DESIGN AND IMPLEMENTATION OF OBSERVATIONAL LABORATORY COMPONENTS FOR INTRODUCTORY ASTRONOMY AT AUGUSTANA UNIVERSITY

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ABSTRACT

We outline the design of observational laboratory material for the introductory astronomy course for non-science majors at Augustana University. These laboratories utilize the Physics Department's 10-inch Schmidt-Cassegrain telescope and high-resolution CCD camera. The laboratories were developed in the Summer of 2017 and implemented in the Fall of 2017. We test the effectiveness of the new laboratories by comparing student's gains in Fall 2016 (without the labs) with Fall 2017 (with the labs) using the *Astronomy Beliefs Inventory*. The Fall 2017 gains are statistically significantly higher than Fall 2016 gains indicating that more learning was done in the semester with the observational laboratories. While it is possible that the observational laboratories contributed to the increase in student learning, other factors, such as the increase in contact hours during Fall 2017 compared to Fall 2016, are discussed.

INTRODUCTION

Prior to 2016 the introductory astronomy course at Augustana University was a non-laboratory science course fulfilling a requirement of the Augustana General Education Plan. The redesigned general education eliminated the requirement for non-laboratory science courses. Therefore, the department created a laboratory component for the course. The first implementation in Fall 2016 relied heavily on simulations. For example, the University of Nebraska has useful introductory content available as web applications using Adobe Flash (http://astro.unl.edu/naap/). Compadre also has a searchable set of material and Java applets (https://www.compadre.org/?). However, we wanted students to gather and analyze data in the laboratory similar to other laboratory science courses. The department purchased a 10" Schmidt-Cassegrain telescope, CCD camera, and color filter wheel to make basic observations and to obtain and analyze images.

Because of the general education curricular changes (see e.g. http://www.augie.edu/academics/augustanas-core-curriculum), the number of pre-service teachers taking the introductory astronomy course rose sharply in 2016. About half of the approximately 30 students were pre-service teachers. The revised Augustana general education, which was implemented starting in the Fall of 2016, requires only one laboratory science course. Therefore, introductory astronomy may likely be the only laboratory science course taken by many pre-service teachers. In a state like South Dakota where many teachers in smaller districts teach outside of their expertise and experience, we felt providing teachers with additional resources for science education was important. Therefore, simultaneous with updating the laboratory manual with new observational laboratories, we decided to include specific K-12 resource material that would be useful for pre-service teachers as they start their service.

In the summer of 2017 we developed the set of observational labs with the new telescope and CCD camera and complied the set of K-12 resources. In this paper we discuss the enhancements to the laboratory manual, their implementation in Fall 2017, and the assessment of student learning by comparing Fall 2016 without the labs and Fall 2017 with the labs. The laboratory development and teacher resources are discussed in Section "Modifications to Astronomy Laboratory Manual". The implementation of the laboratory and the assessment is given in Section "Testing the Effectiveness of the Laboratories".

MODIFICATION TO ASTRONOMY LABORATORY MANUAL

In this section we discuss the details of the modifications to the astronomy laboratory manual. For the observational labs we focus on decisions about the kinds of observational labs that could be performed with our equipment and their time constraints. We give some examples of the kinds of labs developed and details about the K-12 teacher resources that were included.

Observational Laboratories. Because our telescope is not permanently mounted, is not weather shielded, and is used on campus in the middle of an urban area, we chose to observe objects that are bright and easy to locate. This meant that the CCD image exposure was short, less than 1 second. Minimizing the exposure time reduces effects of incomplete telescope alignment that can cause objects to slew in the field of view as the telescope tracks. The brightest stars like Vega, planets like Jupiter and Saturn, and the Moon are natural objects for viewing. There are a number of quantitative analyses that can be performed with these images. In this section we highlight three of the observational laboratories that were the most complete and used during the Fall 2017 course. Each laboratory was designed to fit within the two hour laboratory.

Introduction to CCD Imaging. Prior to taking images using the CCD camera, students need exposure to the device itself. In one of the first labs in the semester, students are introduced to astronomy imaging using a multi-part laboratory. Each part is independent of the others and can be done in any order.

One part of the laboratory lets students use the CCD camera indoors by taking dark images. They learn to use the software: how to connect the camera to the software, how to cool the device, how to take exposures, and how to subtract dark frames when the camera's aperture is not open. Students become familiar with dark counts where pixels register light from background sources such as thermal noise. There are also exercises to identify particular pixel data and to integrate counts within a rectangular window of the image. In a separate part, students explore a tool simulating the digital output of a CCD and what can occur during overexposure (http://astro.unl.edu/naap/vsp/ccds.html). In this exercise the number of bits representing the pixel count and the exposure time can be varied. Students get a feel for saturation as well as the charge being shared with nearby pixels.

In another portion, students learn to measure the apparent magnitude of stars in a star field. This method integrates counts in a small window including the star and a larger window including the star and background. The difference in integrated counts can be used to estimate the background/pixel, which is then subtracted from the smaller integration window in order to determine the integral counts from the star only. The difference in apparent magnitude m_1- m_2 can be determined by the ratio of the counts, c_1 and c_2 for the two different stars.

Assuming one of the stars in the field of view is Vega, the historical reference star for the apparent magnitude scale, the apparent magnitude of each star can be determined. Students have the option to attempt the same analysis using one of the department's images of the Vega star field. Since this is the introduction to the CCD image, it is not expected that the students would take their own images for this lab.

Lunar Crater Depths. Once students have familiarity with CCD images, a first easy image is the Moon. One particularly accessible and popular laboratory of the Moon is the measurement of the depth of craters. We utilized information on the University of Iowa website for this laboratory (http://astro.physics.uiowa.edu/ITU/labs/observational-labs/studying-the-moon/measure-the-height-of-lunar/). Students take an image of the Moon during 1st or 3rd quarter with the terminator, the line dividing the daytime and nighttime sides of the Moon, in view. Assuming a known distance to the Moon, students use geometry to determine the absolute depth of craters, especially for those closest to the terminator.

Figure 1 shows the image of the Moon taken with the telescope and CCD camera. Because of weather, students in Fall 2017 were not able to take an image of the Moon during this phase. They were, however, able to use this image and measure the pixel distances from the terminator to several craters and the pixel widths of crater shadows. Students learn how to translate pixel size to linear distance by knowing the characteristics of the CCD camera and the distance to the Moon.

In a two hour lab, there is sufficient time when images can be taken quite quickly. We estimate 30-45 minutes is necessary to get a sufficient number of images and cycle five groups of three students so that each group can take multiple images. Each group will have about 6-9 minutes to learn about focusing the telescope and aligning the camera field of view and to take images. This leaves about an hour to reconvene in the lab room to analyze images.

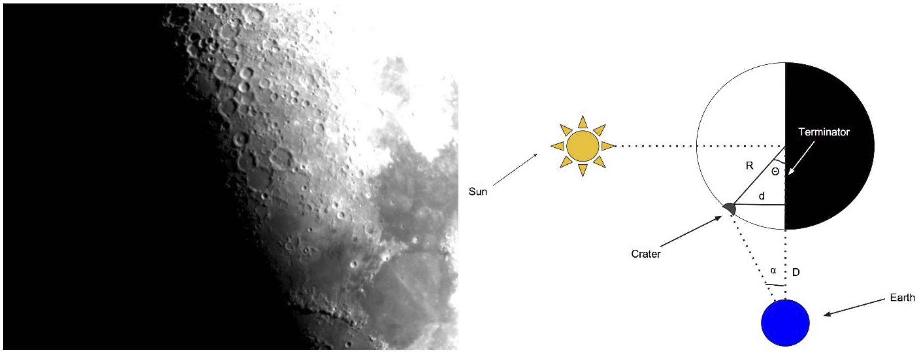

Figure 1.* Left*: Image of the Moon during 3rd quarter along the terminator.* Right*: Laboratory image giving information about the geometry of the problem.

Magnitude Measure of Jupiter's Galilean Moons. A slightly more challenging image is of Jupiter and the Galilean moons. In particular the goal of this laboratory is to take a longer exposure to confirm that students are capturing enough light to measure the apparent magnitude of the Galilean moons. Figure 2 shows the unprocessed image of Jupiter and all four Galilean moons. The image includes the subtraction of a dark frame despite the grainy image. The graininess is likely due to the ambient light from nearby street lights that affect images especially when they are closer to the horizon.

Knowing the apparent magnitude of Jupiter, students can use the method developed for measuring the relative apparent magnitudes of stars from the CCD introduction laboratory. Students discover noticeable differences between the apparent magnitude of the moons. Questions guide them to formulate hypotheses about these differences. Once they realize that the apparent magnitude is due to reflected sunlight, many students can determine that size and surface composition determine the moon's apparent magnitude. Students also learn about uncertainty and speculate about any systematic differences that they observe between their measured values and accepted values.

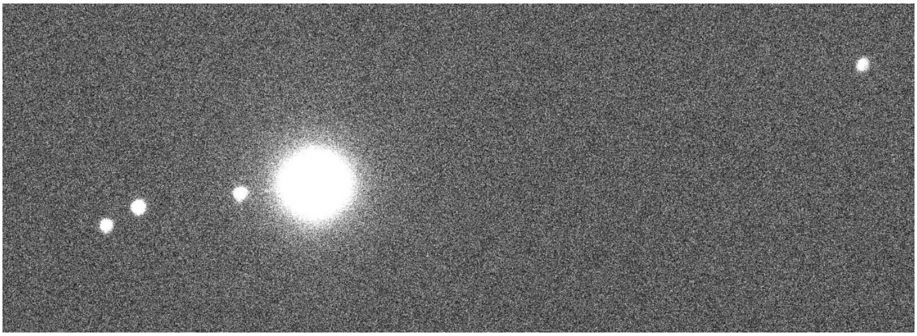

Figure 2. The raw exposure image of Jupiter, the largest object near the center, and all four Galilean moons.

Preservice Teacher Resources. Because of the increase and assumed sustained fraction of pre-service teachers that take astronomy, we envisioned that the laboratory manual would be used as a source for teachers as they enter their service. Every laboratory in the manual . observation, simulation, and modeling . has a "For K-12 Teachers" supplement section. The generic purpose of this section is to summarize and collect resources for K-12 teachers to use in their classrooms that relate to each specific laboratory topic.

Table 1 shows an example of the format of the resources. These pages come directly after the laboratory portion. Each resource begins with some general activities that could be appropriate for all grades. Suggestions include a brief description and a URL for additional information or data. Following the general interest activities are specific activities for elementary (K-5) and secondary (6-12) classes. In addition to activities, there are web resources complied specifically for educators. These sites include information for activities, questions, and lesson plans. At the end there are specific guided questions for teachers to consider when administering or constructing lessons based on the suggested activities.

Pre-service teachers in the Fall 2017 class were alerted to this new feature of the manual and were encouraged to use the resource in their future classrooms. The laboratory manual is printed and bound at Augustana and sold to students for printing costs. Therefore, it should represent a relatively inexpensive resource that we hope to be useful for pre-service teachers as they enter their service.

Table 1. Example of K-12 Teacher Resource pages associated with the simulation laboratory on the Kepler mission: extrasolar planet detection by the transit method.

Hands-On Activities and Virtual Labs (All Grades)

1. 5 Ways To Find a Planet – Exoplanet Exploration – This website explores the five ways of discovering planets in space, showing students the methods used by the Kepler Mission to detect new planets.

   URL: https://explanets.nasa.gove/interactable/11

2. ETD – Exoplanet Transit Database – The place where all new planets are recorded, showing the information of each planet found, when it was found, and its name. This could be a useful website to have students explore the planets found by the Kepler Mission, giving it a real work connection.

   URL: var2.astro.cz/ETD

3. Simulator – Extrasolar Planets – NAAP – Astro UNL – This lab allows students to do their own discovery of extrasolar planets. This teaches students both the methods of finding extrasolar planets and the role of the Kepler Mission.

   URL: astro.unl.edu/naap/exp/animation/transitSimulator.html

4. Exoplanet Transit Hunt – FOSSweb – The Kepler project searches for Earth-like planets. This virtual lab allows students to find out how the Kepler Mission accomplishes the task.

   URL: www.fossweb.com/delegate/ssi-foss-vcm

Table 1. Continued

Websites for Educators (Grades 6-12)
1. Transit Tracks Less Plan – NASA – This includes teacher instructions, graphs, tables, and questions. Teachers will be able to test students on how transits happen using the Orrery Model. *URL: https://www.nasa.gove/kepler/education/formal/transittracks*
2. Exploring Exoplanets with Kepler Activity – NASA/JPL EDU – Students use math concepts related to transits to discover exoplanet transits. Website provides lesson plans for teachers including standards. *URL: https://www.jpl.nasa.gov/edu/teach/activity/exploring-exoplanets-with-kepler/*
Websites for Educators (Grades K-5)
1. A Lesson on Kepler's Discoveries – Kids Discover – Resource for information on Kepler's mission that could be used in an elementary-aged classroom. Provides discussion questions at the end for further assessment and thought. *URL: www.kidsdiscover.com/teacherresources/a-less-on-keplers-discovery*
Websites for Students (Grades 6-12)
1. Kepler News – NASA – Students can stay up-to-date on the latest Kepler explorations. With this website students would be able to research current and past findings both for their personal interest and class purposes.

TESTING THE EFFECTIVENESS OF THE LABORATORIES

The effectiveness of the laboratories were assessed by comparing two classes of introductory astronomy. The Fall 2016 class (FA16) had a laboratory component scheduled concurrently with lecture. The class met from 8-10 AM on Tuesdays and Thursdays weekly for a total of 4 contact hours per week. The Fall 2017 class (FA17) met from 8:30-10 AM on Tuesdays and Thursdays weekly with students attending one of two laboratory sections that met from 8-10 PM on Tuesday or Thursday for a total of 5 contact hours per week. The instruction technique, assignments and most exams were identical between the two courses being considered. In addition, the assessment used to evaluate the instruction was given at the same time and under the same conditions in both semesters.

Both classes FA16 and FA17 ended with 26 students. The FA16 class began with 28, while the FA17 class started with 30. In any analysis that follows, only the 26 students that completed the semester are included.

The Astronomy Course in General. Like other introductory courses in the physics department at Augustana, the astronomy course is taught with minimal lecture and a focus on active learning. Before class, students are assigned readings from the text and a set of pre-instruction questions ("warm-ups"). The "warm-ups" are graded through Pearson's "Mastering Astronomy" (https://www.pearsonmylabandmastering.com/northamerica/masteringastronomy/) and are due online about 8 hours before class. The instructor can implement some just-in-time teaching as necessary. During class, students work in groups of 3-4 on worksheets related to the topic of the day. Students are assigned personal response devices ("clickers") and answer multiple choice questions designed to assess knowledge and deepen understanding. After class, there are homework assignments that are submitted through Mastering Astronomy.

The student groups are an important component of the course. These groups are for the lecture portion only and change after each of the four semester exams in the course. Students self-select into their first group and work with it until the first exam. All subsequent student groupings are chosen by the instructor based on data collected for each student, including their clicker responses, class attendance, and performance on homework and exams. Students are expected to work actively with their group. To encourage group work, we base each student's semester exams scores on a combination of individual and group work.

The laboratory component for FA16 was seamlessly integrated during class time as part of the mix of clicker questions and worksheets. The class met in one of two "Active Learning Classrooms" in the Froiland Science Center. This room has 8 tables with approximately 8 students per table. Each table has two LED monitors over which the instructor has control. The monitors can display the room PC, the document camera, or a wireless device like a tablet. The instructor can release the screens, and one student device can be connected to each monitor via HDMI and VGA connectors within the table. During simulation labs, instead of group members working individually on their devices or huddled around a single device, one student in a group connects their device to the monitors allowing several group members to watch a single large screen. The instructor can monitor simultaneously what each group was working on and give immediate feedback as the groups worked.

To overcome heterogeneous hardware issues, the Information Technology department implemented a server that hosts several Windows PCs accessible by an internet browser. Common software such as the Compadre Java applets and archived images are available. Adobe Flash is also kept up-to-date and active so that students do not have security issues running Flash on their own device. Students can open an internet browser from any device, log into the remote machine, and have a Windows desktop with all software available to them.

For FA17, the lecture portion ran exactly as described above with the exception of a couple of small additions to the clicker questions and worksheets. Some of the shorter laboratories were retained for use during the lecture. For 11 weeks students met during Tuesday or Thursday evenings to work on simulation and observation labs. Because of cloudy weather either Tuesday or Thursday night, only one outside observational lab was completed, and no images were obtained. However, students did learn to use the CCD camera and analyzed images taken with the camera during the summer. Deciding how to deal with the weather to maximize the time with the telescope and taking images will be addressed at the next time the class is offered in Fall of 2018.

Diagnostic Test. To independently assess student learning, we use the Astronomy Beliefs Inventory (ABI) that contains 215 true/false questions (Favia et al. 2014). Students are instructed to indicate the truth of each statement and if they learned about the truth of the statement before high school, during high school, during this course, or had never considered the question. The purpose of the ABI is not only to assess content knowledge, but also to determine why and how misconceptions persist post-instruction. Because the breadth of topics and shear number of questions, we decided on the 64 most relevant questions (Appendix 1) so that students would not need more than about 30 minutes to complete the task. While the ABI was not written to be given pre-instruction, it was given on the first day of class before any instruction and after the syllabus was discussed. No credit was given for completing the pre-test. The ABI was then given post-instruction during the final exam. A small number of points was given as credit for the final exam for completing the post-instruction ABI.

The figure of merit for any assessment tool given pre- and post-instruction is the gain. We use the gain defined by Hake (1998) as here *pre* and *post* are the pre- and post-instruction test scores, respectively, and *max* is maximum score of 64. Assuming that a student does not miss any questions on the post-instruction test that they correctly answered on the pre-instruction test, this definition of gain can be interpreted as the fraction of questions correct on the post-instruction test that were incorrect on the pre-instruction test.

To determine if the ABI is an independent measure of student learning, we have correlated the student gain, which is the measurement of the amount of learning from the assessment tool, to the final course grade, which is the instructor's assessment of student learning. This is shown on the left panel of Figure 3. There is a positive correlation that exists. From the Theil-Sen estimation technique (Sen 1968), the intercept is 0.780 ± 0.006 and the slope is 0.094 ± 0.021. Two students in FA17 had a negative gain, meaning that their post-instruction test score was lower than their pre-instruction test. Since both students had above average pre-instruction scores, they had fewer wrong questions to get right making the absolute value of the gain suspect. If we remove these two negative gain student's from the sample, the course grade vs. gain Theil-Sen slope becomes 0.120 ± 0.024. With the negative gains either included or excluded, the data indicate enough positive correlation that we feel justified to use the ABI as an independent measure of the learning in the course. Throughout the rest of the paper we analyze the FA2017 dataset with and without the negative gains to give a maximum bounds on the gain for that dataset.

Ideally, a correct gain measure and a good diagnostic tool will produce a gain that is independent of pre-instruction score. The right panel of Figure 3 shows the distribution of gain vs. ABI pretest score. Using the Theil-Sen technique we have estimated the linear slope with these data. For all 52 students the slope is -0.003 ± 0.066. Excluding the two negative gain values yields a slope of 0.001 ± 0.066. We conclude that there is no statistically significant correlations between the gain with the pretest score and our test, and that the gain calculation is not biased toward certain pre-instruction knowledge.

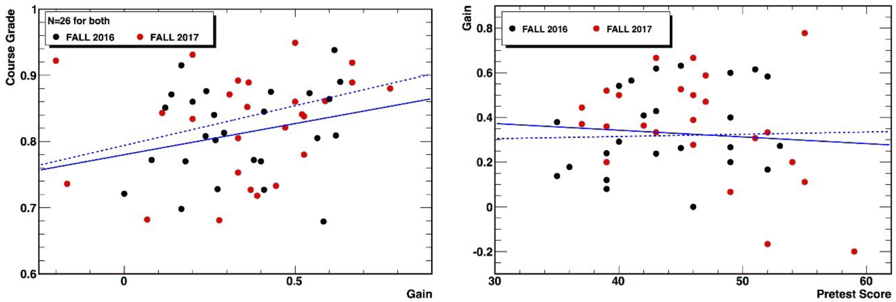

Figure 3.* Left*: The course grade vs. ABI gain for each student from both Fall 2016 (black) and Fall 2017 (red). The blue lines indicate the Theil-Sen best-fit lines for the data with (solid) and without (dashed) the two negative-gain data. A positive correlation between the ABI gain and course grade is measured with a slope of 0.094 ± 0.021 (solid blue) and 0.120 ± 0.024 (dashed blue).* **Right: The gain vs. ABI pretest score. The blue lines indicate the Theil-Sen best-fit lines for the data with (solid) and without (dashed) the two negative-gain data. There is no statistically significant correlation measured since the slopes are -0.003 ± 0.066 and 0.001 ± 0.066 for the data with and without the negative gains, respectively.***

Comparison of Fall 2016 and Fall 2017. With a gain and diagnostic tool that are reliable for measuring student learning, we compared student learning in FA16 without the observational laboratory component to FA17 with the observational laboratory component. Figure 4 shows the distribution of raw ABI scores for both pre- and post-instruction in FA16 and FA17, each with $N = 26$ students. In both years, the post-instruction test scores appear significantly higher. A Welch's t-test (Welch 1947) on the two distributions using a one-tail comparison gives $t = 7 \times 10^{-5}$ and $t = 8 \times 10^{-6}$ for FA16 and FA17, respectively, both resulting in $P << 0.01$. The statistically significant increase in scores is attributed to learning during the course in both semesters.

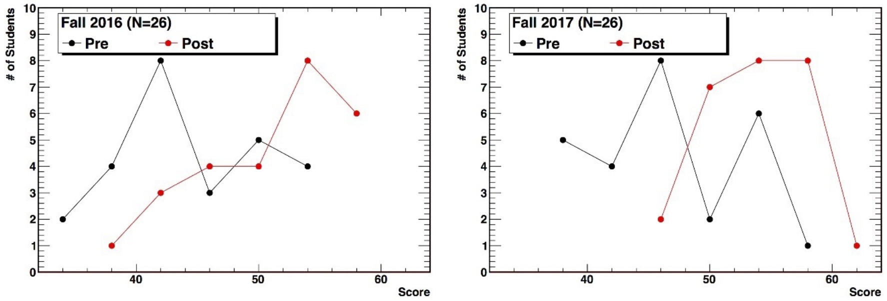

Figure 4. The pre- (black) and post-instruction (red) test scores for students in Fall 2016 (left) and Fall of 2017 (right). Recall the maximum score is 64. The shift of the red distribution compared to the black is an indication of student learning.

Table 2 summarizes the raw pre- and post-instruction scores on the ABI for each semester as well as the FA17 semester, excluding the two students with gains below zero. The gains in the table are calculated from the average scores for the class. The gain of 0.395 in FA17 (*N* = 26) is noticeably higher compared to 0.330 in FA16 (*N* = 26).

Table 2. A summary of the raw scores for the* N *= 26 students that completed both pre- and post-instruction assessment. The total score is 64. The last column excludes two students with gains below zero. The gains calculated from the average raw scores in Fall 2017 are higher than Fall 2016.

	2016 (*N* = 26)		**2017 (*N* = 26)**		**2017 (*N* = 24)**	
	Pre	Post	Pre	Post	Pre	Post
Raw Score	44.19 ± 1.10	50.73 ± 1.14	46.38 ± 1.29	53.35 ± 0.80	45.63 ± 1.14	53.29 ± 0.83
Gain	0.330		0.395		0.417	

We have student-by-student information as well. Figure 5 shows a histogram of individual student gains. Averaging over 26 students yields a gain of 0.339 and 0.364 for FA16 and FA17, respectively. If we remove the two students with negative gain, the average gain in FA17 (*N* = 24) is 0.410. Again, these average gains are larger in FA17 when the observational laboratory was added compared to FA16 without the observational laboratory. A Kolmogorov-Smirnov test (Kolmogorov 1933, Smirnov 1948) was performed on the student gain data. The maximum Kolmogorov distance $z = 0.538$ results in a *P*-value = 0.001 indicating that the two distribution would not likely come from the same underlying distribution. We conclude that the difference in gains is statistically significant.

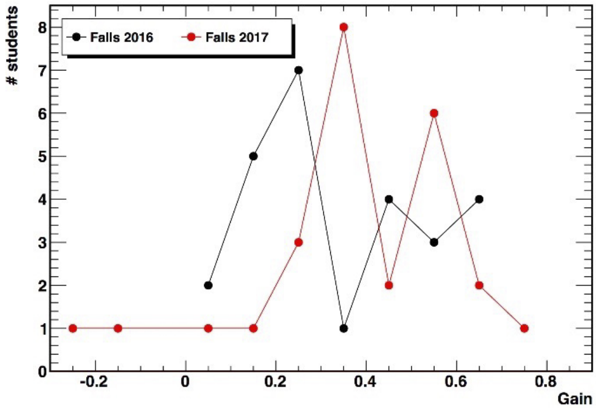

Figure 5. The distribution of student gains in Fall 2016 (black) and Fall 2017 (red). The mean of the Fall 2017 distribution is higher than the Fall 2016 distribution. A Kolmogorov test indicates the two distributions do not come from a single underlying distribution.

SUMMARY AND CONCLUSIONS

In this paper we have presented the update of the laboratory manual of Augustana University's general education course on introductory astronomy with observational laboratories using the department's 10" telescope and CCD camera. The manual was also updated to include K-12 teacher resources for each laboratory topic. The hope is that these will be useful for the pre-service teachers enrolled in the course.

We have attempted to evaluate the inclusion of the observational laboratories by comparing student learning between the Fall of 2016 without the laboratories and Fall of 2017 with the laboratories. The same assessment tool, the Astronomy Beliefs Inventory, was given as a pre- and post-instruction test during both semesters. This assessment tool gains, as defined by Hake (1988), correlate with the course grade indicating it is an independent tool for student learning. The gains are independent of the pre-instruction test scores meaning the gain and tool are not biased in some obvious way.

The ABI gains measured in Fall 2017 are higher than those in Fall 2016. The student gain distribution is statistically different according to a Kolmogorov test. We can conclude that increased learning did occur in Fall 2017 compared to Fall 2016. However, it is not exactly clear that this is entirely due to the addition of the observational labs. There are several possible variables that are difficult or impossible to fix in such an analysis. For example, the class composition could have an impact, i.e. the male/female ratio or the mathematical abilities of the students. However, since pre-instruction test score is a measure of incoming knowledge and the gain is independent of pre-instruction score, the likelihood that class composition is a contributing factor in the increase in gains is probably small.

A more likely contributing factor was the increase in contact hours. Because of the addition of the observational laboratories, an alternative evening laboratory time was needed in Fall 2017. Separating lecture and lab created one additional contact hour compared to Fall 2016. There were two separate laboratory sections with student teaching assistants (TAs) compared to a single lecture and laboratory combination in Fall of 2016 without a TA. Having two sections and TAs meant individual attention increased in Fall 2017 compared to Fall 2016. It is possible that increased individual attention increased student learning. Still, the impetus for separate lab times and the need for TAs was the addition of the observation labs. Therefore, it is possible that the observational laboratories indirectly affected the teaching environment in a positive way to increase student learning.

ACKNOWLEDGEMENTS

One of us (KM) was supported by a South Dakota Space Grant Consortium Student Fellowship. One of us (NG) was supported by a South Dakota Space Grant Consortium Project Innovation Grant. We are also grateful to the Academic Dean of Augustana University for the telescope, CCD camera, and other equipment support to make this work possible.

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Appendix 1. Astronomy Beliefs Inventory

For completeness we have included the 64 questions from the Astronomy Beliefs Inventory (ABI) used for pre and post instruction.

For each statement, **first decide if the statement is true or false.**
After you have decided:

If you think the statement is true, at the end of the statement indicate:
A if you learned this before high school,
B if you learned this in high school,
C if you learned this in this course,
D if you never considered this statement before today.

If you think the statement is false, at the end of the statement indicate:
E if you learned this before high school,
F if you learned this in high school,
G if you learned this in this course,
H if you never considered this statement before today.

1. Astronomers mostly work with telescopes.
2. Astronomy and astrology are different things.
3. Summer is warmer because we are closer to the sun during the summertime.
4. Seasons are caused by speeding up and slowing down of Earth’s rotation.
5. Stars follow you in your car.
6. The north star is the brightest star in the sky.
7. Earth’s axis is tilted compared to the ecliptic.
8. The Sun always sets due west.
9. The Moon sets during daylight hours and is not visible then.
10. The Moon is lit by reflected “Earth light” (that is, sunlight scattered off the Earth toward the Moon).
11. The Moon is involved with eclipses.
12. The Moon’s physical shape remains constant throughout its cycle of phases.
13. Few objects orbit the Sun in circular orbits.
14. The speed of Earth in its orbit changes as it goes around the Sun.
15. The Sun is directly overhead everywhere on Earth at noon.
16. The Moon will someday crash into Earth.
17. Gravity will eventually pull all the planets together.
18. Craters are volcanic in origin.
19. There is plant life on other planets in our solar system.
20. Venus is hotter than the Earth
21. The Earth is the only planet with an atmosphere.
22. The Moon has seas and oceans of water.
23. The Moon has an atmosphere like the Earth
24. The Moon is older than the Earth: a dead planet that used to be like Earth.
25. The asteroid belt is an area like we see in Star Wars, very densely packed.
26. Jovian planets (Jupiter, Saturn, Uranus, Neptune) have gaseous or icy surfaces
27. Saturn’s rings are solid.
28. Saturn is the only planet with rings.
29. Each planet has one moon.
30. There is only one moon. Ours.
31. All stars have planets

32. The Sun is a star.
33. Stars run on nuclear reactions instead of gasoline or natural gas.
34. The Sun's surface temperature is millions of degrees Fahrenheit.
35. The Sun is the smallest star in universe
36. The Sun is the brightest star in universe.
37. The Sun is yellow.
38. We are looking at stars as they are now.
39. All of the stars were created at different times.
40. Stars are at different distances from the Earth.
41. All stars have same color and size.
42. Stars emit many colors of light.
43. The brighter a star is, the hotter it is.
44. Other stars are hotter than the Sun.
45. Many stars are smaller than the Sun.
46. Stars convert energy and change size or color.
47. The Sun will blow up, become a black hole, and swallow the Earth.
48. Jupiter is nowhere large or massive enough to be a star.
49. "Metals" have always existed in the universe
50. New planets and stars are forming today.
51. Black holes create themselves from nothing.
52. Black holes are empty space.
53. Black holes are like huge vacuum cleaners, sucking things in.
54. The Milky Way contains gas and dust.
55. We can see only some of the stars in the Milky Way.
56. The Sun is far away from the center of the Milky Way galaxy.
57. The Sun moves through space.
58. All galaxies are spiral.
59. The galaxy, solar system, and universe are the same things.
60. There are billions of galaxies.
61. The Milky Way is the center of the universe.
62. There is no center to the universe.
63. Space is infinite.
64. The universe as a whole is changing.