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A Pacific Teacher Enhancement Program – Toward Other Planetary Systems

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Abstract. This paper describes a National Science Foundation Teacher Enhancement Program (NSF9731083) based on the theme of "Toward Other Planetary Systems" held in Hawaii from 1999–2004. The purpose of the workshop is to help local and US-affiliated Pacific teachers acquire basic astronomy knowledge, modern teaching skills, and gain insight into exciting contemporary astronomy research. Instructional skills are strengthened by providing new hands-on materials, experience with evaluation techniques and extensive follow-up. The program also has an integrated student component designed to introduce high school students to careers in astronomy, technology and the sciences. Discussions of how astronomers are using the telescopes on Mauna Kea, around the world, and in space to search for evidence of planet formation in other planetary systems – origins – and to search for life elsewhere are opening up a new awareness of the forefront of astronomical research in Hawaii and around the world.

1. Introduction

Humans are at their best when they are stretching for new frontiers — since at our core we have a basic need to dream and to seek out answers. Astronomy is unique and privileged among the sciences to have played a fundamental role in humanity's quest for new frontiers. In the deepening colors of the evening twilight, as the first stars and the planetary wanderers began to appear, primitive man turned his attention to the heavens and perhaps to speculate on the character of the lights that appeared to fill the infinity of the night — to begin to wonder about his origins and the relationship of his world to the nighttime

splendor. As civilization and culture grew, so did science through the meticulous observation of the diurnal and annual motion of objects in the heavens, coupled with the development of rich cosmologies and mythologies. Astronomical observation was the tool by which time and calendars were kept, and insight into the natural world was developed, nurturing the infant sciences of mathematics and physics. This powerful lure of the heavens is still present in the modern society, even though most don't take the time or have the opportunity to recognize it unless one can escape from the light-polluted cities — if even only in a local planetarium. Both the child in the planetarium as the lights dim and the astronomer high atop a mountain suspended between the desert haze far below and the twilight palette above will feel the same mesmerizing wonder about the vault of the heavens.

Recently, an effort to increase the level of appreciation for science research has gained national momentum (Yager & Lutz 1994), as evidenced by the national science education reform movements which include the NRC National Science Education Standarsd, the AAAS Project 2061 and the AGU Earth Systems Science programs, among others. Uniquely, the allure of astronomy and the astronomical search for origins (which encompasses planetary formation, search for extrasolar planets and the search for extra-terrestrial intelligence) serves as a powerful basis for educational outreach. The Institute for Astronomy (IfA) has recently embarked on a major astronomy outreach program called TOPS ("Toward Other Planetary Systems"). This five year NSF-sponsored program is an outgrowth of a smaller pilot NASA-sponsored workshop held in Hawaii from 1993-5. The program's goals are to initiate lasting systemic reform in Hawaii's science education by enabling science and math teachers to implement astronomy in the classrooms. This meets a need for additional science curricula given the recently increased state graduation requirements and UH admissions requirements. The teachers are encouraged to implement astronomy topics in the classroom by participating in an intensive 3-week summer workshop held in part on Oahu and in part on the Big Island at the Hawaii Preparatory Academy, a private boarding school. Here teachers learn basic astronomy content, explore the national science education standards, participate in hands-on activities using exemplary materials (e.g., Hands on Astrophysics), learn student assessment techniques, and conduct nightly telescope observations.

2. The Teacher Enhancement Program

The participants in the first year of the program were 20 local Hawaii high school science / math teachers, 10 teachers from the US-affiliated Pacific entities, and 20 local high school students. We had teachers from Guam, Yap, Kosrae, the Marshall Islands, Palau and Rota. Because of the unique background and diversity of culture that these teachers brought to the program, we blended in a strong cultural astronomy component into the workshop. There is a rich heritage of polynesian voyaging in Hawaii and the Pacific, and astronomy was the basis of this seafaring culture (Meech & Warther 1996; Ruggles 2000).

The 1999 program ran from June 13-July 1, with the first 4 days on the island of Oahu being dedicated to highlighting resources for the teachers that could be used in the implementation of the classroom activities. The teachers

were introduced to the resources at the Bishop Musuem Planetarium, the facilities at the Leeward and Windward community colleges, the facilities at the Institute for Astronomy, and the Palehua Solar Observatory.

The big island portion of the workshop was the primary period for hands-on training. The daily activities were a mixture of lecture, hands-on activities, small discussion groups, demonstrations, and tours. One of the featured activities was the nightly astronomy observing program. With a complement of ≈20 small (8-inch class) telescopes, the participants worked on a variety of observing projects which ranged from telescope familiarization (Fig. 1a; Messier object searches, variable star measurements and light curve plotting, double star separation measurements and lunar sketching), to photography (Fig. 1b; height of lunar relief lab, deep sky astrophotography), and use of a simple spectroscope and CCD cameras. The goal of these projects is to give the participants hands-on astronomy experience and to see ways in which the scientific method as applied to astronomy could be used in their classrooms.

Figure 1. (a) A variety of equipment was used during the workshop, providing a wealth of experiences. Here teacher Clyde Kobashigawa (Oahu) looks through a Dobsonian telescope while student Teresa O'Brien (Maui) looks on. (b) A student and teacher examine the negatives from the previous night of lunar photography.

During parallel daily rotation periods, a number of activities were available concurrently (e.g., solar sunspot mapping (Fig. 2a), solar photography, project physics activities, exploration of astronomy software, topical lectures, observing discussion groups, and discussion of fundraising activities), where teachers and students selected ones which best matched their skill levels, subjects and areas of interest.

A unique example where participants experienced part of the research process, workshop attendees were able to participate in a NASA Infrared Telescope Facility (IRTF) observing run. The IRTF on Mauna Kea was remotely operated during the daytime from the remote observing room at Keck Telescope headquarters by astronomer John Spencer from Lowell Observatory while he executed his program of monitoring Io's volcanos in the infrared (Fig. 2b). He interacted with the students and teachers during the observations, explaining the procedures and science in real time.

Figure 2. (a) Daily solar observing sessions at TOPS. (b) Participants involved in a NASA IRTF observing run focussed on Io.

The Hawaiian and Polynesian cultural heritage of navigation and astronomy was woven into the fabric of the workshop through sessions on basic observational astronomy, the celestial sphere, and on the concepts of archeoastronomy. On June 21, the date of the summer solstice, the entire group took a field trip to the Cape Kumukahi heiau and archeological site at the eastern most point of the Big Island. This site has significance as an ancient astronomical school, and the platform itself is supposedly aligned with the summer solstice sunrise (Johnson 1975). Although a rainy dawn greeted our group, the site visit was extremely worthwhile since one of our Marshallese teachers, who had a heritage of navigation, shared some astronomy and navigation of the South Pacific with the group. He demonstrated the use of the Wapepe, a navigational aide made from shells and sticks.

3. Evaluation

This project uses a unique internal/external evaluation plan where the internal evaluators are active participants in the project activities. The formal evaluation plan is also forming a part of the Ph.D. thesis of a Montana State University physics education research graduate student, combining education and evalutation. In the initial years, the primary role of the evaluation is to document, revise and improve the project on a daily basis. The summative evaluation plan is designed to answer specific questions closely aligned with the project goals, relating to whether the program increased the awareness of exemplary astronomy materials, and if it increased the teacher's content background, assessment skills, and the quantity and quality of the teacher's astronomy in their classrooms. The results of the first year's pre- and post-survey tests have shown that the teacher-participants did make tremendous personal cognitive and attitudinal gains in all aspects.

4. Post-Workshop Followup Activities

Much of the project evaluation is still preliminary, since ensuring that there is systemic reform in the classrooms requires an effective followup plan. In this plan, we have integrated the following followup stategies:

- Follow up activites to reinforce skills (star parties, discussion groups)
- Development of astronomy teaching portfolios
- Assistance with execution of secondary workshops where the teachers must run workshops for other teachers in their school complexes (e.g., their middle and elementary schools
- Teacher involvement in associated outreach activities
- Classroom visits by project staff

The purpose of the academic year workshops is to highlight some of the hands-on activities for second tier middle and elementary teachers. It is hoped that each of the primary workshop teachers will reach 20-100 additional teachers in this manner. When considering the number of students that each teacher interacts with, this will have a large multiplicative impact. We are just beginning the post-workshop follow up stage, and since this is just the first year of the program, we do not have the documentation to show the degree to which systemic change in astronomy education has occurred.

5. Future Efforts

The University of Hawaii and the Faulkes Telescope Corporation are constructing a privately funded (United Kingdom) 2-m research class telescope on Maui which is dedicated to secondary and undergraduate education. The telescope should be available for use in the 2002–2003 timeframe, and we will integrate training sessions into the TOPS program to enable teachers and students to make use of the facility for independent research, which will hopefully lead to internationally competitive science fair projects. We would like to use this as a basis for developing a more rigorous undergraduate program as well as an REU site in Hawaii.

6. Conclusions

The first of 5 annual teacher enhancement workshops to serve high school math and science teachers in Hawaii and the Pacific region was held during June 1999 in Hawaii. The program had 50 participants, and during an intense 3 week period they were exposed to cutting edge astronomy in the area of origins and search for extra-solar planetary systems. Preliminary assessments indicate that participants developed new hands-on skills, learned new content and assessment skills. In addition, the students were exposed to a variety of career choices in astronomy, engineering and technology. We see that the program has already

made an impact on the participants at this early stage. Representative comments include:

"I ran into [a student] and he said he was very impressed with astronomy . . . his mom said she felt he was truly changed by it ..." [teacher]

"That's the best workshop I've ever attended . . . our director of education is so excited about [a plan for a secondary workshop] that he told me to continue communicating with you . . ." [teacher]

"The TOPS program this summer has made a large difference in my life . . . Thank you for placing value in the enhancement of the skill for teachers and for giving tribute to the cultural aspects of astronomy." [teacher]

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