- "Where will we see the moon when it first rises?"
- Turn on moon
- Run daily motion. Show the crescent moon rising and setting, with the sun also in the sky.
  - Notice that the side of the moon that is lit up is the side facing the sun
  - "Let's watch the sun rise again and wait for the moon to rise too." Run daily motion until the moon gets high enough that the students can all see it clearly.
  - "Is it day or night?" We can see the moon and the sun in the sky.
  - "Point out in the sky what you think the moon is going to do during the rest of the day."
- Have kids trace the motion of the moon in the sky while pointing at the sun as well.
  - Make sure they notice that the moon moves with the sun.
- Stop daily motion after the sun sets and it gets dark, but with the crescent moon still in the sky. Have the kids trace out the shape of the moon.
  - "Did the moon change its shape while it was up in the sky?"
- "Does the moon always look the same in the sky?" Show some pictures of what the moon looks like at different times of the month
  - Show **slides** of the waxing crescent, 1st quarter moon, and full moon.
  - Have students trace out the shape of the moon.
- "I am going to change the date on the planetarium. We are going to move ahead 3 days and see what the sun and moon will do 3 days from now."
- Run the moon ahead to 1st quarter.
  - Watch the sun rise again. "Where will the moon rise? Everyone point where they think." Wait for the moon to rise.
  - "Does the moon look the same?"
  - "Does the moon move across the sky the same? "
  - Continue the motion so they can see that it stays in the sky for a while after sunset before setting.
  - "Did the shape of the moon change as it moved across the sky?"
- Repeat the process for the Full moon. Point out that this about 1 week later, and almost two weeks after the first time we looked at the moon.
- As the moon orbits the earth, it gets farther from the sun in the sky. And when it is far from the sun in the sky, we see more of the moon lit up.
- When moon is full, it is opposite sun in the sky. We see it all night long.

The sun later in the year.

- Turn off the moon projector
- Now we're going to talk about what the sun will do in the Winter
  - Turn on ecliptic and move the sun to Dec. 21
- "Do you think that the sun's motion in the sky will be the same in the winter as it was in the summer? How might it be different?"
- "Now point to where you think the sun will be at lunch time."
- "Now, where is it going to set?"
- Observe the motion of the sun in winter. When sun reaches the south, ask the students "Is that the same as when it was summer? Point to the sun's position at lunchtime in the summer."
- Did we ever see the sun right over head?

The sun and stars today

- Show motion of sun today
- Show tonight's sky