A Weekend Workshop on Double Stars for Students

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Abstract A weekend double star workshop was held by Vanguard Preparatory for selected eighth grade students with the purpose of introducing them to astrometric observational science. The students were selected based on an essay provided by their language arts class. Collaboration with local visiting astronomers was established to provide telescopes equipped with an astrometric eyepiece, observational supervision, and expertise. During the workshop students learned how to determine the scale constant of an astrometric eyepiece, and the procedure for measuring separations and position angles of double stars. The students compared their data to past measurements reported in the Washington Double Star Catalog. Three goals were set for the student's outcome: 1) observe, record, and report observations of double stars, 2) write a scientific paper for publication in the Journal of Double Star Observations, and 3) present a PowerPoint presentation to their peers. This paper chronicles the planning, preparation, funding, and execution required to complete a double star workshop at a public middle school.

Introduction

Vanguard Preparatory School is a public middle school in Apple Valley, California and is part of the Apple Valley Unified School District. Apple Valley Unified is a leader in the San Bernardino County Superintendent of Schools' Alliance for Education STEAM 2020 initiative which brings science, technology, engineering, applied arts, and math into the classroom. Vanguard is a magnet school with a competitive entrance process for student enrollment. On March 20-22, 2015, Vanguard Preparatory held the second annual double star workshop for 28 eighth grade students.

Figure 1: Left image: The authors of the High Desert Research Initiative from left to right: Sean Gillette, Reed Estrada, Mark Brewer, and Chris Estrada. Right image: A group photo of the selected eighth grade students in the gym of Vanguard Preparatory.

The students were selected based on an essay written for their language arts class. 181 students submitted an essay and 28 students were selected to participate. The students were separated into three teams where they would learn how to calibrate their equipment, as well as measure the separations and position angles of double stars. Procedures of how to observe and measure visual double stars were adopted from Argyle (2012). The students learned the techniques needed to successfully measure double stars and compare their observations with previous observations reported in the Washington Double Star Catalog (WDS). By the end of the event, the students had written a paper submitted for publication in the Journal of Double Star Observations (JDSO) and presented a PowerPoint presentation to their peers. The four authors of this paper formed the High Desert Research Initiative (HDRI) as a useful artifice in working with the students. Figure 1 shows the leaders of HDRI and the students who participated in the workshop.

Project Outline

This workshop was branded the "Vanguard Double Star Workshop (VDSW)" and lessons learned from the 2014 workshop were incorporated into the 2015 event. Student eligibility was based on an application essay that the students had submitted in late December of 2014. All eighth graders were required to submit an essay through Google Classroom in their language arts class. Google Classroom is a teaching management tool for organizing, assigning, editing, and grading Google Doc assignments in a classroom setting. All eighth graders have a Google Chromebook, which is a small, inexpensive laptop checked out to them for the year, which greatly helps facilitate a digital environment. This proved to be a key asset during the workshop.

The essay was required to be two to three pages in length, include pertinent images, and covered the following astronomy topics: (a) what is astronomy, (b) what do astronomers study, (c) where are the best places to observe astronomy and why are they ideal, (d) how does a telescope work and what are the different types, (e) how are stars formed, (f) what are double stars, (g) and why are double stars important for study. The essays were read and graded over the winter holiday and thirty-six students, plus five alternates, were initially selected. Several students chose to withdraw from the project. Due to the availability of volunteer visiting astronomers, the project was limited to three student teams. To keep the student numbers manageable, it was decided to have an approximately 10-1 ratio of students to visiting astronomer team leaders. A final group size of 28 students on three teams were paired with four visiting astronomers and five classroom teachers.

The budget for this workshop was set at $1000, including t-shirts given to all participants ($400). The remaining funds were spent on three meals, Friday's dinner (pizza), Saturday's dinner (tacos), and Sunday's lunch (sandwiches) as well as miscellaneous snacks and office supplies. In addition, gasoline gift cards totaling $50 dollars were provided to the visiting astronomers, along with plaques of appreciation.

Friday and Saturday night were scheduled for observations and measurements. Apple Valley typically has clear nighttime skies. The event started at 7:00 pm Friday with the students watching a NOVA special on the development of the telescope, narrated by Neil deGrasse Tyson. This film allowed the visiting astronomers ample time to set up their telescopes. After the movie, introductions were given and group photos were taken, followed by dinner. After dinner, the astronomers met with their groups and made their measurements of double stars. With their observations completed, the group was treated to a star party on Saturday led by two of the visiting astronomers. While the telescopes for the star party were being set up, the students used toilet paper to create a scale model of the solar system.

Sunday consisted of morning and afternoon sessions for writing papers, crafting presentations, and delivering their presentations. A template was provided to each group to facilitate their writing and Google Docs expedited the process as the students could work simultaneously on one document. The paper's first draft took approximately two hours to write, with technical assistance provided by the visiting astronomers. Before the students were allowed to eat lunch, they had to create and practice a presentation. After lunch, the three groups delivered their presentations in the format of a professional astronomy conference. Questions were encouraged from the audience, asking the students to explain their measurements and justify their conclusions. Figure 2 shows the students presenting their research. In the future, HDRI plans on inviting parents and past workshop participants to sit in the audience to further stimulate a scientific discourse.

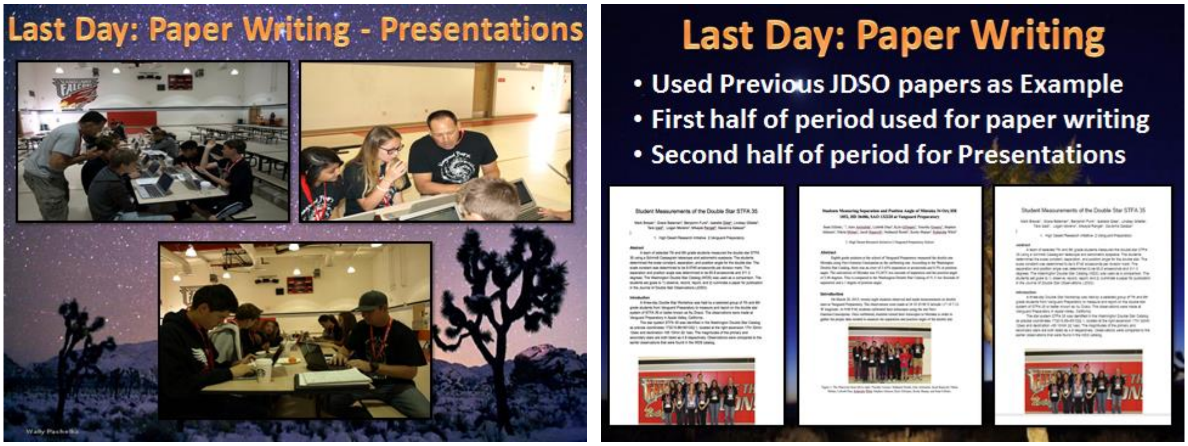

Figure 2: Left image: An image of the three teams structuring the first draft of their scientific paper (first period) and designing their PowerPoint presentation (second period). Right image: The teams complete first draft papers for publication in the Journal of Double Star Observations.

One of the lessons learned from 2014 was the need to schedule student editing time, so as to not burden the visiting astronomers with additional work. This year, three consecutive Mondays were scheduled after school for internal reviews. The visiting astronomers were able to comment on the student papers from afar while the students met and re-worked their papers. At the conclusion of these three sessions, the papers were sent off for external review. The visiting astronomers were responsible for incorporating these external reviews into the papers.

Equipment and Procedures

The three telescopes/eyepiece combinations used were: (1) a 22-inch Newtonian Alt-Az telescope equipped with a 12.5mm Celestron Micro Guide eyepiece attached to a Bell and Howell HD video camera, (2) an 8-inch Celestron Schmidt-Cassegrain telescope mounted on a Celestron Advanced VX and equipped with a 12.5mm Bader Planetarium Micro Guide astrometric eyepiece, and (3) an 8-inch Meade Schmidt-Cassegrain telescope mounted on a Celestron CG-5 German equatorial equipped with a 12.5mm Celestron Micro Guide astrometric eyepiece. Three stopwatches that read to the nearest 0.01 seconds were used for calibrating the linear scale of the eyepieces. Figure 3 shows the student teams collecting data.

A scale constant was determined by each team to calibrate the telescope-eyepiece combination by aligning a bright calibration star. The eyepiece was rotated to allow the star to drift along the linear scale when the tracking motor was disengaged. The students started the timing once the star's centroid drifted across the first division mark and the timing was stopped once the centroid of the star crossed the last division mark. A total of ten drift measurements were timed to determine an average, standard deviation, and a standard error of the mean by using the following equation:

$$Z = \frac{15.0411 t \cos(dec)}{D}$$

where Z is the scale constant in arc seconds per division mark, 15.0411 is the Earth's rotational rate in arc seconds per second, *t* is the average drift time in seconds, cos(dec) is the cosine of the calibration star's declination, and D is the number of divisions on the eyepiece's linear scale.

The separation was determined by aligning the double stars along the linear scale and counting the division marks between them. A total of ten measurements were recorded to determine an average, a standard deviation, and a standard error of the mean. The scale constant was multiplied by the average separation to convert the separation to arc seconds.

The position angle was determined by aligning the stars along the linear scale with the primary (brightest) star on the central division mark. The stars were then allowed to drift to the outer protractor scale by disabling the drive motor of the telescope. The drive motor was re-engaged once the primary star reached the protractor and the position angle was recorded in degrees. A total of ten measurements were recorded to determine an average, standard deviation, and a standard error of the mean. Figure 4 shows the students analyzing their data.

Figure 3: Left image: Sean Gillette manning his 8-inch Celestron Schmidt Cassegrain telescope while one of the students observes and records a measurement. Center image: The 22-inch Newtonian Alt-Az telescope that Reed and Chris Estrada built. A student on their team stands on a ladder to observe and record a measurement. Right image: A group image of Mark Brewer's team observing and recording their measurements with an 8-inch Meade Schmidt Cassegrain telescope.

Figure 4: Left image: Students observing and recording a measurement of the double star from the gathered data on the Bell and Howell HD video camera. The software used was Photoshop. Right image: Excel spreadsheets were designed for the selected students to record their measurements electronically.

Lessons Learned

Several lessons were learned during the 2015 workshop. The first lesson was planning. As the months and days before the event approached, the stress of having the event run smoothly was considerable. The most stress is the unpredictable weather, so back-up dates were planned for the following weekend. Figure 5 shows the planning phases of the workshop. The second lesson was that thorough preparation of the students was an absolute requirement. The third lesson concerned the scientific papers the students wrote. A template was provided with headings that guided each team of students. The fourth lesson was the need for additional astronomer involvement to reduce the student-telescope ratio. The fifth lesson was learned on the last day of the event. The teams presented PowerPoint presentations to their peers, but having the students' parents attend would have allowed them to witness what their children had accomplished.

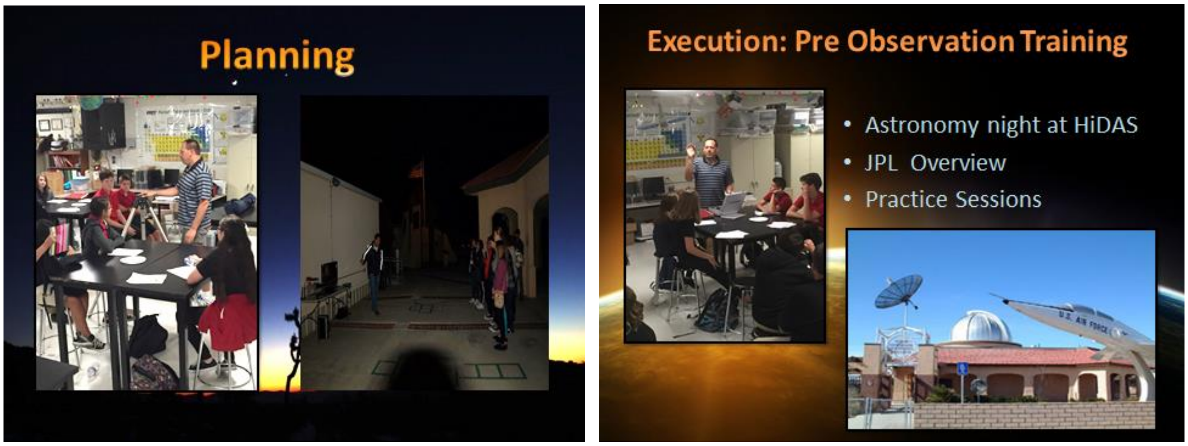

Figure 5: The planning of the event to prepare the students for the weekend workshop.

Conclusions

The weekend of double star measurements that were made by selected eighth grade students from Vanguard Preparatory was completed with success. The students finished the event by completing the goals of 1) observing, recording, and reporting their measurements, 2) writing a scientific paper for publication in the JDSO, and 3) presenting a PowerPoint presentation to their peers. The preparation proved successful, but additional lessons were learned.

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