An Astronomy Workshop for Science Teachers

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Abstract

The Virginia Earth Science Collaborative (VESC) under a grant from National Science Foundation via the Virginia Department of Education sponsored astronomy workshops in 2006 and 2007 for earth science teachers. The format of the workshop, the assessment tools utilized, participant comments, its successes and failures and significance are discussed in this paper.

Introduction

Science teachers from grades 6-12 participated in workshops sponsored by the Virginia Earth Science Collaborative at George Mason University. The workshops ran for two weeks in the Summer of 2006 and 2007, plus two additional Saturday sessions in the Fall of 2006 and 2007. The workshops were directed by the author with assistance from Lee Ann Hennig of Thomas Jefferson High School, Alexandria, Virginia. The venue was the astronomy computer laboratory at Innovation Hall, Fairfax Campus of George Mason University.

Methodology

The astronomy workshops conducted at George Mason University were organized by the College of Science (COS), Department of Physics and Astronomy of GMU, the College of Education and Human Development (CEHD) Office of Adult Learning and
Professional Development (OALPD). These workshops were set up as special topic courses under ASTR 590: Special Topics in Astronomy, Astronomy for Teachers. The class meetings in the summer took place in the computer astronomy laboratory in Innovation Hall at the Fairfax Campus of George Mason University. The classes met from 7 August through 18 August in 2006 and 6 August through 17 August in 2007. During these weeks classes were held 5 days a week, from 10AM through 3PM. The classes were supplemented by evening astronomy observing sessions on specified dates when weather permitted. Two follow up sessions, held one full Saturday in October, 2006/2007 and December 2006/2007.

Participants studied astronomy focusing on the concepts which are required by the Virginia Standards of Learning (SOL). Workshop participants utilized commercially available, inexpensive activities for teaching students the concepts required to understand natural phenomena such as the appearance of the night time sky, reasons for the seasons, phases of the Moon, motion of the stars and planets, surface features of the Moon, and the nature of eclipses. The specific items are discussed in more detail later in this report.

The two week summer section satisfied the criteria for a professional development workshop for teachers in grades 6-12. The two follow-up sessions held in the fall of 2006 and 2007 were utilized to assess the lesson plans developed and implemented by the teachers for their respective teaching venues. It was reiterated that the workshops were designed to aid teachers in comprehending and developing lesson plans to address astronomy concepts that are part of the Virginia Standards of Learning.
The workshops included lectures, group activities, laboratory exercises and open class discussions. In 2007, the author introduced the use of a personal response system (PRS). Information presented in lectures included videos, computer displays, demonstrations and transparencies. Questions were accepted at any time and participants were warned to stay alert during the lecture, prepared to answer questions posed by the author. In 2007 teachers were more likely to pay attention as lecture slides were interspersed with questions which required the use of the PRS, which in 2007 was the iClicker (see http://www.iclicker.com). Collaborative class activities required groups of three or four participants. Each participant was expected to hand in a write-up for each activity. These activities included both computer-based and hands-on exercises. Activity reports were turned in at the conclusion of each class meeting, except in those cases when the activity spanned more than a single meeting, especially if there was an appearance of a guest speaker. In 2006 the guest speakers included Heather Weir of NASA Goddard Space Flight Center; Greg Redfern, one of the NASA JPL Planetary Ambassadors; Steven Berr of Learning Technolgies Inc.; Art Poland, a solar physicist at George Mason University; and, Robert Ehrlich, a physicist at George Mason University. In 2007 the guest speakers included Greg Redfern, NASA JPL Planetary Ambassador; Heather Weir of NASA Goddard Space Flight Center; and, Joe Weingartner, astrophysicist at George Mason University.

The expected outcomes from the workshop included the ability of the participants to explain and develop lesson plans for use in their classrooms to explain the appearance of
the night time sky; explain the reasons for the seasons; explain the phases of the Moon, explain the motions of the stars and planets; explain the surface features of the Moon; and explain the nature of eclipses.

The required textbook and accompanying activity materials were provided to the participants as part of their tuition, which was subsidized by the Virginia Earth Science Collaborative. The textbook utilized was Foundations of Astronomy by Michael A. Seeds, 9th edition [1]. VESC arranged for the participants to obtain a CD-ROM copy of the planetarium software called Starry Night [2] with each copy of the textbook. Supplemental activity materials for the course which were also provided as part of the package offered by VESC, included the Mag 5 Star Atlas [3] from Scientific Online; a Diffraction Grating Film sheet (12 inches by 6 inches) from Scientifics Online; a Cardboard Spectrometer Kit [4] from Learning Technologies Inc.; a Celestial Sphere Kit [5] from Learning Technologies, Inc.; a pamphlet called the Cycles Book [6] from Learning Technologies Inc.; a Miller Planisphere [7] from the Astronomical Society of the Pacific; and a Solar Motion Demonstrator Kit [8] from the Astronomical Society of the Pacific.

The participants were made aware from the first day of class of the grading rubric developed for the teacher workshop. In 2006, the weighting was class activities as 60% of the course grade, with an additional 20% of the course grade allotted to the final examination and the remainder 20% of the course grade allotted to the participation and presentation in the fall follow-up sessions [9]. In 2007, the grading rubric was modified
to incorporate the use of the personal response system known as iClicker. The class activities counted for 50% of the grade, class participation via the iClicker counted for 10% of the grade, the final examination counted for another 10% of the grade, and the two follow-up sessions in the fall accounted for the remaining 20% of the grade (10% for each follow-up session).

The syllabus for each of the workshops followed a similar format. During their first day in the workshop, participants spent time filling out the course forms. This included the contract course enrollment form, the contract course information overview, and the payments and receipt for payments. Participants were also provided lunch passes to the food court at the GMU Johnson Center. After the preliminaries took place the participants were given the course pre-test. The workshop pre-test consisted of a combination of three separate tests, for which a composite score was the course pre-test assessment vehicle.

The first portion of the pre-test assessment was an astronomy survey developed by the Consortium of Astronomy Education Research (CAER) [10]. This pre-test is available to the public on the World Wide Web at the following location http://solar.physics.montana.edu/aae/adt/. The second portion of the pre-test assessment consisted of a general astronomy test under development by Harvard University [11]. It is not yet available to the general public. Harvard University allowed Edward Murphy of the University of Virginia to utilize the examination for the purposes of the workshops sponsored by VESC. The third portion of the pre-test consisted of questions from
previous years' Virginia Standard of Learning (SOL) tests that had been compiled by Dr. Edward Murphy at the University of Virginia, and his staff [12].

The first lecture given by the author addressed the issues of the scaling of the universe, both in time and distance measures. The author's PowerPoint presentations are available on the World Wide Web at this location:

http://physics.gmu.edu/~hgeller/TeacherWorkshop/.

There were two activities utilized in the first session. One dealt with the demonstration of a solar system scale model and how teachers could develop their own model. The author utilized a simple tape measure where the scale was noted as being one inch to every million miles of space. This demonstration has been utilized by the author successfully in classes in elementary school grades 6, 7 and 8. In the activity, a participant volunteers to represent the planet at its respective distance. Ms. Hennig demonstrated another means for depicting the scale of the solar system using a piece of
paper and continuous folding in half to demark distances on the sheet of paper. This was later used by a 2006 workshop participant in her own lesson plan.

The second session of the workshop concentrated on the concepts of the night sky and the movements of the stars and planets. The in-class activity was based upon use of the Miller Planisphere, and had been originally developed by this author for use in astronomy laboratory sessions for non-science majors at GMU. During this second session, all participants were asked to join in the Department of Physics and Astronomy's own Astronomy Journal Club. The Astronomy Journal Club is a bi-weekly meeting of faculty and students at GMU, where graduate students present papers that they have read that are relevant to the research that they are interested in participating. The Astronomy Journal Club at GMU was started by Dr. Joe Weingartner. In the 2006 workshop, there were graduate students presenting papers on topics that included the nature of active galactic nuclei and the formation of planets [13,14]. The workshop participants were fascinated by the interaction among graduate students, faculty and undergraduate students who were present for this session of the astronomy journal club. The 2007 workshop did not coincide with any meetings of the Astronomy Journal Club.

When weather permitted, workshop participants were able to observe the night sky with the help of the university's 12-inch Schmidt Cassegrain Telescope by Meade Instruments. Workshop participants in 2006 were able to observe Jupiter and its Galilean Moons, Io, Europa, Ganymede and Callisto. The Moon was also visible on one of the evenings in 2006 and was the subject of intense observing for quite some time, especially the lunar
morphology. Workshop participants also were able to observe the Ring Nebula, M57, as well as some other clusters of stars in the Cygnus portion of the night sky, both quite typical for a summer evening in the local metropolitan area.

The third meeting of the astronomy workshop was used to focus the attention of the participants to the motion of the Sun and the reasons for the seasons. The Mag 5 Star Atlas [3] was handed out in this session. It was used to keep the participants aware of the motion of the Sun throughout the year, specifically the notion of the ecliptic. The in-class activity utilized the Celestial Sphere Kit [5], however, in lieu of having the participants build their own celestial sphere during class time, it was determined by this author that the time would be better utilized by making use of the department’s assembled celestial spheres. The activity completed by the participants was an activity designed by Mary Ewell of GMU Department of Physics and Astronomy and the author. This activity makes us of a commercially available celestial sphere, while all participants were provided with kits to build their own celestial spheres. The activity was designed to demonstrate the different coordinate systems used in astronomy, i.e. the celestial coordinate system and the local horizon system. In the final challenge of this activity, participants are given the location of a star and the local time, and asked to use the celestial sphere to find the precise location on the Earth. This activity is also available on the World Wide Web at this location:

http://physics.gmu.edu/~hgeller/TeacherWorkshop/.

http://physics.gmu.edu/~hgeller/TeacherWorkshop/.
For this third meeting of the astronomy workshop, the author had invited Ms. Heather Weir of NASA's Goddard Space Flight Center. Ms. Weir is the Education and Public Outreach Officer for the MESSENGER mission [15]. This mission is in flight, on its way to study the planet Mercury. Ms. Weir discussed the mission and its scientific objectives. The mission website can be found at the following URL,

http://messenger.jhuapl.edu/

The fourth meeting of the astronomy workshop for teachers, focused on the night sky and the motion of the stars and planets. This session included activities utilizing the Starry Night planetarium software [2]. The author used the activities that are available online from the software publisher at

http://sunra.lbl.gov/~vhoette/Explorations/sass/docs/Backyard%20Student%20Guide.pdf

These activities are useful in demonstrating the capabilities and controls for Starry Night planetarium software, as well as demonstrating basic astronomy concepts such as the phases of the Moon and the change in the location of the Sun during the year. Retrograde motion is also demonstrated in one of the sample activities for the Starry Night planetarium software.

The fourth meeting also included a guest speaker, the NASA JPL Planetary Ambassador, Greg Redfern. Redfern is not only a representative of NASA JPL but he also is a special science speaker on the local radio station, WTOP in Washington DC. Greg Redfern focused his talk on his participation in the search for the nature and origins of the asteroid impact crater within the Chesapeake Bay. This talk fit well with the discussion provided
by the author of the comets and asteroids in the solar system. Observing sessions for the fourth meeting had to be cancelled due to the inclement weather in both 2006 and 2007.

The fifth meeting of the astronomy workshop for teachers, focused on the cycles of the Moon, including the phases of the Moon and its path around the Earth. The author's presentation for this material, and an alternative presentation which was utilized in the teacher workshop held at the University of Virginia by Edward Murphy, is available online at the author's webpage for the workshop noted above.

The fifth meeting of the workshop in both 2006 and 2007, included a demonstration of the use of a portable planetarium. Steven Berr, the area representative for the Starlab Portable Planetarium [16] was the special guest in 2006. In the 2007 workshop, Lee Ann Hennig and the author were the demonstrators and speakers within the StarLab Portable Planetarium. This workshop session provided participants with an opportunity to see how a portable planetarium was set up and utilized to demonstrate such concepts as the path of the Sun throughout the year, the changing constellations that are visible in the night sky, the names and locations of the constellations, and the change in the constellations during the entire year.
The sixth meeting of the astronomy workshop for teachers was held focused on the relationships between the Sun, Earth and Moon, especially lunar and solar eclipses. The author lectured about eclipses. The in-class activity dealt with the Moons of Jupiter. The activity was a computer based activity utilizing the software by Gettysburg College developed on a grant from the National Science Foundation [17]. Because the effort was publicly funded, the materials developed on the grant by Gettysburg College are available free at the Gettysburg College website. The suite of software is known as CLEA, the Computer Laboratory Exercises for Astronomy. The particular software used in this meeting was the Moons of Jupiter. There is an activity manual utilized for this exercise also available free online from the Gettysburg College web pages at this location:

http://public.gettysburg.edu/~marschal/clea/.

The seventh day of the workshop began with discussion on the origins of modern astronomy, especially the Copernican Revolution and the observations of Tycho Brahe, Galileo Galilei, and Johannes Kepler. The guest speaker in 2006 was Dr. Art Poland.
Dr. Poland retired from NASA's Goddard Space Flight Center. He was the Project Scientist for the SOHO mission [18]. The SOHO mission was focused on the study of the sun its accompanying heliosphere. Inclement weather again forced the cancellation of the observing sessions in 2006 and 2007.

The eighth day of the workshop began with a presentation on Newton’s Laws of Motion, Newton’s Law of Universal Gravitation, and an introduction to Einstein’s Relativity Theory, both the Special Theory of Relativity and the General Theory of Relativity. The participants also concluded their exercise utilizing the Gettysburg College CLEA module on the Moons of Jupiter [17]. The guest speaker at this session in 2006 was Robert Ehrlich of George Mason University’s Department of Physics and Astronomy. Ehrlich focused his presentation on Einstein’s Special Theory of Relativity and an animated presentation that he developed for discussing the Special Theory of Relativity for a contest run by the Pirelli Tire Company [19]. Ehrlich was a finalist in the competition. The winning animation for the competition was also demonstrated by Dr. Ehrlich in class to the teacher participants.

The ninth day of the workshop began with a lecture on light, electromagnetic radiation and telescopes. There were laboratory activities in reflection and refraction utilizing George Mason University’s Department of Physics and Astronomy PASCO equipment. The PASCO Corporation of Roseville, California has developed computer interfaced hardware for physics demonstrations [20]. The activities completed by participants were adapted from the PASCO experiments by Mary Ewell and Harold Geller. The activities
focus on the demonstration of light waves undergoing reflection and refraction, with mirrors and lenses, utilizing a small optical bench. Participants also received their own diffraction gratings (12 inch by 12 inch), for use in their own classrooms and/or classroom activities. Teacher participants had already familiarized themselves with the GMU 12” SCT Meade telescope. However, in the discussion of the different types of telescopes, radio telescopes were also discussed. Teachers were given a demonstration of the GMU Small Radio Telescope, designed by researchers at MIT’s Haystack Observatory [21]. One of the 2006 workshop participants is pictured in Figure 3a next to the GMU Small Radio Telescope. The radio telescope demonstration was followed by an observing session on the roof of the Research 1 building at the Fairfax Campus of George Mason University for the 2006 workshop. Weather interfered with the observing session for the 2007 workshop, however, workshop participants are pictured in the observatory in Figure 3b.

Figure 3a – 2006 Workshop Participant next to Small Radio Telescope at GMU Science and Technology I building

Figure 3a – 2007 Workshop Participants at GMU Observatory at Research I Building
The tenth day of the workshop was also the final meeting day in the summer period of the workshop. The teacher participants first listened to a brief lecture about light and spectroscopy. Each teacher received their own cardboard spectrometer. However, due to time constraints, in lieu of spending an hour building their spectrometers, the participants were given pre-assembled plastic spectrometers. These spectrometers work exactly as the cardboard spectrometers, but their pre-assembly enabled the participants to complete a spectrometer exercise designed by Mary Ewell and Harold Geller in a more timely manner. This exercise has the participant examine a spectrum for different sources. Participants are able to see the difference between the spectrum produced by an incandescent bulb, fluorescent lamp bulbs and three different gases (e.g. hydrogen, helium and neon) utilizing a gas-filled tube and a 10,000 volt arc generating power supply. The spectrometer activity was followed by a post-test. The post-testing consisted of the same tests administered for the pre-testing of the participants. That is, each participant completed the CAER Introductory Astronomy Post-test, the Harvard General Astronomy Post-test, and the Virginia SOL Astronomy Questions Post-test.

Standard course evaluation forms used by the College of Arts and Sciences at George Mason University were handed out to the participants at the end of this final summer session meeting. These forms were delivered to the George Mason University Office of Internal Assessment for recording and analysis. Only the 2006 course evaluation forms were available to be included in this report. The 2007 course evaluation forms were not returned to the author as of the writing of this report.
The first 2006 fall follow-up was held on 14 October 2006, at George Mason University. The first 2007 fall follow-up was held on 13 October 2007. Both follow-up sessions were run in the same manner, except for the allocated time per participant. In 2007, with fewer participants needing to present their lesson plans, more time for presentation and discussion were allotted. Each participant was given guidelines for this meeting, which required presentations made by the teacher participants. Each participant was given 10 minutes in 2006 (20 minutes in 2007) to present their lesson plan which they developed, and which they would use in their classroom. Their presentations had to include at least the following:

- The concept that was to be covered in the lesson plan;
- The approach that was to be taken to pre-test their students;
- A sample of the activity in the classroom;
- The approach that was taken for a post-testing of the students; and,
- A summary of how the lesson plan fit into the overall teaching strategy of the teacher.

Three participants were not able to make the first fall follow-up session for the 2006 workshop. Only one participant failed to make the first follow-up for the 2007 workshop. Those participants who were not able to attend the first fall follow-up sessions were allowed to participate in absentia by doing the assignment and sending a videotape of themselves giving their presentation, just as they would have done in the first fall follow-up session. One teacher in the 2006 workshop had a colleague come to the follow-up
session and present his materials and lesson plan to the workshop participants. In 2006 there was one participant who did not show up even after the staff supporting the workshop had made reservations for her.

An example of the lesson plans presented in 2006 and 2007 are appended to this report. The 2006 workshop lesson plan appended is by Fred Kourmadas. Kourmadas chose to address planetary motion and lunar phases. In the Virginia Standards of Learning, this relates to standards ES.1, ES.2 and ES.4. Kourmadas developed a test which he chose to use for both pre-testing and post-testing of the students. Kourmadas incorporated a number of activities into his lesson plan. He chose to utilize the Starry Night software which was provided to teacher participants of the workshop with their textbooks. He uses Starry Night files to visualize for students the motion of the Moon as well as the changing phases of the Moon. He also developed an activity based upon a diagram in the Seeds textbook. He traced the diagrams from the textbook and developed a hands-on dial activity. He developed a worksheet to go along with the dial which prompts the students in a “do and tell” manner. He then tests the learning done by the students by administering the same test utilized for the pre-test. His lesson plan itself follows what he refers to as the “Five Es,” engage, explore, explain, extend and evaluate (see details from his lesson plan appended to this paper). Fred Kourmadas is a high school earth science teacher.

The 2007 workshop lesson plan appended is by Steven Peters. Peters did not utilize a formal pre-test format. His pre-test allows for the students to demonstrate, by their
actions in the classroom, how far apart, and how large the planets are, compared to one another. He then goes through the activity, using both a hands-on model and a computer generated model of the solar system. The latter is available from the Exploratorium webpage noted on Peters' summary sheet appended to this report. The post-test proposed by Peters is a written test which seeks to have the students demonstrate their knowledge, after the activity, of the relative location and size of the planets of the solar system. It should be noted that Steven Peters is a 6th grade science teacher.

For the most part, participants in the first fall follow-up session presented scientifically accurate depictions of the astronomy concepts that they were trying to teach to their students. Unfortunately, there was a case of one teacher in the 2006 workshop who presented an activity which was not scientifically accurate in its depiction. One of the participants presented an activity for helping her students learn the phases of the Moon. Unfortunately, the activity presented could easily mislead her students into thinking that the phases of the Moon were caused by shadows of the Earth. This leads to confusion between phases of the Moon and Solar and Lunar eclipses. Only one teacher participant spoke up with a valid question regarding this activity. Unfortunately, the teacher’s response to the question about the possibility of misleading students into thinking that shadows cause the phases of the Moon was answered with the irresponsible comment that she “didn’t care if the students got the wrong idea from the activity,” she only cared that “the activity would allow the students to properly answer the questions regarding which phase of the Moon was in the picture on the SOLs.”
Results

The pre- and post test results for the 2006 workshop are depicted in Figure 4. As can be seen by the bar graph representation of the pre-and post-test results, all of the participants improved their scores. Overall, teacher participants in this 2006 VESC sponsored workshop scored a mean of 72 percent correct answers on the pre-test, and a mean of 82 percent correct answers on the post-test.

![Figure 4 – Pre- and Post- test results for workshop participants](image)

The pre- and post test results for the 2007 workshop are depicted in Figure 5. As can be seen by the bar graph representation of the pre-and post-test results, all but one of the participants improved their scores. Overall, teacher participants in this 2007 VESC
sponsored workshop scored a mean of 69 percent correct answers on the pre-test, and a mean of 76 percent correct answers on the post-test.

Figure 5 – Pre- and Post- test results for 2007 workshop participants

Based upon the results of the course evaluation forms from the 2006 workshop (2007 course evaluation forms not available at the time of this writing), teacher participants also seemed to be pleased with the course. Utilizing a Likert scale of 1 through 5, instructor preparation scored a mean of 4.93. On the same scale course organization scored a mean of 4.81, instructor motivation scored a mean of 4.69, intellectual challenge scored a mean of 4.2, instructor fairness scored a mean of 4.94 and overall course rating scored a mean of 4.75.
Written comments from the teacher participants included these positive comments:

- Great guest speakers
- Great teacher resources provided
- Target audience kept in mind
- Excellent organization of learning
- Great visualizations and hands-on learning
- Good activities to demonstrate concepts
- Excellent team teaching approach
- Provided hands-on materials that could be used in classroom

Negative comments from the teachers included the following:

- Desire to gear course more to Virginia SOLs, specifically left out SOL ES.14
  [NOTE: this was addressed by a presentation on ES.14 at the first follow-up session and the same presentation was utilized during the 6th day of the 2007 workshop]
- Preferred to start later in the day, and not have to return for observing sessions
- Preference for having more night time observing sessions
- Desire for it to be more intellectually challenging
- Desire to have a review specifically for the final post-test examination
- Post-test could have had better questions
During the 2006 and 2007 follow-up sessions, the participants presented the respective lessons plans they had developed based upon the coursework in the summer. There was a wide variance in the level of effort placed into developing the lesson plans, as was demonstrated in the length of the presentations and the use of PowerPoint presentation slides. There was one case in the 2006 workshop which was cause for concern. That was the teacher who developed an activity for determining the phases of the Moon, which would mislead students into thinking that the phases of the Moon were caused by shadows of the Earth. It was unfortunate that the teacher felt that it was more important for the students to be able to have a mechanism for getting the answers correct on the statewide examinations than understanding the concept. This may be a fatal flaw. The 1997 Harvard University study [22] regarding the student concepts of the universe around them, demonstrated that misconceptions established early in the student’s academic career, stayed with the students well into their college careers, in spite of the logical inconsistencies that should point the students to knowing better.

While the pre- and post- test results depict a quantitative snapshot of the results from participating in the workshop, there are qualitative measures to evaluate also. Based upon comments received personally from the teacher participants and from comments made on the course evaluation forms, the following was deduced regarding the results of the workshop.

All of the teachers were pleased to receive so many handouts, including materials that could be used as part of activities in their own classroom. All of the teachers also
appeared to benefit from the guest speakers, whether from NASA Goddard Space Flight Center or George Mason University itself. The teachers were a bit split regarding the activities done during the workshop. While many teachers were new to some of the material and thus benefited from all of the activities, a couple of teachers noted in their course evaluation forms that the activities were too simple for them. At the same time, some teachers noted that there were activities which were too difficult. A majority of the teachers commented that the course team, Lee Ann Hennig and Harold Geller had worked well together. Some teachers noted that the pre- and post-testing was not “fair” in that the questions were not specifically answered during the course of the workshop. All of the teacher participants appeared to enjoy and benefit from the demonstration of the StarLab portable planetarium system. Teachers were also pleased with the Gettysburg College CLEA computer exercises as well as the Starry Night exercises.

A number of the teachers were disappointed that the workshop did not go into greater detail about astronomy and astronomical concepts. They were disappointed that the workshop was at the level of the Virginia SOLs. On the other hand, some teachers were disappointed that the workshop was not geared more directly to the questions that were likely to appear on the Virginia SOLs in the future. All teachers expressed a disappointment with the number of observing sessions. Unfortunately, this instructor has not mastered the ability to control the weather. The author was also disappointed that the George Mason University observatory had not yet been completed. The GMU observatory was due to be completed by July at the time that the workshop had been arranged. In fact, the GMU observatory was not completed until the end of 2006, and
officially opened on 24 January 2007. There were also complaints from teachers who had to travel more than 50 miles to the workshop. However, it should be noted that there was a similar workshop run by the University of Virginia and Dr. Edward Murphy in June of 2006 [23]. A number of teachers did not like the requirement for participating in follow-up sessions. However, numerous education surveys and education research in professional development support the need for such sessions to ensure that teachers will utilize what they have learned in their own classroom. In fact, previous studies of professional development courses have concluded that the average lasting effect of a professional development course is about 1 day [24, 25, 26].

Conclusions

Education research into professional development courses has shown a somewhat contradictory set of effects. While studies have demonstrated that such professional development courses are “key mechanisms for providing teachers with ongoing training opportunities,” they have also shown that most professional development courses have a short term effect and lack adequate follow-up. In fact, two studies sponsored by the U.S. Department of Education lead to a conclusion that “formal professional development typically lasts for the equivalent of 1 day.” [26]. This point was highlighted to the author by Donna Sterling [27]. This is not a particularly new issue, as it was highlighted by Thomas Guskey over 20 years ago [28].

It has also been shown that teachers “were most likely to have participated in professional development that focused on state or district curriculum and performance standards.” [26]
Thus, the VESC workshops were focused on the Virginia Standards of Learning. Furthermore, since it was found that “the extent to which teachers felt that participation in the activity improved their teaching depended on whether that activity was followed by various school-based activities,” it was determined that there must be two distinct follow-up sessions in the ensuing fall semester [26].

Based upon the assessment measures derived from the comparison of pre- and post-testing, course evaluation forms, fall follow-up sessions, and individual teacher participant comments, the VESC sponsored teacher workshop in astronomy was a success. However, it must be noted that if not for the research done in the past and the participation of all those individuals mentioned in the acknowledgments of this paper, the outcome from this workshop would have been very different indeed.

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References


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Appendix A – Lesson Plan Submitted by Fred Kourmadas

ES.1 The student will plan and conduct investigations in which
   c) scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted;

ES.2 The student will demonstrate scientific reasoning and logic by
   a) analyzing how science explains and predicts the interactions and dynamics of complex Earth systems;
   b) recognizing that evidence is required to evaluate hypotheses and explanations;
   c) comparing different scientific explanations for a set of observations about the Earth;
   d) explaining that observation and logic are essential for reaching a conclusion;

ES.4 The student will investigate and understand the characteristics of the Earth and the solar system.
   Key concepts include
   a) position of the Earth in the solar system;
   b) sun-Earth-moon relationships (seasons, tides, and eclipses);
   c) characteristics of the sun, planets and their moons, comets, meteors, and asteroids;

Note: This lesson would be part of a unit that would go something like:
Lesson 1: Planetary Motion & Lunar Phases
   - Pretest
   - History – geocentric vs. heliocentric models
   - Earth’s orbit – brief overview (more detail next lesson)
     - The moon’s orbit
       o Tilt
         ▪ Solar eclipses
         ▪ Lunar eclipses
       o Phases

Lesson 2: Earth’s Orbit
   - Tilt
     o Seasonal changes
   - Eliptical orbits
     o Kepler’s law

Lesson 3: Other Planetary Orbits
   - The Ecliptic
   - Historical thought about planetary motion
     o Geocentric model
       ▪ “Retrograde” planetary motion
       ▪ Phases of Venus
   - Copernicus and the Heliocentric model
   - Galleleo, Brahe, Kepler
Lesson Plan Approach: Planetary Motion and Lunar Phases

Engage:
- Using an LCD projector or Aver Key and television set, teacher will show students the Lunar Motion and Phases of the Moon Starry Night files.
- Students are issued the pre-test. (10 minutes)
- Following the pre-test, the teacher will group students in 4’s or 5’s, and ask them to discuss their answers and their orbital diagrams. (5 minutes)
- Teacher asks groups to present their consensus findings. (Teacher is attentive to disagreements and misconceptions.)

Explore:
- Once again showing phases with Starry Night, teacher will ask students to describe the shape of visible moon at key phases (new – not visible, crescent, gibbous, full).
- Teacher will introduce phases vocabulary at this time, students will complete graphic organizer as notes.
- Students will be asked which position on lunar orbit diagram will have which appearance.

Explain:
- Using flashlight and different size balls, teacher will guide students in trying to re-create phase appearances, paying particular care to address any misconceptions that may have arisen (such as phases of moon being caused by earth’s shadow, etc.).
- PowerPoint graphics of phase vs. position in orbit will be shown.
- Teacher will introduce solar and lunar eclipse concepts and vocabulary.
- Continue with PowerPoint, eclipse graphics.
- Again using balls and flashlight, and this time adding a hula hoop to represent lunar orbit, teacher will demonstrate the tilt and the procession of lunar orbit.
- Teacher will demonstrate when eclipses occur and when they do not occur.

Extend:
- Teacher will distribute Lunar Phase activity card, scissors, and brads.
- Students will construct their Lunar Phase dial.
- Teacher will demonstrate its use, then students will answer questions using Lunar Phase dial.

Evaluate:
Post-test. Normally this would be done at the end of the unit, but it will be done this time at the end of the lesson, and only the material actually covered will be evaluated.
Match the **cause** with the **effect**. (Some causes will be used more than once):

**EFFECTS**

___  1. Day and night  
___  2. Summer and winter  
___  3. Sunrise in the East, sunset in the West  
___  4. Phases of the moon  
___  5. Lunar eclipses  
___  6. Solar eclipses  
___  7. Moonrise in the East, set in West  
___  8. Eastward progression of moon compared to stars  
___  9. Apparent revolution of constellations around the North Star  
___ 10. The same side of the moon always faces the Earth

**CAUSES**

A. Rotation of the moon on its axis  
B. Rotation of Earth on its axis  
C. Revolution of the moon around the Earth  
D. Revolution of the Earth around the sun  
E. The tilt of Earth’s axis  
F. The tilt of the moon’s orbit  
G. The shadow of the moon on the Earth  
H. The shadow of the Earth on the moon

In the drawing below (which is NOT to scale), draw the Earth’s orbit and the moon’s orbit. Assume that you are looking directly down at the solar system, from a point above the north pole of the sun. Indicate the direction using an arrow on the orbit.

![Diagram of solar system with labeled planets and orbits]
Space and Our Solar System

How vast is our Solar System?

Goal: One of the hardest things for students at grade 6 to fathom is the vastness and distances between objects in space. The skill associated within the astronomy unit is model making. So we will research the bodies, as a review of our text reading, and construct a model of the Solar system to scale so we can better visualize the expanse between the members that make up our tiny solar system. Additional Goals in this activity include the introduction of group work and the expectations involved, a review of the textual readings and the introduction of scaling as part of model making.

Pretest: I will not be giving a formal pretest. Instead we will use some models we already have of the planets and stars to determine the student perception of their accuracy and the distances between planets, and their relative sizes.

Posttest: This lesson has several goals which includes familiarizing students with the planets and their unique features. Develop their skills in model making and scaling and appreciating the extreme distances even within our own galaxy. Questions covering each of these objectives will be on the final unit test.

Implementation: Working in groups, students will
1) Choose a group leader to manage the task
2) Divide the elements of the solar system up so each student has planet to research and construct
3) Research each element noting statistics and features
4) Create a scale for the universe. (Possible bonus points)
5) Make a model of their planet or item to scale
6) Display and tell about their model orally (1 minute)
7) Set up the model, in order and using the same scale as used in the construction of the piece, outside.
8) Engage in a review discussion about the activity as a follow-up.

Using the program provided by exploratorium (see web address below) students will try to calculate the sizes of the planets with the following prerequisite; the planets must be at least 3 millimeters in diameter so they can be viewed as a model. Bonus points will be given for those who can do the calculations without the programs assistance. Within the given time students will spend a day researching the planet and begin building the models after checking the calculations with the teacher for accuracy. Models will then be prepared and displayed along with a 1 minute or less talk. The models will then be taken and set up outside to show the correct scaled distances between them.

http://www.exploratorium.edu/ronh/solar_system/
Project Goals?

Objectives
- Review the characteristics of the inner and outer planets we have read about in the textbook
- Begin to develop good group-work habits
- Develop model making skills i.e. scaling
- Develop a sense of the size and space of our solar system
Group Work Skills

1. learn to cooperatively solve problems and work together with all types of people
2. learn to break a task into component parts and assign components equitably
3. maximize the talents and skills of each member of the group
4. participate fully in solving the problems or completing the product
5. assist others who need help
6. understand with complete clarity all aspects of the problem and the solution found or projects created
7. develop skills which will help lead or follow the leader of a group
8. learn to communicate effectively and kindly with all members of the group
9. learn to prioritize and organize work so that the time available is used most effectively
10. schedule work so that the project is completed and prepared for presentation on time
## Scaling the Model-Visibility

### Solar System Model

<table>
<thead>
<tr>
<th>Body</th>
<th>Body Diam (km)</th>
<th>Body Diam (in)</th>
<th>Body Diam (mm)</th>
<th>Orbit radius (km)</th>
<th>Scaled orbit radius (ft &amp; in)</th>
<th>Scaled orbit radius (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>1391900</td>
<td>546</td>
<td>200000</td>
<td>81</td>
<td>261.47 ft 31.47 in 24.86 m</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>4866</td>
<td>0.019</td>
<td>0.75</td>
<td>57950000</td>
<td>12.78 ft 15.35 in 4.22 m</td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td>12106</td>
<td>0.054</td>
<td>2.125</td>
<td>108110000</td>
<td>35.31 ft 42.38 in 11.74 m</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>12742</td>
<td>0.512</td>
<td>20.1</td>
<td>149570000</td>
<td>49.36 ft 59.24 in 15.74 m</td>
<td></td>
</tr>
<tr>
<td>Mars</td>
<td>6760</td>
<td>2.67</td>
<td>105.08</td>
<td>227840000</td>
<td>75.90 ft 90.50 in 24.72 m</td>
<td></td>
</tr>
<tr>
<td>Jupiter</td>
<td>139516</td>
<td>5.37</td>
<td>213.3</td>
<td>778140000</td>
<td>253.33 ft 303.90 in 87.89 m</td>
<td></td>
</tr>
<tr>
<td>Saturn</td>
<td>116438</td>
<td>4.76</td>
<td>187.36</td>
<td>1427000000</td>
<td>464.33 ft 557.23 in 172.40 m</td>
<td></td>
</tr>
<tr>
<td>Uranus</td>
<td>46940</td>
<td>1.86</td>
<td>73.6</td>
<td>2870300000</td>
<td>921.40 ft 1093.85 in 299.49 m</td>
<td></td>
</tr>
<tr>
<td>Neptune</td>
<td>45432</td>
<td>0.72</td>
<td>28.64</td>
<td>4499900000</td>
<td>1443.64 ft 1732.40 in 543.95 m</td>
<td></td>
</tr>
<tr>
<td>Pluto</td>
<td>2274</td>
<td>0.09</td>
<td>3.69</td>
<td>5913000000</td>
<td>1909.90 ft 2292.00 in 722.11 m</td>
<td></td>
</tr>
</tbody>
</table>

## Scaling Distance to fit the Classroom

### Solar System Model

<table>
<thead>
<tr>
<th>Body</th>
<th>Body Diam (km)</th>
<th>Body Diam (in)</th>
<th>Body Diam (mm)</th>
<th>Orbit radius (km)</th>
<th>Scaled orbit radius (ft &amp; in)</th>
<th>Scaled orbit radius (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>1391900</td>
<td>0.0003</td>
<td>1.17</td>
<td>57950000</td>
<td>2.78 ft 3.33 in 2.65 m</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>4866</td>
<td>0.0003</td>
<td>0.12</td>
<td>57950000</td>
<td>2.78 ft 3.33 in 2.65 m</td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td>12106</td>
<td>0.0005</td>
<td>0.20</td>
<td>108110000</td>
<td>5.15 ft 6.18 in 4.95 m</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>12742</td>
<td>0.0026</td>
<td>0.10</td>
<td>149570000</td>
<td>5.91 ft 7.09 in 5.68 m</td>
<td></td>
</tr>
<tr>
<td>Mars</td>
<td>6760</td>
<td>0.0033</td>
<td>0.13</td>
<td>227840000</td>
<td>10.95 ft 13.12 in 10.12 m</td>
<td></td>
</tr>
<tr>
<td>Jupiter</td>
<td>139516</td>
<td>0.0057</td>
<td>0.23</td>
<td>778140000</td>
<td>29.81 ft 35.77 in 28.10 m</td>
<td></td>
</tr>
<tr>
<td>Saturn</td>
<td>116438</td>
<td>0.0055</td>
<td>0.22</td>
<td>1427000000</td>
<td>59.62 ft 71.54 in 57.63 m</td>
<td></td>
</tr>
<tr>
<td>Uranus</td>
<td>46940</td>
<td>0.0022</td>
<td>0.09</td>
<td>2870300000</td>
<td>103.00 ft 123.61 in 39.75 m</td>
<td></td>
</tr>
<tr>
<td>Neptune</td>
<td>45432</td>
<td>0.0021</td>
<td>0.09</td>
<td>4499900000</td>
<td>150.30 ft 180.37 in 59.45 m</td>
<td></td>
</tr>
<tr>
<td>Pluto</td>
<td>2274</td>
<td>0.0000</td>
<td>0.00</td>
<td>5913000000</td>
<td>210.00 ft 252.00 in 77.21 m</td>
<td></td>
</tr>
</tbody>
</table>
## Scaling the model-Outside
Size and Distance is the same Scale

**Solar System Model**

<table>
<thead>
<tr>
<th>Body</th>
<th>Body Diam (km)</th>
<th>Body Diam (in)</th>
<th>Body Diam (mm)</th>
<th>Orbit radius (km)</th>
<th>Scaled orbit radius (ft &amp; in)</th>
<th>Scaled orbit radius (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>1391900</td>
<td>23.6</td>
<td>600</td>
<td>57950000</td>
<td>81 ft 11.47 in 24.98 m</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>4866</td>
<td>0.0085</td>
<td>2</td>
<td>108110000</td>
<td>152 ft 10.74 in 46.602 m</td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td>12106</td>
<td>0.0205</td>
<td>5.2</td>
<td>149570000</td>
<td>211 ft 8.38 in 64.494 m</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>6760</td>
<td>0.1119</td>
<td>2.8</td>
<td>227840000</td>
<td>332 ft 5.69 in 103.213 m</td>
<td></td>
</tr>
<tr>
<td>Mars</td>
<td>3666</td>
<td>0.5977</td>
<td>19.5</td>
<td>5913000000</td>
<td>898 ft 6 in 2540.89 m</td>
<td></td>
</tr>
<tr>
<td>Jupiter</td>
<td>139516</td>
<td>2.3077</td>
<td>89.1</td>
<td>7781400000</td>
<td>1168 ft 5.0 in 353.429 m</td>
<td></td>
</tr>
<tr>
<td>Saturn</td>
<td>116438</td>
<td>1.976</td>
<td>78.1</td>
<td>14270000000</td>
<td>2078 ft 7.2 in 635.13 m</td>
<td></td>
</tr>
<tr>
<td>Uranus</td>
<td>46940</td>
<td>0.7986</td>
<td>31.2</td>
<td>28703000000</td>
<td>4092 ft 4.09 in 1237.267 m</td>
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<tr>
<td>Neptune</td>
<td>45432</td>
<td>0.7721</td>
<td>19.5</td>
<td>44999000000</td>
<td>6364 ft 0.16 in 1933.751 m</td>
<td></td>
</tr>
</tbody>
</table>